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BROOKHAVEN NATIONAL LABORATORY

2008 Site Environmental Report

GROUNDWATER STATUS REPORT

Volume II

2008
SITE ENVIRONMENTAL REPORT
VOLUME II
GROUNDWATER STATUS REPORT

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Environmental Protection Division
Groundwater Protection Group

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Acronyms and Abbreviations

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

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
AS/SVE	Air Sparge/Soil Vapor Extraction
AWQS	Ambient Water Quality Standards
BGD	Below Ground Ducts
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven Linac Isotope Producer
bls	below land surface
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
COC	Chain of Custody
Cr	chromium
Cr(VI)	hexavalent chromium
CRDL	Contract Required Detection Limit
CSF	Central Steam Facility
CY	calendar year
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
DCG	Derived Concentration Guide
DNAPL	dense non-aqueous-phase liquid
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DTW	Depth to Water
DWS	Drinking Water Standards
EDB	ethylene dibromide
EDD	Electronic Data Deliverable
EE/CA	Engineering Evaluation/Cost Analysis
EIMS	Environmental Information Management System
EM	Environmental Management
EMS	Environmental Management System
EPA	United States Environmental Protection Agency
EPD	Environmental Protection Division
ERP	Emissions Rate Potential
ES	Environmental Surveillance
ESD	Explanation of Significant Differences
EW	extraction well
FFA	Federal Facility Agreement
ft	feet
ft msl	feet relative to mean sea level
GAC	granular activated carbon
gal/hr	gallons per hour
gpm	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Inter Agency Agreement
ID	identification
lb/gal	pounds per gallon
lb/hr	pounds per hour
lbs	pounds
LIE	Long Island Expressway
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LTRA	Long Term Response Actions
mCi	milli Curies
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDL	Minimum Detection Limit
mg/kg	milligrams per kiolgram
mg/L	milligrams per liter
MGD	millions of gallons per day
MNA	Monitored Natural Attenuation
MPF	Major Petroleum Facility
mrem/yr	millirems per year
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	mean sea level
MTBE	methyl tertiary-butyl ether
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NSE	North Street East
NSLS-II	National Synchrotron Light Source II
NSRL	NASA Space Radiation Laboratory
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance

OU	Operable Unit
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
pCi/L	pico Curies per liter
PFS	Pile Fan sump
PLC	programmable logic controller
QA/QC	Quality Assurance and Quality Control
RA V	Removal Action V
RCRA	Resource Conservation and Recovery Act
RHIC	Relativistic Heavy Ion Collider
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPD	Relative Percent Difference
RTW	Recirculating Treatment Well
RW	remediation well
SBMS	Standards Based Management System
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
STP	Sewage Treatment Plant
SU	standard unit
SVOC	semivolatile organic compound
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TVOC	total volatile organic compound
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
µg/L	micrograms per liter
WCF	Waste Concentration Facility
WLA	Waste Loading Area
WMF	Waste Management Facility

2008 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 contaminated groundwater
- **Restoration** – maintaining groundwater treatment systems and restoring groundwater quality that BNL has impacted
- **Communication** – communicating the findings and the results of the program to regulators and other stakeholders

The *2008 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 thirteenth annual groundwater status report issued by BNL. This document examines the performance of the program on a project-by-project basis.

How to Use This Document. This detailed technical document includes summaries of laboratory data, as well as data interpretations. Area summary level review of this information is presented as Chapter 7 of Volume I of the *Site Environmental Report*. Groundwater restoration is performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) by the Groundwater Protection Group, and includes measuring and monitoring of groundwater remediation performance, and efforts in achieving cleanup goals. Facility Monitoring refers to the monitoring of groundwater quality at active research and support facilities, primarily in response to Department of Energy (DOE) Order 450.1, Environmental Protection. Data are presented in five key areas:

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

This document satisfies BNL's requirement to report groundwater data under the Federal Facility Agreement (FFA), 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 regulatory requirements of the data collection work in 2008, 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 2008. **Section 3** summarizes the groundwater cleanup data, progress towards achieving the site's cleanup goals, and recommended modifications to the remediation systems or monitoring programs. **Section 4** summarizes the facility monitoring 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 2008:

- The desired flow conditions continued to be maintained in the central portion of the site during 2008, with 90 percent of the total site-wide potable and process water pumpage being derived from the western supply-well field. No shifting of contaminant plumes outside of the established monitoring networks was observed on site in 2008.
- Total annual precipitation in 2008 was 51.1 inches, which is above the yearly average of 48 inches. Seven of the past 10 years have featured above-normal average precipitation at BNL.

GROUNDWATER RESTORATION PROGRESS AND ISSUES (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. During 2008, 12 volatile organic compound (VOC) groundwater remediation systems were in operation, along with two Strontium-90 (Sr-90) treatment systems, and a tritium pump and recharge system. In 2008, 220 pounds of VOCs were removed from the aquifers by the treatment systems. To date, 6,117 pounds of VOCs have been removed from the aquifer. The Operable Unit (OU) III Chemical/Animal Holes Sr-90 System removed 0.74 milli Curies (mCi) of Sr-90 from the Upper Glacial aquifer in 2008, for a total of 3.33 mCi since operations began in 2003. The OU III Brookhaven Graphite Research Reactor (BGRR) Sr-90 System removed 2.7 mCi of Sr-90 during the year, for a total of 16.85 mCi since operations began in 2005.

Groundwater remediation is expected to be a long-term process for most of the plumes. Noticeable improvements in groundwater quality are evident in most of the plumes. The OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) system was decommissioned in 2003, and the OU III Carbon Tetrachloride System has remained in standby since 2004. A number of individual extraction wells have been placed on standby. A petition for closure for the Carbon Tetrachloride System will be prepared and submitted to the regulators in 2009. In 2009 a petition for shutdown will be prepared for the Industrial Park East System. Groundwater remediation activities are expected to continue until the cleanup objectives for the plumes have been met. The specific goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030
- Achieve MCLs for VOCs in the Magothy aquifer by 2065
- Achieve the MCL of 8 pico Curies per liter (pCi/L) for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070
- Achieve the MCL of 8 pCi/L for Sr-90 at the Chemical/Animal Holes in the Upper Glacial aquifer by 2040

The cleanup objectives will be met by a combination of active treatment and natural attenuation. The comprehensive groundwater monitoring program will measure the remediation progress.

The locations and extent of the primary VOC and radionuclide plumes at BNL, as of December 2008, are summarized on **Figures E-1** and **E-2**, respectively. Significant items of interest during 2008 were the following:

- A total of 735 monitoring wells were sampled as part of the CERCLA Groundwater Monitoring Program, comprising a total of 1,815 groundwater samples. In 2008, 86 temporary wells were also installed under the CERCLA program. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site.
- During 2008, 1.5 billion gallons of groundwater were treated, and 220 pounds of VOCs and 3.4 mCi of Sr-90 were removed from the aquifer. (**Table E-1**).

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2008.

	1997 – 2007		2008	
VOCs Remediation (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	3,184,952,850	2,569	135,000,000	60
OU III Industrial Park (Sept. 1999)	1,364,478,330	1010	128,000,000	24
OU III W. South Boundary (Sept. 2002)	602,647,000	49	65,000,000	5
OU III Carbon Tetrachloride (Oct. 1999)	153,538,075	349	0	0
OU I South Boundary (Dec. 1996)	3,184,314,000	337	258,000,000	10
OU III HFBR Tritium Plume (May 1997) (a)	248,978,000	180	86,000,000	0
OU IV AS/SVE (Nov. 1997) (b)	0	35	0	0
OU III Building 96 (Feb. 2001)	138,297,416	71	34,000,000	13
OU III Middle Road (Oct. 2001)	1,267,411,550	741	150,000,000	56
OU III Industrial Park East (May 2004)	287,172,000	33	33,000,000	3
OU III North Street (June 2004)	689,122,000	268	180,000,000	21
OU III North Street East (June 2004)	428,976,000	20	64,000,000	5
OU III LIPA/Airport (June 2004)	846,887,000	235	226,000,000	23
OU VI EDB (August 2004)	471,711,000	NA(d)	153,000,000	NA (d)
Totals	12,868,485,221	5,897	1,512,000,000	220

	2003 – 2007		2008	
Sr-90 Remediation (start date)	Water Treated (gallons)	Sr-90 Removed (mCi)	Water Treated (gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes (Feb 2003)	12,404,826	2.59	6,000,000	0.74
OU III BGRR (June 2005)	22,151,000	14.15	8,800,000	2.7
Totals	34,555,826	16.74	14,800,000	3.44

Notes:
(a) System was placed in standby mode on Sept. 29, 2000, but restarted November 2007.
(b) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance measured by pounds of volatile organic compounds (VOCs) removed. System was dismantled in December 2003.
(c) Values rounded to the nearest whole number.
(d) Ethylene dibromide (EDB) has been detected in the system influent at trace levels well below the standard since operations began. Therefore, no removal of VOCs is reported.
NA – Not applicable
mCi – milli Curies

- The High Flux Beam Reactor (HFBR) Pump and Recharge system was operational during 2008. Newly installed extraction well EW-16 is positioned to capture the downgradient high concentration tritium slug, as shown by 2008 temporary and permanent well data. The leading edge of this slug reached EW-16 during the first quarter of 2009. The system is expected to remain operational for several years until this slug has been completely captured, and tritium concentrations in the area decrease below the 20,000 pCi/L Drinking Water Standard (DWS).
- The source of the Building 96 tetrachloroethylene (PCE) plume was identified and delineated during 2008 following a combined soil boring and soil gas characterization effort. A small area of contaminated soils located in the unsaturated zone south of the former Building 96 is planned for excavation and off-site disposal of soils. It is expected that the removal of this source area will reduce groundwater plume PCE concentrations to below the capture goal of 50 micrograms per liter (μg/L) within three to five years, and allow for the Building 96 Air Stripping groundwater treatment system to be turned off and the OU III Record of Decision (ROD) cleanup goal to be achieved. The source area is presently being hydraulically controlled by the groundwater treatment system, and a temporary plastic cover was placed over the contaminated soils source area until excavation is initiated. A draft *Explanation of Significant Differences* (ESD) documenting the source area excavation was submitted to the regulators in April 2009. Following regulator comment, a Final ESD was prepared in July 2009.
- A groundwater characterization consisting of the installation and sampling of 29 temporary wells was performed during the late 2008/early 2009 time frame. The goal of this effort was to define the present location of both the downgradient g-2 tritium plume slug and the high concentration Sr-90 slug downgradient of the Waste Concentration Facility (WCF). Data obtained reveals that the core of the Sr-90 slug is just to the northwest of the HFBR building, while the area of highest tritium concentrations is located just south of the HFBR. The separation of these two areas will allow for the design of additional extraction wells to capture and treat the higher Sr-90 concentrations without entraining significant tritium. This newly acquired data will be used for pre-design groundwater modeling.
- TVOC concentrations up to 120 μg/L were observed in a temporary well installed along Middle Road in the Western South Boundary area in 2008. This was part of a groundwater characterization effort recommended in the *2007 Groundwater Status Report* in response to a comment from The United States Environmental Protection Agency (EPA). Dichlorodifluoromethane (a freon) and 1,1,1-trichloroethane (TCA) were the primary VOCs detected in several of the eight temporary wells installed to investigate this area. This contamination is projected to be captured at the southern site boundary by Western South Boundary System extraction well WSB-1, which has been reinstated to full-time operation. A permanent monitoring well will be installed in 2009 to monitor this contamination. The data will be evaluated for approximately one year to determine if additional actions are necessary.
- A small area of elevated Sr-90 concentrations has been monitored in the OU I area south of the former Hazardous Waste Management Facility (HWMF) over the past several years. In 2008, Sr-90 concentrations exceeded the DWS in the downgradient sentinel well for this plume. This report is recommending that the plume be further characterized and additional sentinel wells installed.
- No rebound of carbon tetrachloride concentrations has been observed since the system has been in standby mode. System standby began in 2004 following the approval of the petition for shutdown of the Carbon Tetrachloride System. A petition for closure of this system will be prepared and submitted to the regulators in 2009.
- VOC concentrations in Industrial Park East monitoring and extraction wells have decreased to levels well below the system capture goals. As a result, a petition for shutdown of this system

will be prepared and submitted to the regulators in 2009.

Progress of the groundwater restoration program is summarized on **Table E-2**.

INSTITUTIONAL CONTROLS

Institutional controls are in place at BNL to ensure effectiveness of all groundwater remedies. During 2008, the institutional controls continued to be effective in protecting human health and the environment. In accordance with the *BNL Land Use Controls Management Plan* (2007a), the following institutional controls continued to be implemented for the groundwater remediation program.

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

An annual update on Institutional Controls summarizing noteworthy issues, changes, breaches, etc. was submitted to the regulatory agencies in February 2009 and approved in June 2009.

FACILITY MONITORING RESULTS

During 2008, the Facility Monitoring Program monitored groundwater quality at 10 active research and support facilities. Groundwater samples were collected from 125 wells, for a total of approximately 240 individual samples. BNL also installed 29 temporary wells to track the downgradient segment of the g-2 Tritium Plume. Although no new impacts to groundwater quality were discovered during 2008, groundwater quality continues to be impacted at two facilities: continued periodic high levels of tritium at the g-2 Tritium Source Area, and continued VOCs at the Upton Service Station.

Highlights for the Facility Monitoring Program are as follow:

- Tritium continues to be detected in the g-2 source area monitoring wells, at concentrations above the 20,000 pCi/L DWS. A short-term spike in tritium levels was observed in January 2008, with a tritium concentration of 186,000 pCi/L detected in the source area. Tritium levels in the source area wells dropped to less than 50,000 pCi/L by the fourth quarter of the year. Although the engineered stormwater controls are effectively protecting the activated soil shielding at the source area, monitoring data indicate that the continued release of tritium appears to be related to the flushing of residual tritium from the vadose zone following significant natural periodic fluctuations in the local water table.
- During 2008 through early 2009, monitoring of the downgradient areas of the g-2 tritium plume was accomplished using a combination of permanent and temporary wells. The highest tritium

concentration in the downgradient segment of the plume was 80,700 pCi/L, observed immediately south of the HFBR. The southern extent of the plume was tracked to the Temple Place area, where a maximum tritium concentration of 33,300 pCi/L was detected. As a result of natural radioactive decay and dispersion in the aquifer, the tritium plume appears to be breaking up into discrete segments.

- At the Brookhaven Linac Isotope Producer (BLIP) facility, tritium concentrations in groundwater have been less than the 20,000 pCi/L since April 2006. The maximum tritium concentration during 2008 was 5,630 pCi/L. These results indicate that the engineered stormwater controls are effectively protecting the activated soil shielding, and that the amount of residual tritium in the deep vadose zone is diminishing.
- At the BNL Onsite Service Station, VOCs associated with petroleum products and the solvent PCE continue to be detected in the groundwater directly downgradient of the facility. Total volatile organic compound (TVOC) concentrations in one well reached a maximum of 1,575 µg/L, with the contamination consisting mostly of xylenes, ethylbenzene, and trimethylbenzenes. Monitoring of the leak detection systems at the Service Station indicates that the gasoline storage tanks and associated distribution lines are not leaking, and that the waste oils and used solvents are being properly stored and recycled. It is believed that the contaminants detected in groundwater originate from historical vehicle maintenance activities and are not related to current operations. The petroleum-related compounds detected in the groundwater at the Motor Pool are not detected in downgradient Carbon Tetrachloride Pump and Treat System wells, indicating that these compounds breakdown within a short distance from the facility.

PROPOSED CHANGES TO THE GROUNDWATER PROTECTION PROGRAM

The data summarized in this report are the basis for several significant operational and groundwater monitoring changes to the groundwater protection program. A summary of the changes follows (specific details of which are provided in **Section 5**):

- **OU I South Boundary System** – Install up to nine shallow temporary wells to characterize the current extent of the elevated Sr-90 contamination.
- **Carbon Tetrachloride System** – Submit a petition for closure of this system based on the continued low concentrations observed in the monitoring and extraction wells over the previous five years.
- **Building 96 System** – Following regulator approval of the OU III ESD, excavate the PCE-contaminated soils from the vadose zone source area and install three additional monitoring wells to monitor the effectiveness of the excavation.
- **Middle Road System** – Install a temporary well west of well RW-1 to identify the vertical distribution of contaminants in this area. Based on the results of this temporary well, evaluate the pumping rates and pump locations in extraction wells RW-1, RW-2 and RW-3.
- **OU III Western South Boundary System** – A permanent monitoring well will be installed in 2009 to monitor the elevated dichlorodifluoromethane detected between Middle Road and Princeton Avenue. Analytical results from this well will be evaluated for approximately one year and the need for additional actions evaluated.
- **Industrial Park East System** – Because the operation and maintenance manual shutdown criteria of achieving less than 50 µg/L TVOCs for at least four consecutive sampling rounds has

been met in the core monitoring and extraction wells, a Petition for Shutdown of the system will be prepared and submitted to the regulators for review and approval.

- **BGRR/WCF Sr-90 System –** Perform groundwater modeling to determine the number and placement of additional extraction wells necessary to reduce Sr-90 concentrations to levels that will allow for achievement of OU III ROD cleanup goals. Several new extraction wells will be installed. Several temporary wells will also be installed for additional plume characterization.
- **Chemical/Animal Holes Sr-90 System –** Install temporary wells to determine the extent of the Sr-90 contamination detected in well 106-48.
- **Building 650 Sr-90 Plume** – Install two to three temporary wells to characterize the leading edge and width of the plume in this area. A permanent monitoring well may be installed if needed, pending the results.
- **CERCLA Groundwater Monitoring Program** – Sampling frequencies were modified for 143 monitoring wells, the details for which are summarized on **Table 5-1**. This table also recommends a number of wells for abandonment.

Table E-2.
Groundwater Restoration Progress.

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU I					
OU I South Boundary (RA V)	VOCs	Operational	P&T with AS	2011	Continue to monitor an area of elevated VOCs slowly migrating towards treatment system.
Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	Groundwater quality slowly improving. VOCs and tritium stable or slightly decreasing.
Former Landfill	VOCs Sr-90 tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	No longer a continuing source of contaminants to groundwater.
Former HWMF	Sr-90	Long Term Response Action	Monitoring	NA	Area of elevated Sr-90 detected above DWS in sentinel well in 2008. Additional characterization recommended.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-1 pulse pumping)	P&T with ion exchange (IE)	2014	Characterized Sr-90 remaining in source area in 2008. System performing as expected.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Standby	P&T with carbon	Complete	No rebound of VOCs observed in monitoring wells during 2008. Preparing Petition for Closure.
Building 96 source control	VOCs	Operational	Recirculation wells with AS for 3 of 4 wells. RTW-1 is P&T with AS.	2014	Treatment well RTW-1 modified for surface discharge in May 2008. Identified high concentration of PCE in soil in 2008. Soil excavation is recommended.
South Boundary	VOCs	Operational (EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2013	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.
Middle Road	VOCs	Operational (RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	Extraction wells RW-1 and RW-2 continue to show moderate VOC levels. Eastern extraction wells showing low VOC concentrations.

continued

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

Project	Target	Mode	Treatment Type	Treatment Progress	Expected System Shutdown	Groundwater Quality Highlights
OU III (cont.)						
Western South Boundary	VOCs	Operational (Pulse)	P&T with AS	54 lbs of VOCs treated to date	2019	Extraction well WSB-1 put back into full-time operation due to increasing VOCs in nearby well. WSB-2 continued pulse pumping. Temporary wells were installed in 2008 to characterize upgradient extent of VOC contamination. Additional characterization planned.
Industrial Park	VOCs	Operational (UVB-1 on standby)	In-well stripping	1,033 lbs. of VOCs treated to date.	2012	VOC concentrations continued to decline. Place UVB-7 on standby.
Industrial Park East	VOCs	Operational (Pulse)	P&T with carbon t	35 lbs. of VOCs treated to date.	2009	Concentrations in plume core wells at very low levels in 2008. Preparing Petition for Shutdown.
North Street	VOCs	Operational	P&T with carbon	290 lbs. of VOCs treated to date.	2012	High concentration segment of plume continues to be located in the capture zone of NS-1 and NS-2. Leading edge of plume beyond the capture zone prior to system start-up, migrating towards the Airport system.
North Street East	VOCs	Operational (Pulse)	P&T with carbon	24 lbs. of VOCs treated to date.	2010	Concentrations in plume core wells at very low levels in 2008.
Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational	P&T and recirculation wells with carbon	260 lbs. of VOCs treated to date.	2014 (LIPA) 2019 (Airport)	Airport wells continued pulse pumping in 2008. A temporary and permanent monitoring well were installed east of RTW-3A.
HFBR Tritium	Tritium	Operational	Pump and recharge	0.2 Curies removed for off-site disposal.* 180 lbs. of VOCs also removed from aquifer & treated.	2012	Leading edge of high concentration slug reaching EW-16.
BGRR/WCF	Sr-90	Operational	P&T with IE	16.9 mCi to date	2019	Continued characterization of area of higher than expected Sr-90 concentrations in downgradient portion of plume that will require system modification to achieve cleanup goal.
OU IV						

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

Project	Target	Mode	Treatment Type	Treatment Progress	Expected System Shutdown	Groundwater Quality Highlights
OU IV AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	35 lbs. of VOCs removed.	Complete	VOC concentrations in monitoring wells remain low. System decommissioned in Dec. 2003.
Building 650 sump outfall	Sr-90	Long Term Response Action	Monitored Natural Attenuation (MNA)	Plume slowly migrating south within monitoring- well network.	NA	Sr-90 plume still migrating slowly southwest from Bldg. 650 sump outfall and attenuating.
OU V						
STP	VOCs, tritium	Long Term Response Action	MNA	NA	NA	Low-level VOC plume concentrations continued to slowly decline during 2008. Tritium continued to be detected in monitoring wells just above detection limits.
OU VI						
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon	NA (due to minimal EDB in influent, no VOC removal is reported).	2015	The EDB plume continues to migrate as predicted. The extraction wells are capturing the plume.

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

* Off-site removal of tritium was conducted during low-flow pumping events conducted in 2000 and 2001.

1.0 INTRODUCTION AND OBJECTIVES

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

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

The *BNL 2008 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2008 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the twelfth annual groundwater status report issued by BNL. This document examines performance of the program on a project-by-project (facility-by-facility) basis, as well as comprehensively.

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 Protection Group. This document can also be obtained through BNL's website. Data are presented in four key subject areas:

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

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

Section 1 discusses the regulatory requirements of the data collection work in 2008, the site's groundwater classification, and the objectives of groundwater monitoring. **Section 2** discusses the hydrogeologic environment at BNL and its surrounding area. It also summarizes the dynamics of the groundwater flow system in 2008. In **Section 3**, the groundwater cleanup data and progress towards achieving the site's cleanup goals are described. **Section 4** outlines the groundwater surveillance data used to verify that operational and engineered controls are preventing further contamination from BNL's active experimental and support facilities. **Section 5** is a summary of the proposed recommendations to the Groundwater Protection Program identified in **Sections 3 and 4**.

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

1.1.1 Regulatory Requirements

Activities at BNL are driven by federal and state regulations as well as Department of Energy (DOE) Orders.

Comprehensive Environmental Response, Compensation and Liability Act

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

New York State Regulations, Permits, and Licenses

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

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

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

DOE Orders

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

1.1.2 Groundwater Quality and Classification

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

For drinking water supplies, the applicable federal maximum contaminant levels (MCLs) are set forth in 40 CFR (Code of Federal Regulations) 141 (for primary MCLs) and 40 CFR 143 (for secondary MCLs). In New York State, the SDWA requirements relating to the distribution and monitoring of public water supplies are promulgated under the NYS Sanitary Code (10 NYCRR Part 5), enforced by the Suffolk County Department of Health Services (SCDHS) as an agent for the New York State Department of Health (NYSDOH). These regulations apply to any water supply that has at least five service connections or that regularly serves at least 25 individuals. BNL supplies water to approximately 3,500 employees and visitors, and therefore must comply with these regulations. In addition, DOE Order 5400.5, *Radiation Protection of the Public and Environment* (DOE 1993), establishes Derived Concentration Guides (DCGs) for radionuclides not covered by existing federal or state regulations.

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

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

1.1.3 Monitoring Objectives

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

Groundwater Resource Management

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

Groundwater Facility Monitoring

- To verify that operational and engineered controls effectively prevent groundwater contamination.

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

Groundwater -CERCLA Monitoring

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

The details of the monitoring are described in the BNL *2008 Environmental Monitoring Plan* (BNL 2008a). This plan includes a description of the source area, description of groundwater quality, criteria for selecting locations for groundwater monitoring, and the frequency of sampling and analysis. **Figure 1-1** highlights BNL's operable unit (OU) locations designated as part of the CERCLA program, and key site features. Details on the sampling parameters, frequency, and analysis by well are listed on **Tables 1-5** and **1-6**. Screen zone, total depth, and ground surface elevations have been summarized on **Table 1-7**. **Figure 1-2** shows the locations of wells monitored as part of the Laboratory's groundwater protection program. Detailed groundwater monitoring rationale can be found in the *BNL Environmental Monitoring Plan*. BNL's CERCLA groundwater monitoring has been streamlined into five general phases **(Table 1-8)**:

<u>Start-up Monitoring</u>

A quarterly sampling frequency is implemented on all wells for a period of two years. This increased sampling frequency provides sufficient data while the system operation is in its early stages.

<u>Operations and Maintenance (O&M) Monitoring</u>

This is a period of reduced monitoring during the time when the system is in a routine operational state. The timeframe for each system varies. This phase is also utilized for several plume monitoring programs not requiring active remediation.

<u>Shutdown Monitoring</u>

This is a two-year period of monitoring implemented just prior to petitioning for system shut down. The increased sampling frequency provides the necessary data to support the shutdown petition.

<u>Standby Monitoring</u>

This is a period of reduced monitoring up to a five-year duration to identify any potential rebounding of contaminant concentrations. If concentrations remain below MCLs, the petition for closure and decommissioning of the system is recommended.

<u>Post Closure Monitoring</u>

This is a monitoring period of varying length for approximately 20% of the key wells in a given project following system closure. Monitoring continues until the Record of Decision (ROD) goal of meeting MCLs in the Upper Glacial aquifer is reached. This is expected to occur by 2030. This phase is considerably longer for the Magothy and Sr-90 cleanups due to greater length of the time to reach MCLs required for those projects.

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

Table 1-8. CERCLA Groundwater Monitoring Program – Well Sampling Frequency.

Project Activity Phase	Well Type	Phase Duration (yrs.)	Sampling Freq. (events/yr.)****
Start-up Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel/Bypass	2	4x
Operations & Maintenance (O&M) Monitoring	Plume Core	End Start-up to Shutdown*	2x
	Plume Perimeter	End Start-up to Shutdown*	2x
	Sentinel/Bypass	End Start-up to Shutdown*	4x
Shutdown Monitoring	Plume Core	2	4x
	Plume Perimeter	2	4x
	Sentinel/Bypass	2	4x
Standby Monitoring	Key Plume Core	5	2x
	Plume Perimeter	5	1x
	Sentinel/Bypass	5	2x
Post Closure Monitoring***	20% of key wells	Up To 2030**	1x

Notes:
*- Varies by project, see Table 1-5.
** - Magothy: 2065, BGRR Sr-90: 2070, S. Boundary Rad: 2038, Chem Holes Sr-90: 2045
*** - Verification monitoring for achieving MCLs.
****- Sr-90 monitoring projects use approximately half the defined sampling frequency.

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

- Background –water quality results will be used to determine upgradient water quality
- Plume Core – utilized to monitor the high concentration or core area of the plume
- Perimeter – used to define the outer edge of the plume both horizontally and vertically
- Bypass – used to determine whether plume capture performance is being met
- Sentinel – An early warning well to detect the leading edge of a plume.

1.2 Private Well Sampling

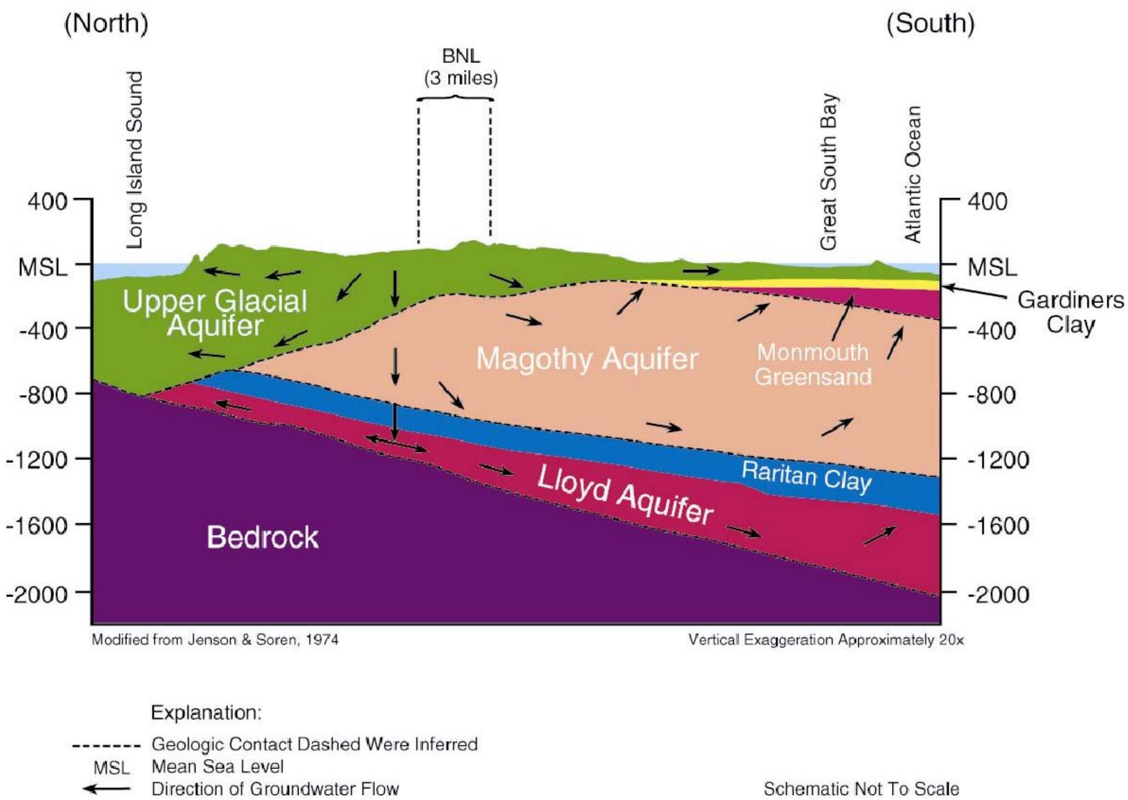
During 2008, there were eight known homeowners in the residential area overlying the plume who continue to use their private wells for drinking water purposes. In accordance with the OU III and OU VI RODs, DOE formally offers these homeowners free testing of their private drinking water wells on an annual basis. SCDHS coordinates and performs the sampling and analysis. During 2008, three of the eight homeowners who were offered the free testing requested the sampling. The results from SCDHS indicate that there were no VOCs detected.

2.0 HYDROGEOLOGY

This section briefly describes the hydrogeologic environment at BNL and the surrounding area. It also summarizes the dynamics of the groundwater flow system in 2008, along with on-site pumping rates and rainfall recharge.

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

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



The Pleistocene deposits are about 100–200 feet thick and are divided into two primary hydrogeologic units: undifferentiated sand and gravel outwash and moraine deposits, and the finer-grained, more poorly sorted 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-grained 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 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 groundwater 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 extensive, 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 flow and movement of groundwater between the Upper Glacial and Magothy aquifers.

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

2.1 Hydrogeologic Data

Various hydrogeologic data collection and summary activities were undertaken as part of the 2008 Groundwater Protection Program to evaluate groundwater flow patterns and conditions. This work is described in the following sections and includes the results of groundwater elevation monitoring, information on pumping and recharging activities on and off site, and precipitation data.

2.1.1 Groundwater Elevation Monitoring

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

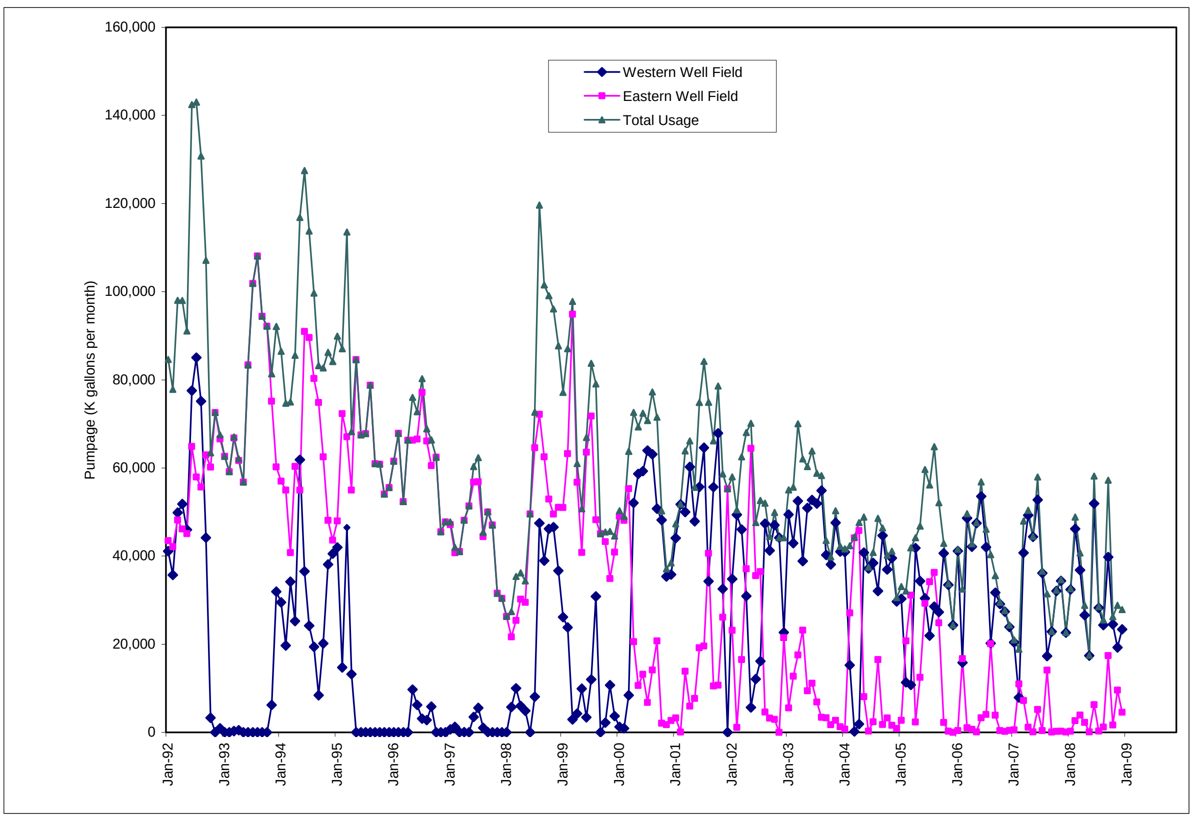
The quarterly synoptic water-level measurement events comprising the complete network of on-site and off-site wells were conducted in June and November 2008, with data collected from approximately 775 wells. Smaller scale synoptic measurement using wells located only in the central part of the BNL site were conducted in April and September 2008, with data collected from approximately 100 shallow glacial wells. Water levels were measured with electronic water-level indicators following the BNL *Environmental Monitoring Standard Operating Procedure* EM-SOP-300. **Appendix A** provides the depth-to-water (DTW) measurements and the calculated groundwater elevations for these measurements. Monitoring results for long-term and short-term hydrographs for select wells are discussed in **Section 2.2**.

2.1.2 Pumpage of On-Site Water Supply and Remediation Wells

BNL operates six water supply wells to provide potable and process cooling water, and 61 treatment wells. All six water supply wells are screened entirely within the Upper Glacial aquifer. During 2008, 14 of the 61 treatment wells were in standby mode. **Figures 2-2** and **2-3** show the locations of the water supply and remediation wells. The effects the groundwater withdrawals have on the aquifer system are discussed in **Section 2.2**.

Table 2-1 provides the monthly and total water usage for 2008 for the six on-site potable 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 to deep sections 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 water supply operating protocols, which have been established by the BNL Water and Sanitary Planning Committee, currently require that the western well field be used as the primary source of water, with a goal of obtaining 75 percent or more of the site-wide water supply from that well field. Using the western well field minimizes the groundwater flow direction effects of supply well pumping on several segments of the groundwater contaminant plumes located in the center of the BNL site. **Figure 2-4** below summarizes monthly pumpage for the eastern and western well fields. Supply well 12 has been out of service since October 2008, when a propane gas explosion destroyed the pump house and associated pump controls.

Figure 2-4.
Summary of BNL Supply Well Pumpage 1992 through 2008.



Since 1999, the implementation of effective water conservation measures has resulted in a significant reduction in the amount of water pumped from the aquifer. During 2008, a total of 421 million gallons of water were withdrawn from the aquifer, and BNL met its goal of obtaining more than 75 percent of its total water supply from the western well field. The western well field provided approximately 90 percent of the water supply, with most of the pumpage obtained from wells 6 and 7. Supply well 10 has been maintained in standby mode since 2000 due to the impacts it might have on contaminant plume flow directions in the central portion of the site (especially on the g-2 tritium plume and the Waste Concentration Facility Sr-90 plume). However, with the loss of well 12 following the October 2008 propane gas explosion, in early 2009 BNL started to use well 10 for short periods of time. **Table 2-2** summarizes the 2008 BNL process water usage. **Table 2-3** summarizes the 2008 monthly water pumpage for the groundwater remediation systems. Additional details on groundwater remediation system pumping are provided in **Section 3** of this report.

2.1.3 Off-Site Water Supply Wells

Several Suffolk County Water Authority (SCWA) well fields are located near BNL. The William Floyd Well Field is west/southwest of BNL (**Figures 2-2 and 2-3**), and consists of three water supply wells that withdraw groundwater from the mid Upper Glacial aquifer and the upper portion of the Magothy aquifer. The Country Club Drive Well Field is south/southeast of BNL, and consists of three water supply wells that withdraw groundwater from the mid section of the Upper Glacial aquifer. Pumpage information for 1989 through 2008 is provided as **Figure 2-5.** In 2008, the William Floyd (Parr Village) and Country Club Drive Well Fields produced 598 and 564 million gallons for the year, respectively. The Lambert Avenue Well Field, located south of BNL, produced 229 million gallons for the year.

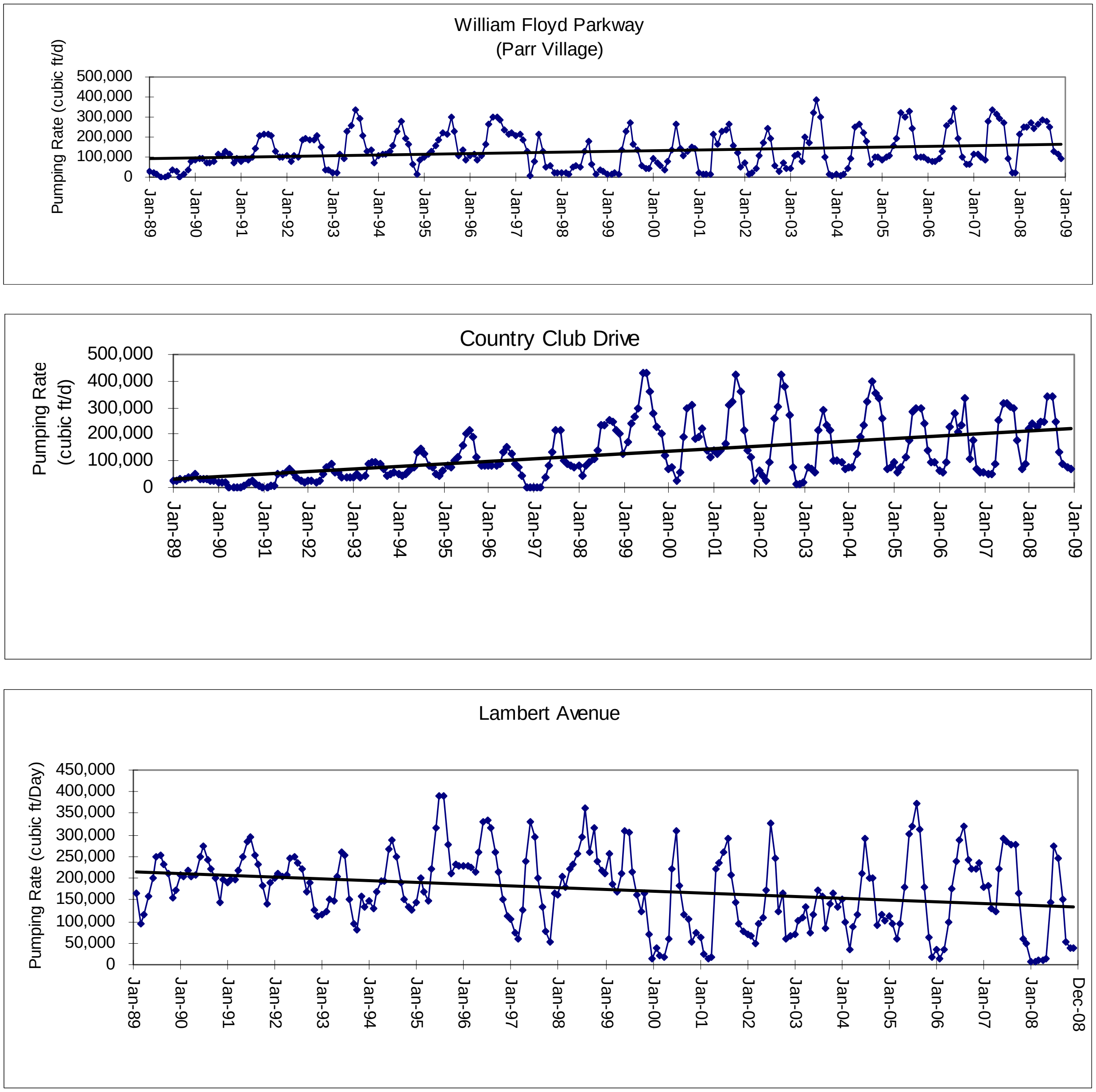
2.1.4 Summary of On-Site Recharge and Precipitation Data

This section summarizes artificial (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-4** summarizes the monthly and total flow of water through 10 on-site recharge basins during 2008. Their locations are shown on **Figures 2-2 and 2-3**. **Section 2.2** (Groundwater Flow) provides a discussion on the effects associated with recharge. Seven of the basins (HN, HO, HS, HT-W, HT-E, HX, and HZ) receive stormwater runoff and cooling water discharges. Flow into these basins is monitored monthly per NYSDEC State Pollutant Discharge Elimination System (SPDES) permit requirements. Generally, the amount of water recharging through the groundwater system to these basins reflects supply well pumpage. Annual water supply flow diagrams show the general relationships between recharge basins and the supply wells, and are published in Volume I of the annual *Site Environmental Report (Chapter 5, Water Quality)*.

The remaining three basins (Removal Action V [RA V], OU III, and Western South Boundary) were constructed to recharge water processed through several of the groundwater remediation systems. Until September 2001, treated groundwater from the OU III South Boundary Pump and Treat System was discharged solely to the OU III basin, adjacent to former recharge basin HP along Princeton Avenue. After September 2001, groundwater from that system and the OU III Middle Road and High Flux Beam Reactor (HFBR) systems 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 2008 (14 and 9 million gallons per month, average, for the OU III and RA V basins, respectively) is significantly greater than that from other individual on-site basins. Pulse pumping and the placement of several groundwater remediation extraction wells on standby resulted in an overall decrease of discharge totals.

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

Figure 2-5.
Suffolk County Water Authority Pumping Near BNL.



Precipitation provides the primary recharge of water to the aquifer system at BNL. In an average year, approximately 24 inches of rainfall recharges the Upper Glacial aquifer. Under long-term conditions in undeveloped areas of Long Island, about 50 percent of precipitation is lost through evapotranspiration and direct runoff to streams; the other 50 percent infiltrates the soil and recharges the groundwater system (Aronson and Seaburn 1974; Franke and McClymonds 1972). In 2008, it is estimated that the recharge at BNL was approximately 25 inches. **Table 2-5** summarizes monthly and annual precipitation results from 1949 to 2008 collected on site by BNL Meteorology Services. Variations in the water table generally can be correlated with seasonal precipitation patterns. As depicted on **Table 2-5**, total annual precipitation in

2008 was 51.17 inches, which was above the long-term yearly average of 48.76 inches. Seven of the past 10 years have featured above-normal annual average precipitation at BNL.

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-site 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 Map

Figure 2-2 is a groundwater elevation contour map representing the configuration of the water table for November 2008. The contours were generated from the water-level data from shallow Upper Glacial aquifer wells, assisted by a contouring package (Quick SURF). Localized hydrogeologic influences on groundwater flow were considered, including on-site and off-site pumping wells, and on-site recharge basins (summarized in **Section 2.1**).

Groundwater flow in the shallow Upper Glacial aquifer is generally characterized by a southeasterly component of flow 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**). The general groundwater flow pattern for 2008 was consistent with historical flow patterns. As described in **Section 2.1.2**, the water supply operating protocols established by BNL in late 2005 require that the western well field be used as the primary source of water, with a goal of obtaining 75 percent or more of the site's water supply from these wells. This protocol has resulted in a more stable south-southeast groundwater flow direction in the central portion of the site.

Localized man-made disturbances to groundwater flow patterns are evident on the groundwater contour maps. They result primarily from active on-site and off-site well pumpage and the discharge of water to on-site recharge basins. Influences from the pumping wells can be seen as cones of depressions, most notably near potable supply wells 4 and 7, and near the groundwater treatment wells along the southern boundary (**Figure 2-2**).

Influences from water recharge activities can be observed as localized mounding of the water table, particularly around recharge basin OU III and the RA V basin (in the center of the site), and the STP. The degree of mounding is generally consistent with the monthly flows to recharge basins summarized in **Section 2.1**. However, the extent of some of the 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 OU III or the RA V basin. However, the presence of near-surface clay layers underlying portions of the STP sand filter beds results in an extensive groundwater mound.

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

2.2.2 Deep Glacial Contour Map

Figure 2-3 shows the potentiometric surface contour map of the deep zone of the Upper Glacial aquifer for November 2008. 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 sections of the Upper Glacial aquifer.

The 2008 patterns for groundwater flow in the deep Upper Glacial are similar to those in the shallow (or water-table) zone. They are characterized by a southeasterly component in the northern portion of the site, with a gradual transition to a more southerly flow at the southern site boundary and beyond. In areas south/southwest of BNL, the deep glacial contour map also indicates flow toward the Carmans River. The localized influences of pumping on the potentiometric surface configurations are evident as cones of depression. As with the water-table configurations, variations in these localized hydrogeologic effects are attributed to the monthly variations in pumpage.

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

2.2.3 Well Hydrographs

Groundwater hydrographs are useful in estimating recharge rates and the location of the water table relative to contaminant sources. Long-term (typically 1950–2008) and short-term (1997–2008) well hydrographs were constructed from water-level data that were obtained for select USGS and BNL wells, respectively. These hydrographs track fluctuations in water level over time. Precipitation data also were compared to natural fluctuations in water levels. **Appendix B** contains the well hydrographs, together with a map depicting the locations of these wells.

A long-term hydrograph was constructed from historical water-level data from BNL well 065-14 (NYSDEC # S-5517.1; USGS Site Number 405149072532201). This well was installed by the USGS for the DOE in the late 1940s. The well is located near the BNL Brookhaven Center building, and is screened in the Upper Glacial aquifer close to the water table. The USGS has collected monthly water-level information from this well from 1953 through 2005. In 2006, the USGS installed a real time continuous water-level recorder in the well. Data from this monitoring station can be accessed on the World Wide Web at: http://groundwaterwatch.usgs.gov/AWLSites.asp?S=405149072532201&ncd=rtn.

The long-term hydrographs indicate that typical seasonal water-table elevation fluctuations are on the order of 4 to 5 feet. Some of the water-table elevation changes have occurred during prolonged periods of low precipitation, where a maximum fluctuation of nearly 14 feet was observed during the regional drought of the early 1960s.

Short-term hydrographs from three well clusters (well cluster 075-39/075-40/075-41, 105-05/105-07/105-24, and 122-01/122-04/122-05) are used to evaluate water-table fluctuations and fluctuations in vertical gradients from 1999 through 2008. Generally, the highest groundwater elevations can be observed during the March-May time period in response to snow melt and spring rains. Normally, the position of the water table drops through the summer and into the fall. Water-table elevations during 2007 and 2008 showed a relatively steady decline from 2006, when precipitation values of nearly 12 inches above average resulted in water levels that were the highest observed since 1997 and just below some of the highest recorded water elevations observed since record keeping began in the early 1950s (**Table 2-5)**.

2.2.4 Groundwater Gradients and Flow Rates

Evaluation of the horizontal hydraulic gradients provides information on the driving force behind groundwater flow. These gradients can be used with estimates of aquifer parameters such as hydraulic conductivity (175 feet per day [ft/day]) and effective porosity (0.24) to assess the velocities of groundwater flow. The horizontal hydraulic gradient at the BNL site is typically 0.001 feet per foot (ft/ft), but in recharge and pumping areas it can steepen to 0.0024 ft/ft or greater. The natural groundwater flow velocity in most parts of the site is estimated to be approximately 0.75 ft/day, but flow velocities in recharge areas can be as high as 1.45 ft/day, and those in areas near BNL supply wells can be as high as 28 ft/day (Scorca et al. 1999).

2.3 New Geologic Data

Although a number of new wells were drilled in the central and southern portions of the BNL site during 2008, most of the geologic information obtained during their installation was consistent with previous investigations. However, data obtained during the installation of OU I vertical profile well 107-38 indicated that the Gardiners Clay is present approximately 300 feet further to the south than previously known. Based upon this information, the geologic map and model layer of the extent of the Gardiners Clay in this area has been modified.

2.4 Monitoring Well Abandonment Program

BNL has a program to abandon groundwater monitoring wells and water supply wells that are no longer needed for routine monitoring or water supply. During 2008, 64 groundwater monitoring wells were abandoned under this program. Eleven of these wells were abandoned because they were located in the construction foot print of the new National Synchrotron Light Source II (NSLS-II). These wells were actively used for collecting water-table elevation data or for surveillance of the HFBR tritium plume. At the conclusion of NSLS-II construction, several new wells will be installed to provide needed piezometric data. Rather than install permanent replacement wells for the HFBR tritium plume, temporary wells will be periodically installed to monitor the migration of the plume in this area. The wells were abandoned using the protocols defined in BNL standard operating procedure EM-SOP-104, *Abandonment of Monitoring Wells, Supply Wells and Remediation Wells*. This procedure conforms to NYSDEC Region II well abandonment guidelines. **Table 5-1** provides a list of the next set of monitoring wells that will be abandoned.

3.0 CERCLA GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during 2008. The chapter is organized first by Operable Unit, and then by the specific groundwater remediation system and/or monitoring program. **Figure 1-2** shows the locations of monitoring wells throughout the site by project. Monitoring well location maps specific to particular monitoring programs are included throughout **Section 3**.

Report and Data on CD

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

About the Plume Maps

Maps are provided that depict the areal extent and magnitude of the contaminant plumes. In most cases, the 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 the individual concentrations of 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. Radionuclide plumes were contoured to their appropriate drinking water standard (DWS). **Figure 3.0-1** shows the VOC and radionuclide plumes as well as the locations and groundwater capture zones for each of the treatment systems.

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

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

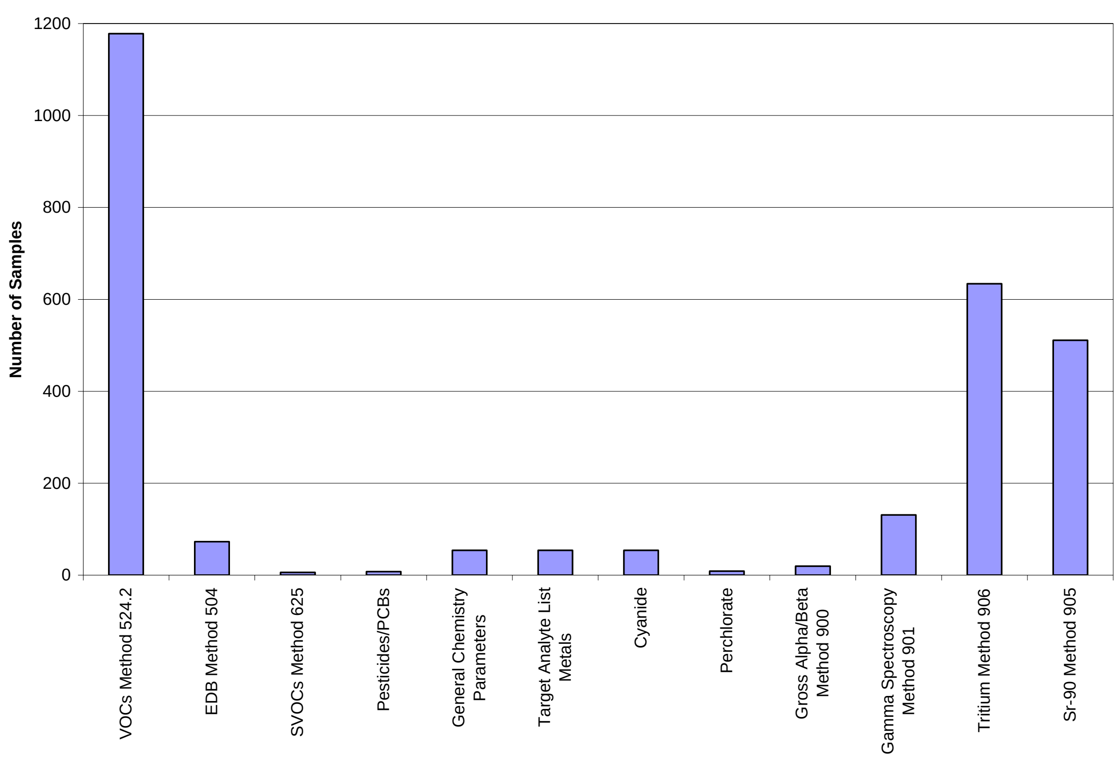
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by the:

- installation of additional permanent monitoring wells to the existing well networks
- installation of temporary wells that helped to fill in data gaps

During 2008, the contaminant plumes were tracked by collecting 1,815 groundwater samples obtained from 735 on-site and off-site monitoring wells. **Figure 3.0-2** below provides a summary of the number of analyses performed, arranged by analytical method. Unless otherwise noted, the extent of contamination for a given plume is depicted by primarily using 2008 data from permanent monitoring wells. In several cases, data from temporary wells installed during the first three months of 2009 were utilized. Contaminant plumes associated with OU I South Boundary, HFBR Tritium, Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) Sr-90, Chemical Holes Sr-90, Building 96, Western South Boundary, Carbon Tetrachloride, Middle Road, and g-2 Tritium Plume projects were further defined in 2008 or the first three months of 2009 using temporary wells (i.e., direct push Geoprobes® or vertical profiles).

A single representative round of monitoring data was usually 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 operations 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 Facility Monitoring Program are evaluated in **Section 4.0**.

Figure 3.0-2.
Summary of Laboratory Analyses Performed for the CERCLA Monitoring Program in 2008.



History and Status of Groundwater Remediation at BNL

Groundwater remediation systems have operated at BNL since 1997 beginning with the OU I South Boundary Pump and Treat System. The goal of groundwater remediation, as defined by the OU III Record of Decision, is to prevent or minimize plume growth and not to exceed MCLs in the Upper Glacial aquifer within 30 years or less (by 2030). Based on additional information obtained during the Strontium-90 Pilot Study, the *OU III Explanation of Significant Differences* (BNL 2005a) identified changes to the cleanup goal timeframes for the Sr-90 plumes. For the BGRR/WCF and Chemical Holes Sr-90 plumes, MCLs must be reached by 2070 and by 2040, respectively. In addition, cleanup of the Magothy aquifer VOC contamination must meet MCLs by 2065.

There are currently 14 groundwater remediation systems in operation. One system remains in standby mode (the Carbon Tetrachloride Pump and Treat System) and a Petition for Closure is being prepared. Another system has met its cleanup goals and has been decommissioned: the OU IV, Area of Concern (AOC) 5, Air Sparge/Soil Vapor Extraction System (OU IV AS/SVE). **Figure 3.0-1** shows the locations and groundwater capture zones for each of the treatment systems. In addition to the groundwater treatment systems, two landfill areas (Current and Former) were capped, which minimizes the potential for groundwater contamination.

BNL's Facilities and Operations personnel perform routine maintenance checks on the treatment systems in addition to their routine and non-routine maintenance. BNL's Environmental Protection Division (EPD) collects the treatment system performance samples. In 2008, 1,023 treatment system samples were obtained from 302 sampling points. The data from the treatment system sampling is available in **Appendix F** tables. Full details of the maintenance checks are recorded in the system's operation and maintenance daily inspection logs. The daily logs are available at the treatment facility, or in the project files.

In general, BNL uses two types of groundwater remediation systems to treat VOC contamination: pump and treat with air stripping or carbon treatment, or recirculation wells with air stripping or carbon treatment. Pump and treat remediation consists of pumping groundwater from the plume up to the surface and piping it to a treatment system, where the contaminants are removed by either air stripping or granular activated carbon. Treated water is then introduced back into the aquifer via recharge basins, injection wells, or dry wells. BNL utilizes pump and treat using ion-exchange resin for remediating Sr-90. Pump and recharge (without treatment) is utilized to hydraulically contain the HFBR tritium plume. Starting in 2008, BNL also used ion-exchange treatment for localized hexavalent chromium groundwater contamination at Building 96.

Table 3.0-1 summarizes the operating remediation systems. Groundwater remediation at BNL is proceeding as projected. As discussed in the following sections, groundwater modeling is also used as a tool to help determine if remediation of the plumes is proceeding as planned to meet the overall groundwater cleanup goals. When modifications to the remediation systems are necessary, the groundwater model is also used as a tool to aid in the design.

Table 3.0-1. 2008 Summary of Groundwater Remediation Systems at BNL.

Operable Unit System	Type	Target Contaminant	No. of Wells	Years in Operation	Recharge Method	Pounds VOCs Removed in 2008/Cumulative
Operable Unit I						
South Boundary	P&T, AS	VOC	2	11	Basin	10/347
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	11	Basin	60/2630
HFBR Pump and Recharge	Pump and Recirculate	Tritium	4	Operate: 4.5 Standby: 6.5	Basin	0/180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC	7	9	Recirculation Well	24/1033
*Carbon Tet	P&T (Carbon)	VOC	3	Operate: 5 Standby: 4	Basin	NA/349
****Building 96	Recirculation Well (AS/Carbon)	VOC	4	Operate: 5 Standby: 3	Recirculation Well	13/84
Middle Road	P&T (AS)	VOC	6	7	Basin	56/798
Western South Boundary	P&T (AS)	VOC	2	6	Basin	5/54
Chemical Holes	P&T (IE)	Sr-90	3	6	Dry Well	0.74**/3.3
North Street	P&T (Carbon)	VOC	2	4	Wells	21/290
North Street East	P&T (Carbon)	VOC	2	4	Wells	5/24
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	10	4	Wells and Recirculation Well	23/260
Industrial Park East	P&T (Carbon)	VOC	2	4	Wells	3/35
BGRR/WCF	P&T (IE)	Sr-90	5	3	Dry Wells	2.7**/16.9
Operable Unit VI						
EDB	P&T (Carbon)	EDB	2	4	Wells	NA***

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
EDB = ethylene dibromide
IE = Ion Exchange
LIPA = Long Island Power Authority
NA = Not Applicable
* This system was shut down August 1, 2004 and put in standby mode.
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen
In-Well = The air stripper in these wells is located in the well vault.

** Sr-90 removal is expressed in mCi.
*** EDB was only detected in the system influent in 2008 below the standard. Therefore, no removal of VOCs is reported.

**** Well RTW-1 was modified from a recirculation well to surface discharge in May 2008. At the same time, hexavalent chromium treatment via ion-exchange resin was also added to RTW-1.

3.1 OPERABLE UNIT I

The two sources of groundwater contamination contained within the OU I project are the former Hazardous Waste Management Facility (HWMF) and the Current Landfill. The former HWMF was BNL's central RCRA receiving facility for processing, neutralizing, and storing hazardous and radioactive wastes for off-site disposal until 1997, when a new Waste Management Facility was constructed along East Fifth Avenue. Several hazardous materials spills were documented at the former HWMF. A soil remediation program was completed for this facility in September of 2005.

The plumes from the Current Landfill and former HWMF became commingled south of the former HWMF. The commingling was partially caused by the pumping and recharge effects of the Spray Aeration System, which operated from 1985 to 1990. This system was designed to treat VOC-contaminated groundwater originating from the former HWMF. The VOC plume is depicted on **Figure 3.1-1**.

The on-site segment of the Current Landfill/former HWMF plume is being remediated by a groundwater pump and treat system consisting of two wells screened in the deep portion of the Upper Glacial aquifer at the site property boundary (OU I South Boundary Treatment System). The extracted groundwater is treated for VOCs by air stripping, and is recharged to the ground at the RA V basin, located northwest of the Current Landfill (**Figure 3.1-1**). A second system (North Street East System) was built to treat the off-site portion of the plume. The off-site groundwater remediation system began operations in June 2004 and was included under the Operable Unit III Record of Decision (**Section 3.2.9**).

Tritium was detected in several on-site monitoring wells at concentrations below the 20,000 pico Curies per liter (pCi/L) DWS in 2008. Sr-90 is detected in on-site wells, two of which exceeded the 8 pCi/L DWS in 2008, as discussed in **Section 3.1.5.**

3.1.1 OU I South Boundary Pump and Treat System

This section summarizes the operational and monitoring well data for 2008 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.

Three quarterly reports were prepared with the operational data from January 1, 2008 through September 30, 2008. This Report also serves as a summary of the fourth quarter operational data. Discharge Monitoring Reports for treated effluent water from the air-stripping tower were submitted to EPA and NYSDEC each month.

3.1.2 System Description

For a complete description of the OU I South Boundary Treatment System, see the *Operations and Maintenance Manual for the RA V Treatment Facility* (BNL 2005b).

3.1.3 Groundwater Monitoring

Well Network

The OU I South Boundary monitoring program uses a network of 46 monitoring wells (**Figure 1-2).** A discussion of monitoring well data specific to the Current Landfill source area is provided in BNL *2008 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2009a).

Sampling Frequency and Analysis

The wells are monitored as per the schedule provided on **Table 1-5**.

3.1.4 Monitoring Well VOC Results

Figure 3.1-1 shows the areal extent of VOC contamination from the Current Landfill/former HWMF area based on the full round of samples collected in the third and fourth quarters of 2008. The primary VOCs detected in the on-site segment of this plume include chloroethane and dichloroethane (DCA), which originated from the Current Landfill. The VOCs prevalent in the off-site segment of the plume (North Street East) are 1,1,1-trichloroethane (TCA), 1,1-dichloroethylene (DCE), trichloroethylene (TCE), and chloroethane. TVOC concentrations less than 40 µg/L are currently detected in monitoring wells immediately downgradient of the Current Landfill. The landfill was capped in November 1995 and the leading edge of the VOC plume appears to be attenuating to TVOC levels below 5 µg/L approximately 800 feet southeast of the landfill footprint.

The OU I South Boundary/North Street East plume (defined by TVOC concentrations greater than 5 µg/L) extends from south of the former HWMF and monitoring well 098-59 to the site boundary (a distance of approximately 2,000 feet), where it has been hydraulically cut off from the off-site segment of the plume by extraction wells EW-1 and EW-2. The areas of the plume displaying the highest TVOC concentrations (greater than 50 µg/L) were between monitoring wells 107-40/107-41 and EW-2. Well 107-41 was installed in 2008 and is approximately 1,000 feet north of EW-2. The off-site portion of the plume is discussed in **Section 3.2.9,** the North Street East Pump and Treat System.

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

The plume remains bounded by the current network of wells. **Figure 3.1-3** gives the historical trends in VOC concentrations for key plume core and bypass wells that monitor the plume. **Appendix C** has a complete set of 2008 analytical results for the 44 wells. Significant findings for 2008 include:

- The trailing edge of the OU I South Boundary plume has migrated approximately 250 feet south of former plume core well 098-59 (**Figure 3.1-3**) based on the last several years of data. This well began to show a steadily decreasing trend in TVOC concentrations during 2002 after peaking at 371 µg/L in 1997, as a high-concentration slug of VOCs continues to migrate southward. The third-quarter 2008 TVOC concentration in this well was 0.5 µg/L and the concentration has remained below 7 µg/L since the third quarter of 2005. This well is screened in the Upton Unit immediately above the Gardiners Clay.
- Monitoring well 107-40 was installed to assist in defining the VOC hot spot migration south of well 098-59 and was sampled for the first time in 2006. TVOC concentrations during 2008 decreased from 154 µg/L in the first quarter to 93 µg/L in the fourth quarter. It appears that the remaining high concentration segment of VOCs is in the vicinity of this well, with the trailing edge of this area located south of well 107-41. Due to the presence of all or part of this portion of the plume within the Upton Unit and Gardiners Clay, the rate at which VOCs are migrating south towards EW-2 is significantly reduced. This is due to the lower hydraulic conductivity of these materials in comparison to the Upper Glacial aquifer sands.
- There were no detections of VOCs above NYS AWQS in perimeter wells.
- VOC concentrations in bypass wells 115-42 and 000-138 remained at levels just above detection limits in 2008. VOCs greater than NYS AWQS continue to be hydraulically contained at the site boundary.

3.1.5 Radionuclide Monitoring Results

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

The tritium concentration in the sampled wells continues to be significantly below the 20,000 pCi/L DWS. The tritium concentration in well 098-30 (immediately south of the former HWMF) declined to barely detectable levels during 2008 following a slight increasing trend begun in 2006 with a detection of 9,210 pCi/L in the fourth quarter of 2006. The occasional short-lived increases in tritium and Sr-90 in wells 088-26 (located within the former HWMF), 098-30, and other downgradient wells, is most likely due to periodic flushing of residual tritium and Sr-90 from the vadose zone in the source area by either high water-table events or significant precipitation events.

A plot of historical tritium results for select OU I South Boundary program wells is shown on **Figure 3.1-4**.

There are 10 wells used to monitor Sr-90 contamination from the former HWMF **(Table 1-5)**. The extent of Sr-90 concentrations is shown on **Figure 3.1-5**. Sr-90 has historically been detected in three wells located within and downgradient of the former HWMF (088-26, 098-21, and 098-30) at concentrations above the 8 pCi/L DWS. Well 088-26 was the only one of the three to show Sr-90 concentrations above the DWS in 2008, with a maximum concentration of 12 pCi/L detected in September 2008.

In 2001, a small area of Sr-90 concentrations (approximately 100 to 150 feet in width by 200 to 300 feet in length) exceeding the DWS, was delineated based on the data collected from 13 temporary wells (obtained using a Geoprobe®). The highest concentration detected during that characterization was 65 pCi/L at a location approximately 300 feet southwest of monitoring well 099-04. Four sentinel monitoring wells (107-34, 107-35, 108-43, and 108-44) were installed in 2002, downgradient of this area of elevated Sr-90. Sr-90 was detected in well 107-35 for the first time during the second half of 2004 at a maximum concentration of 2.6 pCi/L. Concentrations in this well have slowly increased to 14 pCi/L in November 2008. This sentinel well is approximately 1,000 feet from the site boundary. As part of this report, a recommendation will be made to perform additional characterization of this area and install new downgradient sentinel wells. Following this characterization, the groundwater model will be used to evaluate the travel time of this area of elevated Sr-90 to the extraction wells. Sr-90 concentration trends for key monitoring wells are provided on **Figure 3.1-6**.

3.1.6 System Operations

The extraction wells are currently sampled quarterly. The influent and effluent of the air-stripper tower are sampled monthly for VOCs and weekly for pH. **Table 3.1-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system continued full-time operation in 2008 following a period of pulse pumping that was implemented from September 2005 till July 2007.

The following is a summary of the OU I operations for 2008:

January–September 2008
The system was off in January due to remediation and excavation of the former HWMF Waste Loading Area (WLA) requiring an electrical shutdown. The system operated normally during the second and third quarters with only minor electrical and communication problems.

October–December 2008
The system operated normally during the last quarter of 2008. The system was off three days in December due to construction and maintenance activities on a transformer next to the treatment building.

3.1.7 System Operational Data

Extraction Wells
During 2008, 258 million gallons of groundwater were pumped and treated by the OU I system, with an average flow rate of 501 gallons per minute (gpm) for the year. Typical operating flows are 550–650 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells. **Table 3.1-3** contains the monthly extraction well pumping rates. VOC and tritium concentrations in samples from EW-1 and EW-2 are provided on **Table F-1** (**Appendix F**). 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.

Table 3.1-1.
OU I South Boundary Pump and Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Level	Max. Measured Value
pH	6.0 – 9.0 SU	6.1 – 8.8 SU
Benzene	0.8 µg/L	<0.50 µg/L
Chloroform	7.0 µg/L	<0.50 µg/L
Chloroethane	5.0 µg/L	<0.50 µg/L
1,2-Dichloroethane	5.0 µg/L	<0.50 µg/L
1,1-Dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-Trichloroethane	5.0 µg/L	<0.50 µg/L
Carbon tetrachloride	5.0 µg/L	<0.50 µg/L
1,2-Dichloropropane	5.0 µg/L	<0.50 µg/L
Methylene chloride	5.0 µg/L	<0.50 µg/L
Trichloroethylene	5.0 µg/L	<0.50 µg/L
Vinyl chloride	2.0 µg/L	<0.50 µg/L
1,2-Xylene	5.0 µg/L	<0.50 µg/L
Sum of 1,3- & 1,4-Xylene	10.0 µg/L	<0.50 µg/L

Notes:
SU = Standard Units
Required sampling frequency is monthly for VOCs and weekly for pH.

System Influent and Effluent
VOC concentrations in 2008 for the air-stripper influent and effluent are summarized on **Tables F-2** and **F-3** (**Appendix F**). Tritium data for influent and effluent samples are shown on **Table F-4** (**Appendix F**). The influent concentrations of TCA and DCA generally have displayed an overall decrease over the 10 years of OU I South Boundary System operation.

The air-stripper system effectively removed all contaminants from the influent groundwater. All 2008 effluent data for this system were below the analytical method detection limit and below the regulatory limit specified in the equivalency permit conditions.

Cumulative Mass Removal
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 rate of contaminants removed. The cumulative mass of VOCs removed by the treatment system vs. time was then plotted (**Figure 3.1-8**). During 2008, 10.5 pounds of VOCs were removed. Cumulatively, 347 pounds have been removed since 1997. Cumulative mass removal data for this system are summarized on **Table F-5** (**Appendix F**).

Air Discharge

Table 3.1-2 presents the VOC air emissions data for the year 2008 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operations. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to pounds per gallon (lb/gal), which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. The VOC air emissions were well below allowable levels.

Recharge Basin

There are nine sentinel monitoring wells in the immediate area surrounding the RA V recharge basin (**Figure 1-2**). These wells are used to monitor water quality and water levels to assess the impact of the recharge basin on the aquifer. **Appendix C** contains the data for these monitoring wells. During 2008 the highest detection of tritium was 1,520 pCi/L in well 076-174. Beginning November 2001, the RA V recharge basin began receiving treated groundwater from the OU III South Boundary and Middle Road treatment systems. The OU III South Boundary SPDES equivalency permit was modified to include the Middle Road Treatment System and their outfalls at the OU III and RA V recharge basins. The RA V basin resumed receiving water from the HFBR Tritium Pump and Recharge Wells in December 2007.

3.1.8 System Evaluation

The pump and treat system continued to maintain hydraulic control of contaminants originating from the Current Landfill and former HWMF, and to prevent further contaminant migration across the site's southern boundary. No SPDES or air equivalency permit limits have been exceeded, and no operating difficulties were experienced beyond normal maintenance. There have been no 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. Pulse pumping (1 month on, 1 month off) of the system was implemented beginning in September 2005, per recommendations in the *2004 Groundwater Status Report* (BNL 2005c). Pulse pumping was discontinued in July 2007 per the recommendations in the *2006 Groundwater Status Report*.

Table 3.1-2
OU I South Boundary System 2008 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
Carbon tetrachloride	0.016	<0.0002
Chloroform	0.0086	0.0002
1,1-Dichloroethane	10**	0.00043
1,2-Dichloroethane	0.011	<0.0002
1,1-Dichloroethylene	0.194	<0.0002
Chloroethane	10**	0.0004
1,1,1-Trichloroethane	10**	<0.0002
Trichloroethylene	0.119	<0.0002

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

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

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in monitoring or extraction wells associated with the OU I South Boundary Pump and Treat System during 2008.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass wells reveals no significant increases in VOC concentrations in perimeter and bypass monitoring wells during 2008; thus, the VOC plume has not grown and continues to be controlled. **Figure 3.1-1** illustrates that the plume has been effectively cut off at the south boundary and there is separation with the off-site segment of the plume.

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

The area of elevated Sr-90 contamination has increased to concentrations greater than the DWS in sentinel well 107-35. It is recommended that new sentinel wells be installed to monitor this area as it continues to slowly migrate south.

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

Yes. The hydraulic capture performance of the system is operating as previously modeled and the system continues to be effective in capturing and removing VOCs from the deep Upper Glacial aquifer. Monitoring well 107-40 was installed in 2006 and is used to track this high concentration segment as it migrates to the south boundary. The system resumed full-time operation in 2007 based on increasing VOC concentrations in well 107-40. VOC concentrations in EW-1 and EW-2 were observed to remain stable; however, it is anticipated that there will be some increase in concentrations in the near future as the area of higher VOC concentrations arrives at the site boundary. Based on monitoring well results and mass removal of contaminants, the system 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?

Asymptotic conditions are demonstrated by analyzing the average trends in TVOC concentrations in the plume core wells. Asymptotic conditions have not yet been achieved. Aquifer cleanup continues to be demonstrated based on the continued decreasing slope to the trend of average TVOC concentrations in plume core wells, as shown on **Figure 3.1.9**. Changes in the distribution of the plume are shown on **Figure 3.1-10**, which compares the TVOC plume from 1997 to 2008.

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

Yes, the mean TVOC concentration is currently less than 50 µg/L (**Figure 3.1-9**).

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

Monitoring well 107-40, which was installed in 2006, is the only plume core well to have TVOC concentrations exceeding 50 µg/L. TVOC concentrations are currently stable in this well.

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

No. Pulsing of the OU I South Boundary System that began in September 2005 was suspended in July 2007 to allow the plume hot spot detected in well 107-40 to migrate south to the extraction wells. The arrival of the hot spot should result in some increase in VOC concentrations in EW-1 and EW-2.

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

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

3.1.9 Recommendations

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

- Based on an elevated TVOC concentration in upgradient plume core well 107-40, the leading edge of the high concentration segment of the VOC plume is approaching the south boundary. As a result, full-time operation of extraction wells EW-1 and EW-2 will continue until further notice.
- Install up to nine shallow temporary wells using the Geoprobe® to characterize the current extent of the elevated area of Sr-90 contamination. These temporary wells will be installed in east-west transects beginning just south of monitoring well 107-35 and continuing to the north. Following review of the temporary well data, one or two monitoring wells may be installed.
- Add analysis of Sr-90 to system effluent sampling.
- Reduce and/or eliminate sample analyses for monitoring wells 098-33, 098-58, 098-59, 098-61, 107-10, 107-23, 107-24, 107-25, 107-26, 108-08, 108-12, 108-13, 108-14, 108-17, 108-18, 115-03, 115-30, 115-36 as described on **Table 5-1**. The frequencies have been reduced in these wells based on the lack of detections for given parameters over the past several years.
- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued unless otherwise noted. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency. Maintain a quarterly sampling frequency for well 107-40 to monitor the hot spot.

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3.2 OPERABLE UNIT III

There were several VOC, Sr-90, and tritium plumes addressed under the OU III Remedial Investigation/Feasibility Study (RI/FS). The VOC plumes originated from a variety of sources, including Building 96, various small sources in the north-central developed portion of the site, the Former Landfill, OU IV, and the former carbon tetrachloride underground storage tank (UST). **Figure 3.2-1** is a 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. **Figure 3.2-2** is cross-section B–B′, which is drawn through the north–south center-line of the primary OU III VOC plumes, as shown in **Figure 3.2-1**.

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

Figure 3.2-3 presents a comparison of the OU III plumes between 1997 and 2008. Several changes in the plumes can be observed in this comparison:

- The extent of the higher concentration segments of the plumes both on and off-site has decreased over the 11-year period. This is due primarily to the groundwater remediation that has been implemented, along with the affects of natural attenuation.
- Hydraulic control of the plumes by the OU III South Boundary Treatment System at the site boundary is evidenced by the break in the plume in this area.
- Concentrations have been significantly reduced in the vicinity of the Industrial Park East System.
- The attenuation of the on-site portion of the North Street VOC plume.
- The migration of the off-site higher VOC concentration slug from the vicinity of Moriches–Middle Island Road in 1997 to the Airport Treatment System extraction wells in 2008.

Three radiological plumes were addressed under Operable Unit III. The HFBR tritium plume extends several thousand feet south from the HFBR spent fuel pool. The downgradient, higher concentration slug is presently being captured by EW-16. Sr-90 plumes are present downgradient of the former WCF and several sources related to the BGRR. A Sr-90 plume is also present downgradient of the Chemical/Glass Holes and Animal Pits area.

Sections 3.2.1 through **3.2.17** summarize and evaluate the groundwater monitoring and system operations data for the OU III VOC and radiological plumes, including both operational groundwater treatment systems and the monitoring-only programs.

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3.2.1 Carbon Tetrachloride Pump and Treat System

This section summarizes the data from the OU III Carbon Tetrachloride Pump and Treat System and offers conclusions and recommendations for monitoring. This system began operating on October 6, 1999, and was formally shut down and placed in standby mode on August 1, 2004 after receiving regulatory approval of the petition for shutdown. This plume originated from a former 1000-gallon UST that had been used to store carbon tetrachloride. The tank was removed in 1998 and several gallons of carbon tetrachloride were released to the groundwater during this removal.

3.2.1.1 System Description

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

3.2.1.2 Groundwater Monitoring

Well Network

A network of 32 wells was designed to monitor the extent of the plume and the effectiveness of remediation. As was recommended in the petition to shut down the carbon tetrachloride pump and treat system, two monitoring wells (095-300 and 095-301) were installed in the vicinity of extraction well EW-15 in 2004. Well 095-300 was installed to monitor the western edge of the plume in the vicinity of well EW-15, and well 095-301 was installed upgradient of well EW-15.

Sampling Frequency and Analysis

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

3.2.1.3 Monitoring Well Results

Carbon tetrachloride is the primary contaminant in this plume, but there are also low levels of chloroform (a breakdown compound of carbon tetrachloride). The plume extends from the former UST southeast to the vicinity of Weaver Drive, a distance of approximately 1,300 feet (**Figure 3.2.1-1**). The width of the plume, as defined by the 5 µg/L carbon tetrachloride isocontour, is approximately 125 feet. The complete 2008 analytical results from the monitoring of wells in the carbon tetrachloride program are provided in **Appendix C**. A summary of key monitoring well data for 2008 follows.

- Plume core well 085-98, just south of the former UST, had carbon tetrachloride concentrations greater than 150,000 µg/L in 1999. A dramatic reduction in concentrations has been observed in this well, beginning in 1999 with the start of groundwater pump and treat. The concentration of carbon tetrachloride was 3.9 µg/L in October 2008 (**Figure 3.2.1-2**).
- Plume core well 085-17 is sited next to the BNL service station on Rochester Avenue and downgradient of the source area. It has continued to show declining carbon tetrachloride trends from a peak of more than 4,000 µg/L in 2000 to a concentration of 36 µg/L in October 2008 **(Figure 3.2.1-2)**. Note that other compounds related to petroleum products were also detected in this well due to the service station located in this area (**Section 4.8)**.
- Plume core well 85-161 is approximately 120 feet downgradient of the source area. Concentrations in this well have remained low throughout 2008, with a concentration of 1.3 µg/L detected in October 2008.
- Plume core well 095-183 is approximately 450 feet downgradient of the source area. Carbon tetrachloride concentrations in this well have decreased from greater than 2,000 µg/L in 2000, to <0.5 µg/L in October 2008 **(Figure 3.2.1-2)**.
- Plume perimeter well 095-300 and core well 095-301 were installed in 2004, as recommended in the *Petition to Shutdown the OU III Carbon Tetrachloride Treatment System* (BNL 2004a).

Well 095-300 was installed west of EW-15 to confirm the western edge of the carbon tetrachloride plume. The October 2008 analytical results for this well show a carbon tetrachloride concentration of 0.79µg/L, thus confirming the western edge of the plume. Well 095-301 was installed to monitor concentrations of the plume immediately upgradient of well EW-15. Concentrations of carbon tetrachloride were <0.5 ug/L in October 2008.

- Four Geoprobe® groundwater sample locations were installed in February 2009. These were installed to obtain supplemental groundwater data and confirm the low levels of carbon tetrachloride detected in the monitoring wells. Three Geoprobe® points were installed in an east-west line near well 095-88 (GP-01CCl4–2 009, GP-02CCl4-2009, GP-03 CCl4–2009) and one was installed further south, upgradient of well 095-279. The locations and data are shown on **Figure 3.2.1-1**. Each location was sampled at ten-foot increments from a depth of approximately 82 feet bls to the water table at about 40 feet bls. The data showed low and non-detectable levels of carbon tetrachloride, with a high concentration of 43 µg/L in GP-4 at 52 feet below land surface (bls) (**Table 3.2.1-1**) These data will also be included in the Petition for Closure being prepared concurrently with this report.

3.2.1.4 System Operations

Operating Parameters

In 2008, the extraction wells were sampled quarterly. These samples are analyzed for VOCs. The extraction well data are located on **Table F-6** (**Appendix F**). The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. However, the system was in standby in 2008. The system operations are summarized below.

January – December 2008

The system was in standby mode during this period. Sampling for the SPDES equivalency permit was stopped, but will be resumed if the system is restarted.

3.2.1.5 System Operational Data

The system was shut down for the entire year so only quarterly sample data were collected from the extraction wells. All samples collected from the extraction wells in 2008 showed concentrations below the NYS AWQS of 5 µg/L for carbon tetrachloride.

3.2.1.6 System Evaluation

The system was placed in a standby mode in August 2004 after approval of the petition for shutdown. The system remained in standby mode for all of 2006, 2007 and 2008. The groundwater extraction wells will remain on a quarterly sampling schedule to monitor for any significant rebound in concentrations of carbon tetrachloride.

The Carbon Tetrachloride Pump and Treat System performance can be evaluated based on the five major decision rules identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no detections of either carbon tetrachloride or any other contaminants in wells associated with this monitoring network during 2008 that would have triggered the BNL Groundwater Contingency Plan.

2. Were the cleanup goals met?

Yes. The groundwater cleanup goals for the system have been met. The system was shut down in August 2004. A petition to close the system is being prepared.

3. Has the plume been controlled?
Yes. The plume has been controlled, and the system is in standby mode.

4. Is the system operating as planned?
The system is currently shut down and being maintained in standby mode. Shutdown of the system at these concentrations is consistent with obtaining the OU III ROD cleanup objectives of meeting MCLs by 2030.

5. Is an engineering evaluation needed to modify the Middle Road treatment system to ensure the capture and remediation of the carbon tetrachloride plume?
Based on data from bypass and Middle Road tracking wells, no engineering study is required at this time. The Middle Road system will capture any higher levels of carbon tetrachloride not captured by this system.

3.2.1.7 Recommendations

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

- Submit the Petition for Closure to the Regulators.
- Maintain the system in standby mode until the Petition for Closure is reviewed and approved.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2008 operational data from the OU III Building 96 Treatment System, which consists of recirculation wells with air stripping and vapor-phase carbon treatment. It also presents conclusions and recommendations for future operation of the system. The system began operation in February 2001. Well RTW-1 was placed in standby mode in June 2006, and downgradient well RTW-2 was restarted in October 2007 due to a rebound in TVOC concentrations. Due to increasing TVOCs in upgradient monitoring wells, wells RTW-3 and RTW-4 were placed back on-line in March of 2008. In May 2008, well RTW-1 was modified from a recirculation well to a pumping well with hexavalent ion exchange treatment, and discharge to the nearby surface drainage culvert.

3.2.2.1 System Description

Contaminated groundwater is drawn from the aquifer via a submersible well pump in a lower well screen, 48 to 58 feet bls, near the base of the contaminant plume. The groundwater then is pumped into a stripping tray adjacent to each of the four wells. After treatment the clean water is recharged back to the shallow portion of the plume through the upper screen, 25 to 35 feet bls. As recommended in the *2007 Groundwater Status Report* (BNL 2008b, in February 2008 a design modification for treatment well RTW-1 was submitted to the regulators, along with the SPDES equivalency permit application. In addition to VOC treatment using air stripping, ion exchange resin was added to treat for hexavalent chromium prior to discharge. In March 2008 NYSDEC approved the SPDES equivalency permit. In May 2008 the discharge from well RTW-1 was redirected to the nearby surface drainage culvert. The contaminated air stream from the air stripper from the four treatment wells, is routed to a treatment and control building, where it is passed through two vapor-phase granular activated carbon (GAC) units in series to remove the VOCs. Treated air is then discharged to the atmosphere. A complete description of the system is included in the *Building 96 Groundwater Source Control Treatment System Operations and Maintenance Manual* (BNL 2002a). A modification to this manual was prepared and is titled *OU III Building 96 Operations and Maintenance Manual Modification* (BNL 2004b).

3.2.2.2 2008 Source Area Characterization

Initial subsurface characterization of the area identified a shallow low permeability zone, referred to as the “silt zone.” Monitoring data indicate that high concentrations of VOCs were present in this zone. Due to the high concentrations of VOCs in the silt zone, three injections of the oxidizer potassium permanganate ($KMnO_4$) were conducted from December 2004 through January 2006. Based on the data collected since these injections, VOCs remain in high concentrations in groundwater.

To reevaluate the nature and extent of the source area, from April through October 2008, 22 soil borings were drilled in the area of the most contaminated groundwater (**Figure 3.2.2-1**). The soil data indicate that high PCE concentrations are located in the unsaturated zone from just below land surface to a depth of approximately 15 feet bls, and not below the water table as previously thought. This area of approximately 25 by 25 feet is just south of former Building 96. Maximum PCE concentrations detected in the soil were 1,800 milligrams per kilogram (mg/kg) at approximately 9 feet bls. This subsurface zone is characterized by interbedded thin silt layers. The soil data are included on **Table 3.2.2-1**. Cross sections of the soil contamination area are shown on **Figures 3.2.2-2 and 3.2.2-3**. In September 2008, a soil vapor survey was performed to supplement the soil boring data and identify any additional high concentration soil contamination areas that may have been located outside the area identified by the soil borings. A total of 58 locations were sampled, spaced at 25-foot increments. The soil vapor results confirmed that the area previously identified in the vicinity of soil boring B-2 contains the highest soil vapor concentrations. **Figure 3.2.2-4** shows the soil vapor locations and PCE concentrations detected.

The delineation of the contaminated soils to a discrete relatively small and shallow area resulted in focusing remedial alternatives on excavation due to its implementability and effectiveness in completely removing the contamination.

In November 2008, as a temporary measure to minimize infiltration from precipitation, a plastic liner was installed over the soil contamination area.

To optimize the effectiveness of the Building 96 groundwater remedy, in December 2008 BNL recommended excavation of contaminated soils with off-site disposal. This is in addition to the continued operation of the groundwater treatment system until the capture goal is attained, which is expected within several years of the soil excavation. Optimization of the remedy by reducing the number of years of treatment will enable BNL to achieve the cleanup goal of the ROD for this groundwater plume (i.e., meeting drinking water standards by 2030). The regulatory approach for this action will be to document the change in an Explanation of Significant Differences (ESD) to the OU III ROD. Agreement was reached with the regulators for the approach, and BNL issued the *Final Report for Building 96 Recommendation for Source Area Remediation* in March 2009. The Draft ESD to the OU III ROD was submitted to the regulators for review in April 2009. Following regulatory review and approval of the ESD in the summer of 2009, excavation will be performed.

3.2.2.3 Groundwater Monitoring

A network of 33 wells is used to monitor the VOC plume and the effectiveness of the Building 96 groundwater remediation system (**Figure 1-2**). The wells are sampled quarterly and analyzed for VOCs in accordance with **Table 1-5**. As per the recommendation in the *2007 Groundwater Status Report,* quarterly sampling for chromium (Cr) and hexavalent chromium (Cr [VI]) began in 2008.

3.2.2.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2008 plume is shown on **Figure 3.2.2-5**. A summary of key monitoring well data for 2008 follows.

- The highest TVOC concentration seen in 2008 was 3,255 µg/L in groundwater from core well 085-347 during the first quarter sampling round. The primary contaminant in this plume is PCE, with a value of 3,200 µg/L in well 085-347. As shown in trend **Figure 3.2.2-6**, this well has historically detected significant contamination, with TVOC levels never lower than 600 µg/L. Although these levels are high, they are approximately 20% of the historical maximum concentration seen in this area of 18,000 µg/L in well 095-84. In early 2009, well 085-353 detected a TVOC concentration of 7,345 µg/L. Well 085-353 is located in the center of the soil contamination source area identified in **Section 3.2.2.2**. As shown on trend **Figure 3.2.2-6**, plume core monitoring wells 085-347, 085-353, and 095-84 continue to show significant rebounding of contaminant levels over the last few years.

- TVOC concentrations in plume core well 085-352 (screened in the silt zone) continued rebounding in 2007 and 2008 (up to 720 µg/L in October 2008) after two years of lower concentrations from mid 2005 through 2006 (maximum of 110 µg/L in May 2006). Similarly, in well 085-351 the TVOC concentration rose to 1,925 µg/L in July 2008, from less than 400 µg/L in 2006 and 2007. Except for an elevated TVOC detection in late 2004 of 1,200 µg/L when plume core well 095-306 was installed, concentrations have been below 300 µg/L. However, in 2008 concentrations started rebounding back up to 1,200 µg/L TVOCs detected in October. This contamination will be captured by RTW-1.

- Plume core wells 095-162 and 095-172 (located between treatment well RTW-1 and downgradient recirculation wells RTW-2 through RTW-4) began showing increasing TVOC concentrations in 2006 and 2007 after several years of concentrations below 50 µg/L. This is due to the plume passing by RTW-1 while it was in standby mode from June 2006 through May 2008. In 2008, maximum TVOC concentrations in these wells were 510 µg/L and 652 µg/L, respectively. However, well 095-162 dropped to 2.0 µg/L TVOCs in July 2008. Plume core well 095-159 also increased to 185 µg/L TVOCs in October 2008, its highest level since 2001. This contamination will be captured by the downgradient recirculation treatment wells.

- Plume perimeter well 095-295, located on the west side of the plume, maintained low TVOC concentrations from 2006 through 2008. The highest 2008 TVOC concentration in well 095-295 was 4.7 µg/L. Plume perimeter wells 085-97 and 095-171, located east of the plume, remained below the NYS AWQS.
- The bypass monitoring wells immediately downgradient of extraction wells RTW-2, RTW-3, and RTW-4 generally showed lower TVOC concentrations in 2008 when compared to 2007. The reduced concentrations are consistent with the downgradient extraction wells being placed back in service. In 2008, TVOC concentrations in the bypass wells were below 5.0 µg/L, except for well 095-169. Well 095-169, located immediately downgradient and between RTW-3 and RTW-4, showed a maximum concentration of 750 µg/L in February 2008. Concentrations reduced to 2.2 µg/L in April 2008 and have remained low since. As noted in **Section 3.2.2**, extraction well RTW-2 was placed back in service in October 2007, and RTW-3 and RTW-4 were placed back in service in March 2008.
- In conjunction with the soil investigation previously described (**Section 3.2.2.2**), in June 2008 a temporary vertical profile well was installed as Boring B-16 to check for the presence of dense non-aqueous phase liquid (DNAPL) in a location immediately downgradient of the highest soil PCE concentrations (detected at B-2). This boring encountered a clay layer at 175 feet bls. Groundwater samples were obtained at 10-foot intervals from just above the top of the clay to the water table. PCE was detected at a concentration of 80 µg/L just below the water table. The remainder of the sample intervals revealed little or no PCE, and therefore no DNAPL immediately downgradient of the source area. See **Figure 3.2.2-7** for the cross section identifying this well.
- As recommended in the *2007 Groundwater Status Report*, in February 2009 a core monitoring well (B96-MW01-2009) was installed west of well 095-172 to monitor VOC concentrations just upgradient of RTW-2.
- Seven of 33 monitoring wells detected hexavalent chromium above 100 µg/L. The highest hexavalent chromium detection of 389 µg/L was in January 2008 in monitoring well 095-169. The hexavalent chromium monitoring well data for 2008 is posted on **Figure 3.2.2-8.**

3.2.2.5 System Operations

Operating Parameters

Due to a rebound in VOC concentrations in the downgradient portion of the plume, recirculation well RTW-2 was restarted in October of 2007, and recirculation wells RTW-3 and RTW-4 were placed back in service in March 2008. Extraction well RTW-1 was placed back on-line in May 2008 following the modification to surface discharge.

January – September 2008

Due to increasing VOC concentrations in upgradient monitoring wells, recirculation wells RTW-3 and RTW-4 were placed back on-line in March of 2008. RTW-2 was on line for this period. In May, well RTW-1 was modified from a recirculation well to a pumping well with hexavalent ion exchange treatment, and the treated water is discharged to the nearby surface drainage culvert. Well RTW-4 was off during August and September due to a faulty flow transmitter. From January through September, approximately 22 million gallons of water were pumped.

October – December 2008

All wells operated normally this period with the exception of well RTW-4, which was turned off from October 1 to 14 due to replacement of a faulty flow transmitter. The groundwater treatment system pumped and treated approximately 12 million gallons of water in the third quarter of 2008.

During 2008, the groundwater treatment system pumped and treated a total of approximately 34 million gallons of water.

Table 3.2.2-2
OU III Building 96 RTW-1 Pump & Treat Well
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	5.7–8.0 SU
chromium (hexavalent)	100	23.8
tetrachloroethylene	5.0	<0.5
1,1,1-trichloroethane	5.0	<0.5
Thallium	Monitor	0.79

Note:Required effluent sampling frequency is monthly following a period of 24 consecutive weekly with no exceedances. Weekly for pH.

3.2.2.6 System Operational Data

Recirculation/Treatment Well Influent and Effluent

Table F-7 (**Appendix F**) lists the quarterly influent and effluent TVOC concentrations for the three recirculation wells and treatment well RTW-1. The highest TVOC concentration from the influent of these wells was 187 µg/L in RTW-1 in the second quarter. The maximum TVOC in the influent of the downgradient wells was 121 µg/L in RTW-4 in March 2008. RTW-2 and RTW-3 influent showed a maximum of 8 µg/L and 42 µg/L TVOCs in 2008, respectively. **Figure 3.2.2-9** shows the TVOC concentrations in the treatment wells over time. The highest effluent TVOC concentration was 9.7 µg/L in RTW-4 in February 2008. This sample showed the only historical detection of PCE (at 9.2 µg/L) above the DWS in the effluent of any of the treatment wells, and it is believed that it was a sampling error. (Note: There is no discharge equivalency permit for recirculation treatment well RTW-4). **Table 3.2.2-2** shows the maximum measured contaminant concentrations compared to the equivalency permit for well RTW-1. The maximum hexavalent chromium detection in the influent to RTW-1 in 2008 was 52.8 µg/L, approximately half of the SPDES discharge standard. The maximum discharge level detected in this well for the year was 23.8 µg/L.

Air Treatment System

In 2008, quarterly air sampling was performed from the GAC vessels before treatment (influent), between the two vessels (midpoint), and after the second vessel (effluent). The analytical data are available on **Table F-8** (**Appendix F**), and the VOC emission rates are summarized on **Table 3.2.2-3** below**.** The findings are utilized to monitor the efficiency of the GAC units and to determine when a carbon change-out is required. Airflow rates, measured for each air-stripping unit inside the treatment building, show that they typically range between 250 and 450 cubic feet per minute (cfm) for each of the four wells. Assuming a total airflow rate of 1,200 cfm, all compounds detected in the carbon effluent during the operating year were much lower than the New York State DAR-1 Air Toxics Assessment limits for the worst-case potential impacts to the public.

Cumulative Mass Removal

Table 3.2.2-4 shows the monthly extraction well pumping rates. The pumping and mass removal data are summarized on **Table F-9** (**Appendix F**). In 2008, approximately 13 pounds of VOCs were removed. Since February 2001, the system has removed approximately 84 pounds of VOCs.

3.2.2.7 System Evaluation

The OU III Building 96 Treatment System performance can be evaluated based on the five major decisions identified by applying the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?

Yes. As noted in Section 3.2.2.2, high concentrations of PCE (up to 1,800 mg/kg) were identified in the soil borings obtained near the high PCE contamination in the groundwater. The regulators were informed of the results. This area was characterized as a significant source of contamination to the underlying groundwater. Although the intent of the sampling was to try to identify an existing source area, the significant concentrations detected in the vadose zone were not expected. As noted previously, excavation of the source area is planned to address this issue.

As a follow-up to the triggering of the Contingency Plan in 2007, ion-exchange resin treatment for hexavalent chromium was included on well RTW-1 in 2008.

Table 3.2.2-3.
OU III Building 96
2008 Average VOC Emission Rates

Parameter	Allowable ERP*	Actual** ER
dichlorodifluoromethane	0.0000187	0.00000222
acetone	0.000674	ND
methylene chloride	0.000749	0.00000105
2-butanone	0.000187	ND
benzene	0.000112	0.00000657
tetrachloroethylene	0.000165	ND
m,p-xylene	0.0000116	0.00000161
isopropylbenzene	0.000243	ND
n-propylbenzene	0.0000599	ND
1,3,5-trimethylbenzene	0.000375	0.00000143
1,2,4-trimethylbenzene	0.000225	0.00000442
4-isopropyltoluene	0.00000749	ND
naphthalene	0.0000225	ND
carbon disulfide	0.0000487	ND
styrene	0.00000637	ND
trans-1,3-dichloropropane	0.0000157	ND

Notes:

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

2. Have the source control objectives been met?

No. As a result of the soil boring investigation performed in 2008, a localized continuing source area exists in the vadose zone. Excavation of the source area followed by continued operation of the existing RTW-1 treatment well will allow for the source control objectives to be met. Groundwater modeling performed in late 2008 determined that without excavation of the source area, the overall cleanup goals would probably not be achieved. Modeling also determined that following some "tailing" effect from the vadose zone source area after it is excavated, well RTW-1 will need to operate for another three to six years (2012 - 2015).

3. Has the plume been controlled?

Yes. With all four extraction wells in operation, the plume is hydraulically controlled (**Figure 3.2.2-10**).

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

No. The effectiveness of treatment well RTW-1, located near the source area, has reached a plateau without significantly reducing the high concentrations of PCE. Significant reduction of PCE in groundwater cannot be achieved without excavation of the source area defined in 2008.

5. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements. Significant concentrations of VOCs continue to slowly leach into the groundwater from the source area upgradient of RTW-1. In addition, elevated VOCs are located just upgradient of the three recirculation wells.

5a. Is the mean TVOC concentration in core wells less than 50 µg/L?
No. The mean TVOC concentration in the core wells was 384 µg/L during the fourth quarter 2008.

5b. How many individual plume core wells are above 50 µg/L TVOCs?
TVOC concentrations in 16 of 20 core wells were above 50 µg/L in 2008.

5c. Have the groundwater cleanup goals been met? Are MCLs expected to be achieved by 2030?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, following soil excavation and several more years of treatment system operation, MCLs are expected to be achieved by 2030.

3.2.2.8 Recommendations

The following are recommendations for the OU III Building 96 Groundwater Remediation System and monitoring program:

- Maintain operation of treatment well RTW-1 and downgradient recirculation wells RTW-2, RTW-3, and RTW-4. Continue operation until TVOC concentrations <50 µg/L are seen in the influent and adjacent monitoring wells. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Maintain integrity of the plastic liner covering the PCE-contaminated soils. Following regulator approval of the OU III ESD, excavate the PCE-contaminated soils from the vadose zone source area. This also involves the removal of monitoring well 085-353 located in the center of the proposed excavation area. Following excavation, three additional monitoring wells will be installed to monitor the effectiveness of the excavation, including a replacement for well 085-353.
- Once hexavalent chromium concentrations drop below allowable discharge levels and all monitoring wells in the vicinity of the pumping well are below these levels, treatment for chromium will be eliminated.
- Due to low historical TVOC detections, the sampling frequency for the following monitoring wells will be reduced as follows:
  - Wells 085-97, 095-171, and 095-296 will change from quarterly to annual.
  - Wells 095-294, 095-295, 095-307, and 095-308 will change from quarterly to semiannual.
  - The remaining monitoring wells will remain at the quarterly sampling frequency.
- Continue to analyze for total chromium (Cr) and hexavalent chromium (Cr [VI]) in the monitoring wells.

3.2.3 Middle Road Pump and Treat System

The Middle Road Groundwater Pump and Treat System began operating on October 23, 2001. This section summarizes the operational data from the Middle Road system for 2008, and presents conclusions and recommendations for future operation. The analytical data from the monitoring wells are also evaluated in detail.

3.2.3.1 System Description

The Middle Road system was designed with six extraction wells and air-stripping technology to remove VOCs from the groundwater. In September 2003, extraction wells RW-4 and RW-5 were placed in standby mode due to low concentrations of TVOCs. In September 2006, well RW-6 was also placed in standby mode due to low TVOC concentrations. The system is currently operating utilizing wells RW-1, RW-2 and RW-3 at a pumping rate of approximately 300 to 400 gpm. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003a).

3.2.3.2 Groundwater Monitoring

The Middle Road Monitoring Program consists of a network of 29 monitoring wells located between the Princeton Avenue firebreak road and the OU III South Boundary Pump and Treat System (**Figure 1-2**). Four new monitoring wells were added in 2008: one upgradient of well RW-1 (MW 105-66), one approximately 100 feet to the west of well 113-09 (113-29), and two upgradient wells, located just south of Princeton Avenue (104-37 and 104-38).

The 29 Middle Road wells are sampled and analyzed for VOCs. Nine of the wells are sampled quarterly, and the remainder are sampled semiannually (**Table 1-5**).

3.2.3.3 Monitoring Well Results

The complete VOC results are provided in **Appendix C**. The highest plume concentrations are found between extraction wells RW-1 and RW-3, based on influent data for these wells and available monitoring well data (**Figure 3.2.3-2**). TVOC concentrations in monitoring wells east of RW-3 are generally below 10 µg/L. TVOC concentrations have generally been stable in 2008. Results for key monitoring wells are as follow.

- The highest TVOC concentration detected (519 µg/L) was in bypass detection well 113-11 in October 2008. 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.
- Bypass well 113-17 has shown a significant decrease in TVOCs since 2005, with concentrations dropping from 1,347 µg/L to less than 200 µg/L in 2008.
- Plume core well 105-23 is approximately 2,000 feet upgradient of RW-1, near Princeton Avenue. TVOC concentrations have decreased from 1,794 µg/L during 2001, to 52 µg/L in the fourth quarter of 2008 (**Figure 3.2.3-1)**.
- TVOC concentrations in plume core wells to the east of well 105-23, along Princeton Avenue, were generally below 100 µg/L in 2008. This includes the two new wells 104-37 (43 ug/L) and 104-38 (111 µg/L). TVOC concentrations decreased in well 105-44, from 423 µg/L in 2001 to 6 µg/L in the fourth quarter of 2008. These two wells will be sampled semiannually. (**Figure 3.2.3-1)**.
- New monitoring well 113-29, located west of RW-1, showed TVOC concentrations of 26 µg/L in 2008. This well is a perimeter monitoring well for the Middle Road System and will be sampled semiannually.

- New monitoring well 105-66, installed upgradient of extraction wells RW-1 and RW-2, showed TVOC concentrations of 242 µg/L in 2008. This is a new core well installed to monitor levels of TVOCs migrating to these extraction wells. This well will be sampled on a quarterly basis.

Figure 3.2.3-2 shows the vertical distribution of contamination running along an east–west line through the extraction wells; the location of this cross section (E–E') is given on **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. This figure shows that the area of TVOCs exceeding the capture goal of 50 µg/L is limited to the western portion of the treatment system in the vicinity of RW-1, RW-2 and RW-3.

3.2.3.4 System Operations

The effluent sampling parameters for pH and VOCs follow the requirements for monthly sampling, as per the SPDES equivalency permit (**Table 3.2.3-1**). In addition, system influent samples are analyzed for tritium during each system-sampling event. Tritium remains below detection limits in these samples. The effluent concentrations from the treatment system during this period of operation were below equivalency permit levels.

Table 3.2.3-1.
OU III Middle Road Air Stripping Tower
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Observed Value
pH range (SU)	6.5–8.5	6.6 – 7.54
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2-trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units
Required sampling frequency is monthly for VOCs and pH.

Approximately 150 million gallons of water were pumped and treated in 2008 by the OU III Middle Road System. The following paragraphs summarize the Middle Road System operations for 2008.

January – September 2008

The system operated sporadically from March to June due to electrical repairs and numerous electrical storms that knocked out electric and communications to the system. Approximately 97 million gallons of water were treated.

October – December 2008

The system operated normally in October and November, and pumped and treated approximately 53 million gallons of water during this quarter. The system was down most of December due to communication problems between the extraction wells and stripping tower.

3.2.3.5 System Operational Data

System Influent and Effluent

Figure 3.2.3-3 plots the TVOC concentrations in the extraction wells versus time. Results of the extraction wells samples are found on **Table F-10 (Appendix F).** The influent VOC concentrations remained constant over the reporting period. The average TVOC concentration in the influent during 2008 was 41 µg/L . The results of the influent and effluent sampling are summarized on **Tables F-11** and **F-12** (**Appendix F**), 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 331 gpm during 2008 (**Table 2-3**, and **Table F-13** in **Appendix F**), and approximately 56 pounds of VOCs were removed. Approximately 798 pounds of VOCs have been removed since the system began start-up testing on October 23, 2001. The cumulative total of VOCs removed vs. time is plotted on **Figure 3.2.3-3**.

Table 3.2.3-2.
OU III Middle Road Air Stripper
2008 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0004
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	0.000048
1,2-dichloroethane	0.008	0.000004
1,1-dichloroethylene	0.034	0.0003
cis-1,2-dichloroethylene	10***	0.0001
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0069
1,1,1-trichloroethane	10***	0.0008
trichloroethylene	0.143	0.0004

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

Air Discharge

Table 3.2.3-2 shows the air emissions data from the system for the OU III Middle Road tower during 2008, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for the water treated during that time (**Table F-10** in **Appendix F**). The concentration of each constituent was averaged for 2008, and those values were used in determining the emissions rate. The air emissions determined for the Middle Road system were below permitted limits.

Extraction Wells

Extraction wells RW-4 and RW-5 were shut down in September 2003 and placed on standby due to low concentrations of VOCs. The extraction wells are sampled quarterly. RW-6 was shut down in September 2006 due to low VOC concentrations in this well. Quarterly sampling of the wells will continue. The influent VOC concentrations remained constant over the reporting period for the operational wells. **Table 3.2.3-3** shows the monthly extraction well pumping rates.

3.2.3.6 System Evaluation

The system has been operating since October 23, 2001. Groundwater contours indicate 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 or extraction wells associated with the OU III Middle Road Pump and Treat System during 2008.

2. Has the plume been controlled?
Yes. TVOC concentrations in plume perimeter wells remained stable at low concentrations during 2008, indicating that the plume is being controlled. High TVOC concentrations in bypass wells were present before the system was operational and are not within the capture zone of the extraction wells. It will take several additional years before the contaminants migrate to the South Boundary System. Semiannual groundwater elevation data were 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 monitoring areas. Groundwater contour maps are generated using these data (**Figures 2-2** and **2-3**).

The capture zone for the OU III Middle Road system is depicted on **Figure 3.0-1**. The capture zone includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this treatment system?
Yes. The system is operating as planned based on the mass removal of VOCs. Monitoring wells show generally steady concentration trends during 2008 (**Figure 3.2.3-1**).

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. Monitoring and extraction wells have shown generally decreasing concentration trends since 2002 and these trends have continued.

4b. Is the mean TVOC concentration in core wells less than 50 µg/L (expected by 2025)?
No, the average TVOC concentration for the plume core wells was 52 µg/L (**Figure 3.2.3-5**).

4c. How many individual plume core wells are above 50 µg/L?
Five of the 16 plume core wells contain TVOC concentrations greater than 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
To date, the OU III Middle Road System has not been pulsed.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.3.7 Recommendations

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

- Maintain the routine operation and maintenance monitoring frequency that began in 2003. However, the following wells will be changed to an annual sampling frequency due to low VOC concentrations: 105-52, 105-54, 113-06, 113-07, 113-16, 113-18, 113-20, and 113-21.
- Maintain extraction wells RW-4, RW-5, and RW-6 in standby mode during 2009. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Install a temporary well approximately 100 feet west of well RW-1 to identify the vertical distribution of contaminants in this area. Based on the results of this temporary well, evaluate the pumping rates and pump locations in extraction wells RW-1, RW-2 and RW-3.

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 2008, and gives conclusions and recommendations for future operation. Also included within this section is an evaluation of the system and extraction well monitoring and sampling data.

3.2.4.1 System Description

This system began operation in June 1997. It utilizes air-stripping technology for treatment of groundwater contaminated with chlorinated solvents. There are seven extraction wells. The system is currently operating at a pumping rate of approximately 350 gpm, utilizing three extraction wells. Extraction wells EW-12 and EW-8 were placed on standby in October 2003 and October 2006, respectively, due to low VOC concentrations. Wells EW-6 and EW-7 were placed in standby mode in November and December 2007, respectively. A complete description of the system is included in the *Operation and Maintenance Manual for the OU III Middle Road and South Boundary Groundwater Treatment Systems, Revision 1* (BNL 2003a).

3.2.4.2 Groundwater Monitoring

The monitoring well network consists of 43 wells and was designed to monitor the VOC plume(s) in this area of the southern site boundary, as well as the efficiency of the groundwater remediation system (**Figure 3.2.4-1**). The South Boundary wells are sampled and analyzed for VOCs at frequencies detailed on **Table 1-5**. A number of OU III South Boundary wells are also analyzed for radionuclides as detailed in **Section 3.2.14**.

3.2.4.3 Monitoring Well Results

The south boundary segment of the OU III VOC plume continued to be bounded by the existing monitoring well network. Individual VOC concentrations in the plume perimeter wells were less than 5 μg/L except for well 121-08, which had a concentration of 5.5 μg/L TCA in October 2008 (TVOCs at 21 μg/L) (**Figure 3.2.4-1**). This is still well below the capture goal of the system of 50 μg/L TVOCs. VOCs were detected in the deep Upper Glacial aquifer in the vicinity of the site boundary, as depicted on **Figures 3.2-2, 3.2.4-1, and 3.2.4-2. Appendix C** has the complete groundwater monitoring results for 2008.

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. The bulk of the VOC contamination in this area is currently located between EW-3 and EW-5, as can be seen on **Figure 3.2.4-2,** which is a cross section (F–F') drawn along the south boundary. The VOC concentration trends for specific key wells are shown on **Figure 3.2.3-1.** Results for key monitoring wells are as follow:

- Plume core well 114-07 is immediately upgradient of EW-12. Increasing VOC concentrations in this well during 1998 prompted the addition of EW-12, which began pumping in December 1999. VOC concentrations in 2008 remained below the NYS AWQS, with no VOCs exceeding NYS AWQS since 2001.
- Plume core well 122-22 is immediately 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 only PCE being detected at 5 μg/L in 2008.
- Plume core well 122-19 is directly downgradient of EW-8. TVOC concentrations were as high as 367 μg/L in 1997; VOCs have not been detected above standards during 2008.
- Plume core well 122-04 is located between EW-7 and EW-8. VOC concentrations remained low during 2008 with no detections above standards.

- Plume core well 121-23 is immediately downgradient of EW-5. During 2008, the TVOC concentrations ranged between 33 and 42 µg/L. The primary contaminant detected was PCE. This is consistent with the contaminants in EW-4 and EW-5.
- Plume core well 121-13 is 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. The PCE concentration in this well was 2.6 µg/L in October 2008. PCE is the primary compound in wells 121-13, 121-23, EW-4, and EW-5.
- New monitoring well 121-45 was installed in 2006 to monitor the higher VOC concentrations present at wells 113-17 and 113-11. This well is located between the Middle Road and South Boundary systems. The 2008 results showed TVOC concentrations as high as 456 µg/L during July **(Figure 3.2-2)**.
- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations ranged from 29 µg/L in April 2008 to approximately 33 µg/L in October 2008.
- Bypass detection wells 122-34 and 122-35, located south of EW-8, were below NYS AWQS for VOCs from 2003 through 2008.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations have been showing a declining trend with a concentration of 26 µg/L in October 2008.

3.2.4.4 System Operations

The individual extraction wells are sampled quarterly and analyzed for VOCs. The effluent sampling parameters of pH and VOCs are done monthly, in accordance with SPDES permit equivalency requirements (**Table 3.2.4-1**). In addition, samples are analyzed for tritium with each system-sampling event. In these samples, tritium continues to remain below analytical reporting limits. Effluent VOC concentrations from the treatment system during this period of operation were below permit equivalency requirements.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit*	Max. Observed Value
pH range (SU)	6.5 – 8.5	6.8–7.9
carbon tetrachloride	5 µg/L	ND
chloroform	7 µg/L	ND
dichlorodifluoromethane	5 µg/L	ND
1,1-dichloroethane	5 µg/L	ND
1,1-dichloroethylene	5 µg/L	ND
methyl chloride	5 µg/L	ND
tetrachloroethylene	5 µg/L	ND
toluene	5 µg/L	ND
1,1,1-trichloroethane	5 µg/L	ND
1,1,2-trichloroethane	5 µg/L	ND
trichloroethylene	10 µg/L	ND

Notes:
*Maximum allowed by requirements equivalent to a SPDES permit.
ND = Not detected above method detection limit of 0.50 µg/L.
Required sampling frequency is monthly for VOCs and pH.

System Operations

In 2008, approximately 135 million gallons of water were pumped and treated by the OU III South Boundary System. Well EW-8 was put in standby mode in October 2006, and EW-12 has remained in standby since 2003. Wells EW-6 and EW-7 were put on standby near the end of 2007.

January – September 2008

Approximately 107 million gallons of water were pumped and treated. There were communications and electrical problems during this period, which resulted in the system operating sporadically during the summer months.

October 2008 – December 2008

The OU III South Boundary System pumped and treated approximately 28 million gallons of water. There were flow meter problems with EW-3 during this quarter, which resulted in down time due to repair. In addition, the system was off for part of December due to communications problems with the wells and NSLS-II construction activities affecting electrical supply to the system.

3.2.4.5 System Operational Data

System Influent and Effluent

Figure 3.2.4-3 plots the concentrations of TVOCs in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a general declining trend of concentrations. The system was also sampled monthly for tritium, which was not detected above the reporting limit in any sample during 2008. System influent and effluent sampling results are summarized on **Tables F-15** and **F-16 (Appendix F**), 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 (**Table F-17** in **Appendix F**). The cumulative total of VOCs removed by the treatment system versus time is plotted on **Figure 3.2.4-4**. The 2008 total was approximately 60 pounds. Cumulatively, the system has removed approximately 2,630 pounds since it was started in June 1997.

Table 3.2.4-2.
OU III South Boundary Air Stripper
VOC Emission Rates, 2008 Average

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0007
chloroform	0.0031	0.0001
1,1-dichloroethane	10***	<0.0002
1,2-dichloroethane	0.008	<0.0002
1,1-dichloroethylene	0.034	0.0001
cis-1,2-dichloroethylene	10***	<0.0002
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0060
1,1,1-trichloroethane	10***	0.0003
trichloroethylene	0.143	0.0001

Notes:

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

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary system for 2008, and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are obtained through mass-balance calculations for water treated during that time (**Table F-15**). The concentration of each constituent was averaged for the year, and that value was used in the calculation. System air emissions were below allowable levels.

Extraction Wells

In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2008 (**Figure 3.2.4-3**). **Table F-14** in **Appendix F** summarizes the data for the extraction wells. **Table 3.2.4-3** shows the monthly extraction well pumping rates.

3.2.4.6 System Evaluation

The pump and treat system continues to maintain hydraulic control and continues to prevent further plume migration across the southern site boundary. Plume core and bypass wells continued to show stable or decreasing VOC concentrations. The system operated at an average of 259 gpm during 2008. There was some significant downtime due to electrical problems and scheduled maintenance. No permit equivalency standards were exceeded. 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 Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC concentrations observed in the monitoring and extraction wells associated with the OU III South Boundary Pump and Treat System during 2008.

2. Has the plume been controlled?
Yes. The capture zone for the OU III South Boundary Pump and Treat System is depicted on **Figure 3.0-1**. The capture zone depicted includes the 50 µg/L isocontour, which is the capture goal of this system.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate for this 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. 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 15 years; at the end of 2008 it had operated for approximately 11.5 years. The system is removing contamination at the expected rate and hydraulic control of the plume was demonstrated. The duration of operation for the OU III South Boundary System is dependent on the effectiveness of the Middle Road System, and the travel time from Middle Road to the South Boundary. 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 approximately 5 to 10 years. Therefore, the high concentrations observed in the vicinity of well 113-17 (located just south of the Middle Road System) will likely determine the operating period of this system (**Figures 3.2-1 and 3.2-2**). This well has shown a significant decrease in TVOCs from over 1,300 µg/L to 174 µg/L. New monitoring well 121-45 was installed in 2009 to monitor concentrations of TVOCs immediately upgradient of EW-2, which has historically had the highest TVOC concentrations.

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 showed a slight increase in 2008 (**Figure 3.2.4-5**).

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?
Yes, starting in late 2005 and continuing through 2008. The average TVOC concentration in 2008 was 35 µg/L **(Figure 3.2.4-5)**.

4c. How many individual plume core wells are above 50 µg/L?
One core well, 121-45, has TVOC concentrations above 50 µg/L. Extraction well EW-4 also has concentrations above 50 µg/L.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
To date, the OU III South Boundary System has not been pulsed.

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

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

3.2.4.7 Recommendations

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

- Maintain wells EW-6, EW-7, EW-8, and EW-12 in standby mode. The system's extraction wells will continue to be sampled on a quarterly basis. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Maintain the routine operations and maintenance monitoring frequency that began in 2003 except for the changes noted below.
- Stop sampling the following wells that have historically been below MCLs: 121-07, 121-19, 122-02, 122-15, and 122-16. The following wells are to be reduced to an annual sampling schedule due to low VOC concentrations: 122-04, 122-19, 122-18, 122-20, 122-31, 122-32, 122-33, 122-34, and 122-35.

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3.2.5 Western South Boundary Pump and Treat System

The Western South Boundary Pump and Treat System was designed to capture TVOC concentrations exceeding 20 µg/L in the Upper Glacial aquifer along the western portion of the BNL south boundary. The system reduces 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 and was changed to pulse pumping in late 2005, one month on and two months off. Based on increasing VOC concentrations in a monitoring well, extraction well WSB-1 was put back into full-time operation in November 2008. Extraction well WSB-2 remains in a pulse-pumping mode.

3.2.5.1 System Description

A complete description of the Western South Boundary Treatment System is contained in the *Operations and Maintenance Manual for the Western South Boundary Treatment System* (BNL 2002b).

3.2.5.2 Groundwater Monitoring

A network of 18 wells is used to monitor this portion of the plume. As noted below, well 119-06 was installed in October 2008. Their locations are shown on **Figure 1-2**. The wells are sampled at the O&M phase frequency (see **Table 1-5** for details).

3.2.5.3 Monitoring Well Results

The primary VOCs associated with this portion of the plume are dichlorodifluoromethane (a freon), TCA, TCE, and chloroform. VOC contamination is located in the mid to deep Upper Glacial aquifer. Groundwater monitoring for this system was initiated in 2002. **Figure 3.2-1** presents fourth-quarter 2008 monitoring well concentrations. A summary of key monitoring well data for 2008 follows.

- Plume core wells 121-42, 126-13, 127-04, and 127-06 have been generally decreasing in concentrations since the treatment system was started in 2002. TVOC concentrations in wells 121-42 and 127-06, located upgradient of extraction well WSB-2, have remained around 20 µg/L since 2005. TVOC concentrations in core well 126-15, located midway between the two extraction wells, has remained consistently below 5 µg/L from 2002 through most of 2006. In late 2006 and 2007, the concentrations began increasing but still remained below 20 µg/L TVOCs. In 2008, the TVOC levels did not exceed 10 µg/L.
- TVOC concentrations in plume core well 126-14, located upgradient of WSB-1, have decreased slightly since system start-up, but have remained above 20 µg/L. TVOC concentrations (primarily TCA) in plume core well 126-11, located adjacent to WSB-1, dropped off significantly since system start-up; however, TVOC concentrations began increasing since 2006 and reached 31 µg/L in the second quarter 2008 (see trends on **Figure 3.2.5-1**). This was the highest TVOC concentration detected in the seven downgradient plume core wells in 2008.
- As a follow-up to a recommendation from EPA, six temporary wells were installed in September and October 2008 along Middle Road to further characterize the extent of VOC contamination in the upgradient portion of the plume (**Figure 3.2-1**). The maximum TVOC concentration detected was 120 µg/L in WSB VP-1 at 135 feet bls. The maximum individual VOC detected at this interval was TCA at 72 µg/L. The second highest temporary well TVOC concentration was 70 µg/L at 145 feet bls in WSB VP-4. The maximum individual VOC detected at this interval was TCA at 40 µg/L. See **Figure 3.2.3-2** for a cross-sectional view of these temporary wells.
- In March 2009, two additional temporary wells (WSB VP-7 and WSB VP-8) were installed between Middle Road and Princeton Avenue to further evaluate the upgradient extent of the VOC contamination. The maximum TVOC concentration detected was 63 µg/L in WSB VP-7 at 192 feet bls. This was the deepest interval for the temporary well. The maximum individual VOC

detected at this interval was dichlorodifluoromethane at 50 µg/L. TVOC concentrations in WSB VP-8 were less than 10 µg/L. **Table 3.2.5-1** presents the detections for the eight temporary wells.

- As a follow-up to the six temporary wells along Middle Road, monitoring well 119-06 was installed at the location of WSB VP-1. This core well had TVOC concentrations up to 170 µg/L in December 2008, with TCA (100 µg/L) as the primary compound. This is the highest VOC detection for the plume in 2008.
- In bypass detection well 130-08, located south of extraction well WSB-1, the maximum TVOC concentration during 2008 was 48 µg/L in the first quarter. The highest individual VOC detected was dichlorodifluoromethane at 25 µg/L.
- In bypass well 126-16, located south and between the two extraction wells, TVOC concentrations were approximately 35 µg/L. Bypass well 127-07, located downgradient of WSB-2, has shown steadily declining VOCs since 2005. In 2008, TVOC concentrations were less than 10 µg/L.

Table 3.2.5-2
OU III Western South Boundary Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.9–8.0 SU
carbon tetrachloride	5	<0.5
chloroform	7	<0.5
dichlorodifluoromethane	5	<0.5
1,1-dichloroethane	5	<0.5
1,1-dichloroethylene	5	<0.5
methyl chloride	5	<0.5
tetrachloroethylene	5	<0.5
toluene	5	<0.5
1,1,1-trichloroethane	5	<0.5
1,1,2-trichloroethane	5	<0.5
trichloroethylene	10	<0.5

Note:
Required effluent sampling frequency is 2x/month for VOCs and monthly for pH.

- Plume perimeter well 130-03, located west of extraction well WSB-1, had a maximum TVOC concentration of 24 µg/L in May 2008. This well has shown a decreasing trend from the historical high TVOC concentration of 58 µg/L in December 2004. The capture zones of the Western South Boundary extraction wells were not intended to include this area.
- Because there have been no detections of VOCs exceeding NYS AWQS for plume perimeter wells 119-03 and 125-01 since they were installed in 2002, per the recommendation in the *2007 Groundwater Status Report*, VOC analysis was discontinued in mid 2008. These wells monitored the groundwater quality in the vicinity of the OU III Western South Boundary recharge basin. Also, since background well 124-02 has not had any detections of VOCs above the NYS AWQS, this parameter was dropped.

3.2.5.4 System Operations

During 2008, the extraction wells were sampled quarterly. The influent and effluent of the air-stripper tower were sampled twice per month when the system was running in February, May, August, November, and December. The system was in standby mode for pulse pumping the remainder of the time. As per the recommendation in the *2007 Groundwater Status Report* (BNL 2008b), extraction well WSB-1 was put back into full-time operation in November 2008 due to increasing TVOC concentrations greater than the capture goal of 20 µg/L in core well 126-11. System samples were analyzed for VOCs. In addition, the effluent sample was analyzed for pH and tritium twice a month. No tritium was detected in 2008. **Table 3.2.5-2** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system's effluent discharges met the SPDES equivalency permit requirements. The system operations are summarized below.

January – September 2008

The treatment system operated normally from January to September. The system has been on a pulse-pumping schedule since 2005. The schedule is one month on and two months off. The system operated in February, May, and August. During this time, approximately 39 million gallons of groundwater were pumped and treated.

October – December 2008

The system was off in October as part of the pulse-pumping schedule. In November, WSB-1 was placed back into full-time operations. WSB-2 continued following the pulse-pumping schedule of one month on and two months off. The system operated without interruption. During this quarter, approximately 20 million gallons of groundwater were pumped and treated.

Table 3.2.5-4
OU III Western South Boundary
2008 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	<0.0002
chloroform	0.0086	0.0002
1,1-dichloroethane	10**	<0.0002
1,2-dichloroethane	0.011	<0.0002
1,1-dichloroethene	0.194	0.0004
chloroethane	10**	<0.0002
1,1,1-trichloroethane	10**	0.0006
trichloroethylene	0.119	0.0002

Notes:

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

3.2.5.5 System Operational Data

Extraction Wells

During 2008, approximately 60 million gallons of groundwater were pumped and treated by the OU III Western South Boundary System, with an average flow rate of approximately 274 gpm while in operation. **Table 2-3** gives monthly pumping data for the two extraction wells. **Table 3.2.5-3** shows the monthly extraction well pumping rates. VOC and tritium concentrations for extraction wells WSB-1 and WSB-2 are provided on **Table F-18** (**Appendix F**). VOC levels in both wells continued to show a slight decreasing trend since system start-up in 2002, through 2005. In 2006 WSB-2 showed increasing TVOCs, but has been decreasing in 2007 and 2008. The maximum TVOC concentration in 2008 was 10 µg/L. Since 2006 there has been a slight increasing trend in WSB-1 TVOC concentrations; however, they were still lower than the 20 µg/L capture goal. **Figure 3.2.5-2** provides a graph of extraction well trends over time. Most of the individual VOC compounds were either below or slightly above the NYS AWQS.

System Influent and Effluent

Influent TVOC concentrations were less than 15 µg/L, and individual VOC concentrations were less than the NYS AWQS, except for February and December 2008 data that detected TCA up to 5.2 µg/L. These levels are consistent with the historical influent concentrations. The influent consists primarily of dichlorodifluoromethane, TCA, TCE, and chloroform (**Tables F-19** and **F-20** in **Appendix F**).

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

Cumulative Mass Removal

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 of VOCs removed per month (**Table F-21** in **Appendix F**). The cumulative mass of VOCs removed by the treatment system is provided on **Figure 3.2.5-3**. During 2008, 5 pounds of VOCs were removed. A total of 54 pounds have been removed since the start-up of the system in 2002.

Air Discharge

Table 3.2.5-4 presents the VOC air emission data for the year 2008 and compares the values to levels stipulated in NYSDEC Air Guide 1 regulations. Emission rates are calculated through mass balance for water treated during operation. The concentration of each constituent of the air-stripper's influent was averaged for the year. That value was converted from µg/L to lb/gal, which was multiplied by the average pumping rate (gal/hr) to compare with the regulatory value. The VOC air emissions were well below allowable levels.

3.2.5.6 System Evaluation

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

1. Was the BNL Groundwater Contingency Plan triggered?

Yes. TVOC concentrations up to 120 µg/L in WSB VP-1 were detected in the upgradient portion of the plume at 135 feet bls along Middle Road. The maximum individual VOC concentration detected at this interval was 72 µg/L TCA. This was an unexpected concentration based on historical data. The intent of the investigation was to further characterize the extent of VOC contamination in this upgradient portion of the plume. The regulators were informed of the results and additional temporary wells were installed. This contamination will be captured by existing extraction well WSB-1.

2. Has the plume been controlled?

Yes. VOC concentrations in the plume perimeter wells (except 130-03) remained stable at or below the drinking water standard during 2008, indicating that the plume is being controlled. Perimeter well 130-03 has been slowly decreasing since late 2004 to a low of 24 µg/L in the second quarter of 2008. The capture zone of WSB-1 was not intended to include this area. As noted above, low VOC concentrations in the bypass wells were present before the system was operational and not within the capture zone of the extraction wells. The capture zone for the treatment system is depicted on **Figure 3.0-1**.

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

Yes. The system is operating as planned based on meeting the capture goal of 20 µg/L TVOCs. Plume core monitoring wells began showing decreasing concentration trends since 2002. Well 126-11 began decreasing in 2006 and 2007. In 2008, VOC concentrations in well 126-11 also started declining. VOCs present in monitoring wells immediately upgradient of WSB-1 (i.e., 126-11 and 126-14) will be captured by the system. Based on groundwater modeling performed in late 2008, it is projected that VOCs detected in the temporary wells installed along Middle Road will be captured by existing extraction well WSB-1. However, the estimated duration for operation of the treatment system would be extended until approximately 2019.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements. However, the extraction wells began pulse pumping in late 2005 based on low VOC concentrations in core monitoring wells and the extraction wells (see 4a through 4b). Extraction well WSB-1 was placed back into full-time operation in late 2008 due to elevated VOCs in a nearby monitoring well.

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

No. Although there has been a steady decrease of VOCs in most core wells since 2002, there have been fluctuations. As noted in **Section 3.2.5.3**, core monitoring wells have been steadily decreasing since the system became operational in mid 2002, except for well 126-11. This well, immediately upgradient of WSB-1, steadily increased from 2006 through early 2008.

4b. Is the mean TVOC concentration in core wells less than 20 µg/L?
No. The mean TVOC concentration in the core wells is 32 µg/L (**Figure 3.2.5-4**). This value includes recently installed monitoring well 119-06.

4c. How many individual plume core wells are above 20 µg/L TVOC?
TVOC concentrations in three of eight core wells were above 20 µg/L. Wells 126-11, 126-14, and 119-06 showed TVOC concentrations up to 170 µg/L in 2008.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
Yes. As noted above, plume core well 126-11 has been steadily increasing since 2006, shortly after pulse pumping began. The highest TVOC concentration in 2008 was 31 µg/L. TVOC concentrations in the extraction wells increased slightly since 2006; however, they remained below 20 µg/L in 2008.

5. Have the groundwater cleanup goals been met? Are MCLs expected to be been achieved by 2030?
No. MCLs have not been achieved for individual VOCs in all plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.5.7 Recommendations

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

- Continue full-time operation of extraction well WSB-1, and pulse pumping of WSB-2 at the schedule of one month on and two months off. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.
- If any of the three bypass detection wells starts showing increasing trends, the need to take further action will be evaluated.
- Due to the elevated dichlorodifluoromethane detected at the deepest interval in WSB VP-7 between Middle Road and Princeton Avenue, a monitoring well will be installed in 2009. The data will be evaluated for approximately one year to determine if additional actions are necessary.
- Maintain the routine O&M monitoring frequency that began in 2005.
- Due to low historical detections of VOCs, the sampling frequency for monitoring wells 126-01 and 130-04 will be reduced from semiannual to annual.

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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 2008 and presents conclusions and recommendations for its future operation. The system began operation on September 27, 1999. The OU III Industrial Park system was designed to contain and remediate a portion of the OU III plume between BNL's southern boundary and the southern boundary of the Parr Industrial Park. **Figure 3.2.4-1** illustrates the extent of the OU III contaminant plume in the vicinity of the Industrial Park. The primary VOCs associated with this portion of the OU III plume are TCA, TCE, and carbon tetrachloride.

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 recirculates 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 GAC units in series to remove the VOCs. Treated air is then recirculated back to the wellhead. The carbon units, system blower, and system control panel are all housed in a one-story masonry treatment building. A complete description of the system is included in the *Operations and Maintenance Manual for the OU III Offsite Removal Action* (BNL 2000b).

3.2.6.2 Groundwater Monitoring

Well Network

The monitoring well network consists of 43 wells and is designed to monitor the VOC plumes in the vicinity of the industrial park south of the site, and also the effectiveness of the in-well air stripping groundwater treatment system on this part of the high-concentration OU III VOC plumes. The wells are located throughout the industrial park and on Carleton Drive, as shown on **Figure 3.2.4-1.** Screen depths are set to capture water levels at multiple depths and to obtain water quality data as follow:

1) above the treatment well effluent depth, 2) at the effluent depth, and 3) at the treatment well influent depth.

Sampling Frequency and Analysis

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

3.2.6.3 Monitoring Well Results

The complete analytical results are included in **Appendix C**. VOC concentrations in the plume perimeter wells that monitor the width of the plume (000-245 and 000-272) remained below NYS AWQS during 2008. Based on these data, the plume is effectively bounded by the current well network. **Figure 3.2.4-1** shows the plume distribution based on fourth-quarter 2008 data. The vertical extent of contamination is shown on **Figure 3.2.6-1**. The location of this cross section (G–G') is illustrated on **Figures 3.2-1 and 3.2.4-1**. 2008 results for key monitoring wells are as follow:

Plume Core Wells

- Wells 000-253 (just east of UVB-1) and 000-256 (between UVB-1 and UVB-2), which both contained TVOC concentrations over 1,000 µg/L in 2001, have continued to show concentrations at or below NYS AWQS. Since 2003, UVB-1 has remained in standby due to low VOC concentrations.
- Well 000-259 (located between UVB-2 and UVB-3), which was sampled in May and November 2008, had elevated TVOC concentrations of 102 µg/L and 161 µg/L, respectively. This is consistent with data observed in extraction wells UVB-2 and UVB-3.
- A steady decline in TVOC concentrations was observed in well 000-112 (immediately upgradient of UVB-1 and UVB-2) since 1999, when concentrations were near 2,000 µg/L. TVOC concentrations were at 13 µg/L in November 2008 (**Figure 3.2.6-2**).
- Well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002 (**Figure 3.2.6-2**). The TVOC concentration in this well peaked at 2,175 µg/L in 2001 and has fluctuated for the past few years between 200 and 600 µg/L. Data from 2008 showed TVOC concentrations of 385 µg/L in May and 224 µg/L in November.
- The TVOC concentration in well 000-268 (between UVB-6 and UVB-7) was 14 µg/L in November 2008 (**Figure 3.2.6-2**). This is consistent with data observed in UVB wells 6 and 7.

Plume Bypass Wells

- TVOC concentrations in most of the wells located near Carleton Drive were stable or decreasing during 2008. Wells 000-431 and 000-432 serve as bypass monitoring points downgradient of UVB-2. Well 000-432 has shown TVOC concentrations between 6 and 10 µg/L during 2008. TVOC concentrations in 000-431 were below NYS AWQS during 2008. The low TVOC concentrations in these wells indicate that the system is effective in hydraulically controlling the plume.
- TVOC concentrations in wells 000-275, 000-276, and 000-277 are below the capture goal of 50 µg/L, indicating that the system is effective in capturing the plume. The highest concentration observed was 12 µg/L (November 2008) in well 000-277.
- In 2008, well 000-278 showed a significant increase in TVOC concentrations, from 14 µg/L in January to 217 µg/L in November. This well is directly downgradient of well UVB-4, which had been shutdown for about one year, and it is likely detecting contaminants were hung up in the "stagnation zone." The data from January 2009 shows concentrations decreasing to 109 µg/L.
- TVOC concentrations in well 000-273 decreased from 177 µg/L in May 2008 to 34 µg/L in November 2008. Well 000-274 varied from 44 µg/L in May 2008 to 176 µg/L in November 2008. These wells are located immediately downgradient of well UVB-1, which was shut down in October 2005. These TVOC concentrations observed in the monitoring wells are from contamination that was in the "stagnation zone" downgradient of UVB-1 while it was operating. Now that it has been shut down, the contaminants have migrated downgradient of the extraction well. These contaminants could not be captured by the extraction well because they were too far downgradient but were held up by the pumping. As these higher concentration slugs of contaminants are passing by the monitoring wells, the concentrations first increase then decline. These contaminants will be captured by the down gradient LIPA extraction wells.

Perimeter Wells

VOC concentrations for individual constituents remained below NYS AWQS (5 µg/L) in each of the shallow wells screened to monitor above the adjacent UVB effluent well screens.

3.2.6.4 System Operations

In 2008, approximately 128 million gallons of groundwater were pumped and treated by the Industrial Park In-Well Air Stripping System.

Operating Parameters

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

System Operations

System extraction well pumping rates are included on **Table 3.2.6-1**. The following summarizes the system operations for 2008.

Well UVB-1 remained in standby mode throughout the year.

January – September 2008

In March, wells UVB-4 and UVB-5 were off for part of the month due to electrical problems. In June, wells UVB-3 and UVB-4 were down for the month for repairs. Wells UVB-2 through UVB-4 were off for the month of August waiting for new flow meters. The system was off from August 12 to 22 due to problems with the blower.

October – December 2008

The system was off from October 13 to 21 due to electrical problems. Well #7 was off for the month of December in order to install a new drive. Wells UVB-4 and UVB-6 ran sporadically in December due to electrical and mechanical problems. The rest of the system operated normally for the remainder of the period. Well UVB-1 remained in standby mode for this period.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2008, influent TVOC concentrations in the treatment system wells showed a steady or declining trend, except for well UVB-5 which showed an increase (**Figure 3.2.6-3**). The corresponding effluent well concentrations (**Figure 3.2.6-4**) showed decreasing or stable TVOC concentrations for the year. UVB-1 remained in standby mode for 2008. There was significant downtime for individual wells in 2008 due to electrical problems, and routine maintenance and cleaning of the wells.

For 2008, the overall average removal efficiency was 83 percent (**Table F-22** in **Appendix F**). Well UVB-1 was not used in this calculation because it was off.

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. **Table F-23** summarizes these data (**Appendix F**). During 2008, flow averaged approximately 41 gpm per well for the six operating wells. **Figure 3.2.6-5** plots the total pounds of TVOCs removed by the treatment system vs. time. During 2008, 24 pounds were removed from the aquifer, with a total of 1,033 pounds removed since 1999.

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 was 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 536 cfm during 2008 (**Table F-24** in **Appendix F**).

3.2.6.6 System Evaluation

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

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the OU III Industrial Park System during 2008.

2. Has the plume been controlled?

Yes. An analysis of the plume perimeter and bypass well data reveals that there were no significant VOC concentration increases in these wells during 2008, except for higher concentrations in wells 000-273 and 000-274, 000-277 and 000-278. These concentrations were expected, as explained in **Section 3.2.6.3**. Therefore, it is concluded that there has been no plume growth and the plume continues to be controlled.

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

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

Yes. The treatment system is effectively removing contamination. The current estimate for treatment system operations is approximately 12 years (through 2012). The OU III Industrial Park System continues to effectively remove VOCs from the deep Upper Glacial aquifer. **Figure 3.2-3** compares the OU III plume from 1997 to 2008. The overall reduction in the high-concentration areas of the plume near the south boundary is evident. This is an indication that concentrations of VOCs approaching the Industrial Park System will continue to decrease over time.

The overall trend in the mean TVOC concentrations in the core groundwater monitoring wells is declining (**Figure 3.2.6-6**). The system is removing contamination at the expected rate and hydraulic control of the plume is demonstrated; hence, it is operating as planned.

4. Can the groundwater treatment system be shut down?

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

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

No. Concentrations show an overall slightly decreasing trend.

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

Yes, the mean TVOC concentration in the plume core wells was approximately 47 µg/L.

4c. How many individual plume core wells are above 50 µg/L TVOC?
Three (000-249, 000-259, and 000-262) of the nine plume core wells had TVOC concentrations exceeding 50 µg/L in 2008.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
No. To date, the OU III Industrial Park In-Well Air Stripping System has not been pulsed.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in plume core wells. Based on model predictions, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.6.7 Recommendations

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

- The current routine operations and maintenance monitoring frequency will be maintained during 2009.
- The system will continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. It is recommended that well UVB-7 be placed in standby as TVOC concentrations have dropped to below 5 µg/L in this well. Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, well UVB-1 or UVB-7 will be restarted.
- Wells 000-272 and 000-280 (plume perimeter wells) should be changed to an annual sampling schedule, as these have historically shown low VOC concentrations.

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3.2.7 Industrial Park East Pump and Treat System

This section summarizes the 2008 operational and monitoring well data for the OU III Industrial Park East (IPE) Groundwater Pump and Treat System, and presents conclusions and recommendations for its future operation. The system began full operation in June 2004 to provide capture and control for a downgradient portion of the OU III VOC plume, which has migrated beyond the BNL site boundary.

3.2.7.1 System Description

The IPE treatment facility (Building OS-2) is located at the Industrial Park immediately east of Building OS-1, the Industrial Park Groundwater Treatment System. This system includes two extraction wells and two recharge wells. Extraction well EWI-1 is screened in the Upper Glacial Aquifer and EW I-2 is screened in the upper portion of the Magothy aquifer (**Figures 3.2.6-1 and 3.2.7-1**). Extraction well EWI-1 is designed to operate at a maximum rate of approximately 120 gpm; extraction well EWI-2 is designed for approximately 100 gpm. In 2007, a new injection well was added to this system.

The treated water is recharged to the Upper Glacial aquifer through two recharge wells located near the extraction wells, designated as DWI-1 and DWI-2. A complete description of the system is contained in the *Operations and Maintenance Manual for the Industrial Park East Offsite Groundwater Remediation System* (BNL 2004c).

3.2.7.2 Groundwater Monitoring

The monitoring network consists of 12 wells (**Figure 1-2**) that are sampled quarterly and analyzed for VOCs. These wells monitor the VOC plume south of the Long Island Expressway (LIE) to Astor Drive in the East Yaphank residential area, as well as the effectiveness of the groundwater treatment system.

3.2.7.3 Monitoring Well Results

The primary VOCs associated with this portion of the OU III plume are TCA, trichloroethylene, and 1,1-dichloroethylene. Groundwater monitoring for this system was initiated in 2004; however, three of the wells have been monitoring the plume since 1999. Fourth-quarter well data are posted on **Figures 3.2.4-1, 3.2.6-1, and 3.2.7.1**. The complete analytical results are in **Appendix C.** Results for key monitoring wells are as follow:

- The maximum TVOC concentration detected during 2008 was 38 µg/L in downgradient well 000-494 during the fourth quarter, with TCA (22 µg/L) as the highest individual VOC detection (**Figure 3.2.6-2**). TVOC concentrations in well 000-494 have recently increased to 38 µg/L in November 2008. This is a Magothy monitoring well screened to 310 feet below land surface and located 1,200 feet downgradient of the extraction wells. This contamination was likely downgradient of the extraction wells prior to their installation.
- In plume core well 000-514, approximately 100 feet west of the extraction wells, VOC concentrations were less than NYS AWQS during 2008.
- VOCs in plume bypass well 000-493, have remained below the MCL since it was installed in June 2004.
- Upgradient wells 122-24 and 122-25, which had shown concentrations as high as 570 µg/L in 2002, have been below 50 µg/L since August 2004. All VOCs analyzed were below MCLs in 2008.

3.2.7.4 System Operations

Operating Parameters

The influent, midpoint, and effluent of the carbon vessels are sampled once a month and analyzed for pH and VOCs. The extraction wells are sampled monthly and are analyzed for VOCs. Sampling for pH and VOCs adheres to the requirements of the SPDES equivalency permit. The system's effluent samples during this period of operation were within the permit levels (**Table 3.2.7-1**). In November 2007, the system began a one month on and one month off pulse-pumping schedule.

Table 3.2.7-1.
OU III Industrial Park East Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.5–8.5 SU	5.7–6.4 SU
bromoform	50	<0.50
carbon tetrachloride	5	<0.50
chloroform	5	0.54
methylene chloride	5	<0.50
tetrachloroethylene	5	<0.50
toluene	5	<0.50
trichloroethylene	10	<0.50
1,2-dichloroethane	5	<0.50
1,1-dichloroethane	5	<0.50
1,1-dichloroethylene	5	<0.50
1,1,1-trichloroethane	5	<0.50

Note:
Required sampling frequency is monthly for VOCs and pH.

System Operations

The following information summarizes the system operations for 2008.

January – September 2008

The system was off for most of the month of February due to electrical problems. The system was also off part of June due to damage caused by a lightning strike, and August 12 to 21 due to a bad power supply card in the programmable logic controller (PLC). The system operated normally for the rest of this period. Eighteen million gallons were pumped and treated during the first three quarters of 2008.

October – December 2008

The system operated normally for this period. The system pumped and treated 15 million gallons of groundwater this quarter.

Extraction Wells Operational Data

During 2008, approximately 33 million gallons were pumped and treated by the IPE system, with an average flow rate of 66 gpm. The system is pulse pumped, one month on and one month off, so the average rate for the months it was in operation was 132 gpm. **Table 3.2.7-2** shows the monthly pumping data for the system. VOC concentrations for the IPE extractions wells are provided on **Table F-25** (**Appendix F**). In 2008, TVOC concentrations in EWI-1 ranged from 2.3 to 3.7 µg/L and 5.7 to 8.3 µg/L in EWI-2.

3.2.7.5 System Operational Data

System Influent and Effluent

The overall TVOC influent concentrations to the carbon vessels were slightly lower than 2007 levels (**Figure 3.2.7-3**). **Tables F-27** and **F-28** (**Appendix F**) present the influent and effluent data.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system.

Table F-26 lists and gives total pounds of VOCs removed by the treatment system in 2008. **Figure 3.2.7-2** plots mass removal versus time. Approximately 2.7 pounds of VOCs were removed from the aquifer during 2008 and 34.5 pounds since system start-up in 2004.

3.2.7.6 System Evaluation

This system is designed to achieve the overall OU III ROD objectives of minimizing plume growth and meeting MCLs in the Upper Glacial aquifer in 30 years (i.e., 2030) or less. According to the *OU III Explanation of Significant Differences* (BNL 2005a), MCLs within the Magothy aquifer must be met within 65 years (i.e., 2065) or less. The system will address the highest VOC concentration portion of the plume (above 50 µg/L).

The Industrial Park East Pump and Treat System performance during 2008 can be evaluated based on the five major decisions identified for this system from the groundwater DQO process:

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC concentrations observed in the monitoring wells or extraction wells associated with the Industrial Park East Groundwater Pump and Treat System during 2008.

2.Has the plume been controlled?
Yes, the downgradient monitoring shows concentrations of TVOCs below the capture goal of 50 µg/L.

3. Is the System operating as planned?
Yes, the system is operating as planned.

4. Can the groundwater treatment system be shut down?
Yes, the system has met all shutdown requirements.

4a. Have asymptotic VOC concentrations been reached in core wells?
IPE monitoring wells are below the capture goal of 50 µg/L for the treatment system, therefore reaching asymptotic conditions is no longer required since other shutdown criteria have been met.

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

4c. How many individual plume core wells are above 50 µg/L?
None.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
The Industrial Park East System began pulse pumping in November 2007, and no rebound has been observed to date.

5. Have the groundwater cleanup goals been met? Specifically, have MCLs been achieved in the Upper Glacial aquifer (expected by 2030) and the Magothy aquifer (expected by 2065)?
No. MCLs have not been achieved for individual VOCs in all IPE plume core wells. However, concentrations are very close to this level, with the highest concentration being 5.1 µg/L TCA in well 122-24. MCLs are expected to be achieved by 2030 and 2065 for the Upper Glacial and Magothy aquifers, respectively, as required by the OU III ROD and ESD.

3.2.7.7 Recommendations

The following is recommended for the Industrial Park East Pump and Treat System and groundwater monitoring program.

- Submit Petition for Shutdown to the Regulators in July 2009. The system has met all shutdown requirements.

3.2.8 North Street Pump and Treat System

The North Street Pump and Treat System addresses a VOC plume that originated at the Former Landfill/Chemical Holes area. The VOC plume is presently located south of the site boundary, with the leading edge extending south to the vicinity of the Brookhaven Airport. The groundwater pump and treat system began operating in May 2004 (**Figure 3.2-1**).

Groundwater treatment consists of two extraction wells operating at a combined pumping rate of approximately 450 gpm. This pumping captures the higher concentration portion of the VOC plume (i.e., TVOC concentrations greater than 50 µg/L) in the Upper Glacial aquifer, and will minimize the potential for VOC migration into the Magothy aquifer.

The North Street plume has been divided into two segments for remediation purposes. The area to the north of extraction well NS-2 is being addressed by the remediation system on North Street, whereas the Airport System handles the area to the south (**Figure 3.0-1**). The Airport System was constructed to address the leading edge of this plume (**Section 3.2.10**).

3.2.8.1 System Description

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

3.2.8.2 Groundwater Monitoring

Well Network

A network of 28 wells monitors the North Street VOC plume (**Figure 1-2**). However, two wells (086-05 and 086-70) were abandoned in 2008 due to the planned construction of the NSLS-II. The VOC concentrations in these wells had decreased to levels below the NYS AWQS. The monitoring program also addresses radiological contaminants that may have been introduced to groundwater in the OU IV portion of the site (particularly the Building 650 and 650 sump outfall areas), as well as the Former Landfill/Chemical Holes. Wells sampled under the Airport program are also utilized for mapping this plume.

Sampling Frequency and Analysis

The 26 wells are sampled and analyzed for VOCs at the operations and maintenance sampling frequency according to the schedule on **Table 1-5**. As recommended in the *2007 Groundwater Status Report* (BNL 2008b), Sr-90, gamma spectroscopy, and gross alpha/beta analysis for monitoring wells were eliminated due to the absence of any detections of radionuclides over the past several years. The 26 wells are sampled and analyzed annually for tritium.

3.2.8.3 Monitoring Well Results

The primary VOCs associated with this plume are carbon tetrachloride, PCE, TCA, and chloroform. **Figure 3.2-1** and **Figure 3.2.8-1** depict the TVOC plume distribution and include data from the monitoring wells. The complete groundwater monitoring well data for 2008 are included in **Appendix C**. A north–south hydrogeologic cross section (H–H') of the plume is provided on **Figure 3.2.8-2.** The location for the cross section is shown on **Figure 3.2-1**. A summary of key monitoring well data for 2008 follows.

- In 2008 the highest TVOC concentration in the plume was 174 µg/L in well 800-63 in January. TVOC concentrations started declining in late 2008 to 67 µg/L. The primary VOC in this well is chloroform at a maximum concentration of 95 µg/L in July 2008. This well is located on Vita

Drive, approximately 1,600 feet south of extraction well NS-1. As noted in trend **Figure 3.2.8-3** this well has displayed increasing VOC concentrations since late 2003. The leading edge of the higher concentration plume segment, which had migrated beyond the extraction well location prior to system start-up, has reached this location. This contamination will be captured by the Airport System.

- Plume core well 000-465 was installed 100 feet upgradient of extraction well NS-1 in 2004. This well had historically shown the highest VOC concentrations (primarily carbon tetrachloride) in the North Street area. TVOC concentrations were as high as 1,796 μg/L in 2004 and have since declined to 25 μg/L in May 2008. This correlates well with the TVOC concentrations observed in NS-1.
- VOC concentrations in plume core well 000-463, located approximately 200 feet north of NS-1, remain elevated (peak TVOC of 74 μg/L in during 2007 and 2008), but have been steadily declining, as shown on **Figure 3.2.8-3.**
- Plume core well 000-154 had historically shown high 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 to approximately 5 μg/L in 2008. The trailing edge of the higher concentration segment of this plume has migrated south of this location.
- Plume core well 000-472, adjacent to NS-2, has shown a steady decline in the TVOC concentration in the past two years, from 308 μg/L in 2006 to 70 μg/L in the second-quarter 2008 sample. This contamination will be captured by NS-2.
- The plume continues to be bounded by perimeter wells.
- Several Airport monitoring wells (800-90, 800-92, 800-59, and 800-106) located south of the North Street extraction wells have displayed increasing TVOC concentrations over the past several years. Well 800-92 reached a high of 90 μg/L TVOCs in the second quarter 2008 and Magothy well 800-90 detected a maximum TVOC concentration of 81μg/L in January 2008. This suggests that the leading edge of the higher concentration segment, which had migrated beyond the North Street extraction well locations prior to that system start-up, has reached this location. This contamination will be captured by the Airport System treatment wells RTW-3A and RTW-4A.
- Historically, tritium has been detected in localized off-site areas approximately within the area covered by the North Street VOC plume. Potential sources for this tritium were located in the Former Landfill/Chemical Holes and OU IV Building 650 areas of the site. Tritium has been detected in the deep Upper Glacial aquifer at concentrations well below the DWS of 20,000 pCi/L. Historically, the highest tritium concentration (9,130 pCi/L) was detected in 2001 in temporary well 000-337. This location is approximately 300 feet north of well 000-153. Tritium has been detected historically in well 000-153, but concentrations have decreased from 2,560 pCi/L in 2001 to below minimum detectable activity (<MDA) in 2007 and 2008. In 2008, tritium was detected in three wells within the North Street plume at estimated values below 600 pCi/L. This is consistent with the steady decline in tritium concentrations observed over the past several years. Tritium monitoring of North Street wells will continue in 200.

3.2.8.4 System Operations

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

Table 3.2.8-1
OU III North Street
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH (range)	5.5 – 8.5 SU	5.6 - 7.0 SU
carbon tetrachloride	5	ND
chloroform	5	ND
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
Required effluent sampling frequency is monthly for VOCs and pH.

January – September 2008

Routine operations continued from January through September, with approximately 141 million gallons pumped and treated during the first three quarters. The system was off periodically to allow for scheduled carbon filter change-outs. Various power surges due to lightning strikes were experienced during the first three quarters, all of which required system restarts and repair.

October – December 2008

Routine operations continued from October through December. The system was off periodically to allow for scheduled carbon change-outs. Approximately 39 million gallons were pumped and treated during this quarter.

3.2.8.5 System Operational Data

The system was operational from January to December 2008, with only minor shutdowns due to electrical outages, PLC issues, scheduled maintenance, and GAC change-outs.

Extraction Wells

Table F-29 (**Appendix F**) contains the monthly pumping data and mass removal data for the system. **Table 3.2.8-2** shows the monthly extraction well pumping rates. **Figure 3.2.8-4** shows the plot of the TVOC concentrations from the extraction wells over time. VOC concentrations for the extraction wells are provided on **Table F-30** (**Appendix F**). TVOC values in well NS-1 declined from 21 to 13 µg/L over the year, and well NS-2 remained virtually unchanged, with TVOC values ranging from 11 to 13 µg/L. The decline in NS-1 TVOC concentrations correlates to the concentrations in monitoring wells 000-463, 000-464, and 000-465, located immediately upgradient of NS-1. There was no tritium detected in the extraction wells in 2008.

System Influent and Effluent

The 2008 VOC concentrations for the NS carbon influent and effluent are summarized on **Tables F-31** and **F-32** (**Appendix F**). The combined influent TVOC concentration declined from 75 µg/L in December 2004 to 13 µg/L in December 2008. There was only one estimated detection of tritium (380 pCi/L) in the effluent in 2008. The influent is no longer sampled for tritium.

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. All 2008 effluent data for this system were below the MDL.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III North Street Pump and Treat System was calculated using the average flow rates for each monthly monitoring period, in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds removed per month. The cumulative mass of VOCs removed by the treatment system vs. time is plotted on **Figure 3.2.8-5**. During 2008, approximately 181 million gallons of groundwater were pumped and treated by the North Street system, and approximately 21 pounds of VOCs were removed. Since May 2004, the system has removed 290 pounds of VOCs. The mass removal data are summarized on **Table F-29** (**Appendix F**).

3.2.8.6 System Evaluation

Figure 3.2.8-6 compares the TVOC plume from 1997 to 2008. The following significant changes were observed in the plume over this period:

- The trailing edge of the plume has migrated south of the BNL site.
- Monitoring wells 200 feet upgradient of NS-1 are showing a steady decline in TVOC concentrations.
- In wells downgradient of NS-1 and NS-2, TVOC concentrations are increasing as this plume segment that was south of the North Street system prior to start-up migrates toward the Airport.

The OU III North Street Monitoring Program can be evaluated from the five decision rules identified in 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 or extraction wells associated with the North Street Pump and Treat System during 2008.

2. Has the plume been controlled?

Yes. The cleanup goals have not been met; and it must be verified that the plume is not growing. An analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2008; thus, it can be concluded that that plume has not grown and continues to be controlled. As noted above, a segment of the plume now located near Vita Drive was beyond the capture zone of the North Street extraction well NS-1 at the time of system start-up. This portion of the plume will be addressed by the Airport extraction wells directly downgradient.

The leading edge of the plume was defined at Flower Hill Drive at concentrations below the NYS AWQS for individual VOCs. The Airport Pump and Treat System is designed to capture any contaminants migrating south of Flower Hill Drive.

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

The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing VOCs from the deep Upper Glacial aquifer. After four years of operation, the system influent VOC concentrations have been slightly higher than originally projected in the final design. The pre-design modeling predicted that the system will need to operate until 2012. Based on current data this prediction appears to remain valid.

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

No. As noted in **Section 3.2.8.3**, during 2008 there were only estimated values of tritium detected in three monitoring wells with concentrations below 600 pCi/L.

5. Can the groundwater treatment system be shut down?

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

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

No. Although concentrations in a few of the upgradient wells have plateaued over time, overall asymptotic conditions have not yet been achieved.

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

Currently five of 12 plume core wells are showing concentrations greater than 50 µg/L TVOC.

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

To date, the North Street System has not been pulsed.

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

MCLs have not been achieved for individual VOCs in plume core wells. Based on groundwater modeling and current system performance, MCLs are expected to be achieved by 2030.

3.2.8.7 Recommendations

The following are recommended for the North Street Pump and Treat System and groundwater monitoring program:

- Maintain the operations and maintenance sampling frequency for monitoring wells.
- Due to historically low VOC concentrations, the sampling frequency for monitoring wells 000-108, 000-154, and 000-212 will be reduced from semiannual to annual.
- Due to the location of well 086-43 north of the Former Landfill and since groundwater samples have not exceeded DWS since it was installed, it is recommended that this well be dropped from the North Street monitoring program.
- VOCs have remained below DWS for wells 115-33, 115-34, and 115-35 since they were installed in 1996, and there have been no detections above DWS for well 115-32 since 2004. Additionally, tritium concentrations have been less than 400 pCi/L in each of these four wells since they were installed. As a result, it is recommended that these four wells be dropped from the North Street monitoring program.

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3.2.9 North Street East Pump and Treat System

This section summarizes the 2008 operational and monitoring well data for the OU III North Street East (NSE) Groundwater Pump and Treat System, and presents conclusions and recommendations for its future operation. The system began operation in June 2004 to provide capture and control of the downgradient portion of the OU I VOC plume, which has migrated beyond the BNL site boundary.

3.2.9.1 System Description

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

3.2.9.2 Groundwater Monitoring

The monitoring network consists of 15 wells. The monitoring program was designed to monitor the VOC plume off site, south of the OU I South Boundary System, as well as the efficiency of the NSE groundwater remediation system (**Figure 1-2**). During 2008, the wells were sampled at the O&M phase frequency (i.e., core and perimeter wells sampled semiannually, and sentinel wells sampled quarterly). However, as recommended in the *2007 Groundwater Status Report* (BNL 2008b), plume core wells 000-481, 000-482, 000-483, and 000-484 were maintained at a quarterly sampling frequency because they are immediately upgradient of extraction well NSE-2. Since there have been no detections above the standards in any of the monitoring wells, Sr-90, gross alpha/beta, and gamma spectroscopy were removed from the analyte list in 2008. The wells have continued to be sampled annually for tritium. See **Table 1-5** for details.

3.2.9.3 Monitoring Well Results

Figure 3.1-1 shows the extent of the VOC plume. The plume originated from the Current Landfill and former HWMF (sources in OU I). The OU I South Boundary Remediation System is treating the on-site segment of the plume. The NSE Remediation System is addressing the off-site segment of the plume, located south of BNL. This segment of the plume extends from the vicinity of North Street to south of the Long Island Power Authority (LIPA) right-of-way. The length of the plume exceeding the DWS is approximately 2,500 feet. The maximum width of this segment of the plume is approximately 400 feet. The higher concentration segment of the plume (greater than 10 µg/L TVOCs) is just north of the LIPA right-of-way and extraction well NSE-1.

Figure 3.1-2 depicts the vertical distribution of VOCs (primarily TCA, DCE, TCE, chloroform, and choroethane) within the deep Upper Glacial aquifer. The transect line for cross section A–A' is shown on **Figure 3.1-1**. **Figure 3.1-3** gives the historical trends in VOC concentrations for key core and bypass wells along the Current Landfill/former HWMF/NSE plume. **Appendix C** contains a complete set of 2008 analytical results for the 15 NSE program wells. A summary of key monitoring well data for 2008 follows:

- The plume continues to be bounded by the current network of wells.
- All monitoring wells in the plume have remained below the treatment system capture goal of 50 µg/L TVOCs from 2005 through 2008, except for one detection in well 000-478 (58 µg/L) in March 2005.
- The maximum plume TVOC concentration observed in 2008 was 30 µg/L in plume core well 000-480. The primary compound identified in the sample was chloroform at 23 µg/L. This well is

located in the center of the plume downgradient of well 000-478 and just upgradient of NSE-1. This is the highest historical TVOC concentration detected in this well, except during system start-up in mid 2004. From 2005 through 2007, TVOC concentrations in this well were less than 2 µg/L.

- The 2008 TVOC concentrations in core well 000-478 were significantly less than the previous year's results. In 2008, the maximum TVOC concentration was 17 µg/L. When the well was installed in 2004, TVOC concentrations were as high as 205 µg/L. This is indicative that the plume is migrating south to the extraction well. Plume core well, 000-477, located slightly west of 000-478, has remained consistent with TVOC concentrations less than 40 µg/L since system start-up. The primary VOC in this well is TCA.
- TVOC concentrations in core well 000-479 were as high as 77 µg/L in 2004, but have dropped to less than 5 µg/L from mid 2005 through 2007. In 2008, TVOC concentrations increased slightly to 12 µg/L. This well is upgradient of NSE-1.
- TVOC concentrations in plume perimeter well 000-137 remained very low, with detections below 5 µg/L since 2002. This signifies that the trailing edge of the shallower lobe of this plume has migrated south of North Street (**Figure 3.1-2**). TVOC concentrations in core well 000-138 have dropped from 253 µg/L in 1999 to less than 50 µg/L since 2000. In 2007 and 2008, TVOC concentrations dropped below 5 µg/L.
- The maximum TVOC concentration in plume core well 000-124 was less than 5 µg/L in 2007 and 2008, down from a high of 489 µg/L in 1998.
- Following an increase in the TVOC concentration in 2005 and 2006 in plume core well 000-481, located between NSE-1 and NSE-2, the concentration has dropped over an order of magnitude to less than 5 µg/L in 2007 and 2008. In addition, nearby core wells 000-482, 000-483, 000-484, and 000-485 have remained below 5 µg/L since 2005. As recommended in the *2007 Groundwater Status Report* (BNL 2008a), in the first quarter 2008 the pump location was lowered four feet in monitor wells 000-482, 000-483, and 000-484 to obtain data from a slightly deeper portion of the aquifer. However, no significant differences in concentrations were observed.
- Plume bypass well 000-486 has not detected TVOCs above 2 µg/L since it was installed in 2004.
- In 2008, the highest tritium concentration in the plume (520 pCi/L) was detected in well 000-215. There have been no detections of tritium above 1,000 pCi/L in any of the NSE wells since 2005. Historically, the maximum tritium concentration in NSE monitoring wells was 8,200 pCi/L in well 000-215 (less than half of the DWS) in 1998.

3.2.9.4 System Operations

Influent, midpoint, and effluent samples from the GAC units are sampled every other month since the system is in pulse-pumping mode. The extraction wells were sampled quarterly during 2008. All NSE system samples were analyzed for VOCs. In addition, the influent and effluent samples were analyzed monthly for pH. During 2008, the extraction wells and system effluent were also analyzed quarterly and monthly for tritium, respectively. **Table 3.2.9-1** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit.

Table 3.2.9-1.
OU III North Street East
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Observed Value (µg/L)
pH range	5.5–8.5 SU	5.6– 6.66 SU
carbon tetrachloride	5	ND
chloroform	5	2.5
1,1-dichloroethane	5	ND
1,2-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
tetrachloroethylene	5	ND
toluene	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not Detected above method detection limit of 0.50 µg/L.
Required effluent sampling freq. is monthly for VOCs and pH.

3.2.9.5 System Operational Data

The system was operational throughout 2008 with only minor shutdowns due to electrical outages, PLC issues, and scheduled maintenance. During 2008, approximately 4.5 pounds of VOCs were removed. Since October 2006 the system has been pulse pumped with the system on one month and off the next.

January through September 2008

The system operated normally with only minor shut downs due to electrical surges and injection well maintenance. The system pumped and treated approximately 49 million gallons of water.

October through December 2008

The system operated normally for the last quarter of 2008. Due to a pulse-pumping schedule, the system was only operational in November. In this quarter, the system pumped and treated approximately 14 million gallons of water.

Extraction Wells

During 2008, 64 million gallons were pumped and treated by the NSE system; **Table 2-3** contains the monthly pumping data for the two extraction wells. **Table 3.2.9-2** shows the monthly extraction well pumping rates. **Figure 3.2.9-2** plots the TVOC concentrations in the extraction wells. VOC concentrations for NSE-1 and NSE-2 are provided on **Table F-33** (**Appendix F**). Steady TVOC concentration trends are noted for both wells during 2008, with concentrations below 15 µg/L reported in both wells during the entire year. This is significantly below the 50 µg/L capture goal for the extraction wells. The historical maximum TVOC concentrations in NSE-1 and NSE-2 were 58 and 25 µg/L at system start-up, respectively.

System Influent and Effluent

VOC concentrations for 2008 for the carbon treatment influent and effluent are summarized on **Tables F-34** and **F-35** (**Appendix F**). Influent TVOC concentrations have been at or below 12 µg/L since 2005. The carbon treatment system effectively removed VOCs from the influent groundwater resulting in all 2008 NSE effluent concentrations being below the regulatory limit specified in the equivalency permit. No tritium has been detected in the system effluent above 600 pCi/L since the system began operating in 2004.

Cumulative Mass Removal

Using average flow rates for each monthly monitoring period, in combination with the VOC concentration in the system influent, the rate of contaminant removal was calculated (**Table F-36** in **Appendix F**). The cumulative mass of VOCs removed by the treatment system versus time is shown on **Figure 3.2.9-1**. During 2008, 4.5 pounds of VOCs were removed, with a cumulative total of 24 pounds of VOCs removed since system start-up in April 2004.

3.2.9.6 System Evaluation

The system began operations in June 2004 and was predicted to run for approximately 10 years. The system is operating as designed. No operating difficulties were experienced beyond normal maintenance, and system effluent concentrations did not exceed SPDES equivalency permit requirements.

The North Street East Pump and Treat System performance can be evaluated based on the four major decisions identified for this system from the groundwater DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected concentrations of contaminants observed in monitoring or extraction wells associated with the NSE System.

2. Has the plume been controlled?
Yes. The system has been in operation for four years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2008, indicating that the plume has not grown and is controlled.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?
The system is operating as designed, and the system has been effectively removing VOCs from the deep Upper Glacial aquifer. System influent VOC concentrations have been less than originally projected. In addition, the monitoring wells have shown low concentrations following initial start-up of the system.

4. Can the groundwater treatment system be shut down?

Yes. The shutdown criteria of reaching less than 50 µg/L TVOCs for at least four consecutive sampling rounds has been met in the core monitoring and extraction wells. However, additional monitoring data will be collected and, if concentrations remain below the capture goal of 50 µg/L TVOCs, a Petition for Shutdown of the NSE system will be prepared.

4a. Have asymptotic TVOC concentrations been reached in core wells?
No. Since the shutdown criteria of less than 50 µg/L has been achieved, asymptotic conditions are no longer a required measure for system shutdown.

4b. Are there individual plume core wells above 50 µg/L TVOC ?
No. All NSE core wells were below 50 µg/L TVOCs.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?
Since the system was first shut down for pulse pumping starting October 2006, all core wells have remained low and no significant rebounding has been identified.

4d. Have the groundwater cleanup goals been met? Have MCLs been achieved (expected by 2030)?
No. MCLs have not been achieved for individual VOCs in plume core wells. However, MCLs are expected to be achieved by 2030.

3.2.9.7 Recommendations

The following recommendations are made for the NSE Pump and Treat System and groundwater monitoring program:

- Continue pulse pumping of both extraction wells. The pulse pumping consists of having the system on for one month, then off in standby mode for the next month. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, the extraction well(s) will be put back into full-time operation.

- Following the review of additional monitoring well data, a Petition for Shutdown of the system will be prepared.
- Change the monitoring frequency for the monitoring wells from routine operations and maintenance to shutdown monitoring in the second quarter 2009. This calls for all NSE monitoring wells to be sampled quarterly.
- It is recommended that monitoring well 000-394 be added to the North Street East well network.

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3.2.10 LIPA/Airport Pump and Treat System

3.2.10.1 System Description

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

1. The Magothy extraction well (EW-4L) on Stratler Drive (**Figure 3.2.10-1**) addresses high-level VOCs identified in the Magothy aquifer immediately upgradient of this well on Carleton Drive. The capture goal for this well is 50 µg/L TVOCs.
2. The three LIPA extraction wells (EW-1L, EW-2L, and EW-3L) were installed to address high concentrations of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The capture goal for these extraction wells is 50 µg/L TVOC.
3. Six extraction wells in the Airport System were installed to address the leading edge of the plumes and to prevent further migration of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells. The sixth well (RW-6A) was added in 2007 to address concentrations of VOCs observed to the west of extraction well RTW-1A. The Airport system wells have a capture goal of 10 µg/L TVOC.

The water from the four LIPA wells is pumped to the treatment plant, about one mile south on Brookhaven [Town] Airport property, where it is combined with the water from the six airport extraction wells (RTW-1A through RW-6A) and treated via granular activated carbon. The treated water is released back to the ground via a series of shallow reinjection wells located on Brookhaven Airport and Dowling College property.

A more detailed description of this system is contained in the *Operations and Maintenance Manual for the LIPA/Airport Groundwater Treatment System* (BNL 2008c).

3.2.10.2 Groundwater Monitoring

Well Network

The monitoring network consists of 53 wells. There are 18 wells associated with the LIPA Upper Glacial portion of the plume that were installed to monitor the VOC plume off site, south of the OU III Industrial Park System. The Airport System network has 29 monitoring wells, which monitor the portions of the plume south of the LIPA and the North Street systems. The Magothy extraction well on Stratler Drive has six monitoring wells associated with its operation. All of these wells are used to monitor and evaluate the effectiveness and progress of the cleanup associated with these three components of the system. **Figure 1-2** identifies the monitoring wells for these plumes.

Sampling Frequency and Analysis

The monitoring wells for LIPA are currently on a quarterly and semiannual sampling schedule for VOCs. The Airport wells are sampled quarterly (**Table 1-5**).

3.2.10.3 Monitoring Results

The primary VOCs associated with these portions of the plume are carbon tetrachloride, TCA, TCE, and 1,1-dichloroethylene. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter 2008 well data are posted on **Figures 3.2-1, 3.2.10-1** and **3.2.10-2**. The complete analytical results are in **Appendix C.** Results for key monitoring wells and extraction wells are as follow.

- During 2008 TVOC concentrations for the Magothy extraction well EW-4L on Stratler Drive ranged from 63 µg/L in January to 45 µg/L in October. Carbon tetrachloride is the primary VOC detected in this well. The Magothy monitoring wells associated with this portion of the plume show concentrations below 50 µg/L TVOCs, with well 000-130 showing the highest concentration (31 µg/L) in January 2008. **Figure 3.2.10.3** plots the TVOC influent trends for the LIPA extraction wells.

- Two of the three Upper Glacial LIPA extraction wells, EW-1L and EW-3L, were shutdown in October 2007. Well EW-2L had a high TVOC concentration of 29 µg/L in January and a low of 18 µg/L in October 2008. Well EW-3L continued to show VOC concentrations below MCLs. EW-1L showed TVOC concentrations ranging from 15 µg/L in April to 11 µg/L in January 2008. The highest individual VOC concentration detected in this well was 9.6 µg/L PCE in April 2008. The capture goal of the LIPA extraction wells is 50 µg/L TVOCs.
- VOC concentrations in monitoring wells near the Airport System extraction wells are below MCLs, except for well 800-96. However, upgradient monitoring wells 800-94 and 800-95, approximately 1,500 feet north of wells RTW-1A and RTW-2A, have historically shown TVOC concentrations primarily composed of carbon tetrachloride ranging up to 100 µg/L.
- Five of the six airport extraction wells had VOC concentrations below MCLs throughout 2008. Newly installed extraction well RW-6A showed TVOC concentrations of 18 µg/L in January dropping to 10 µg/L in December.
- Well 800-96 was installed as a western perimeter monitoring well for extraction well RTW-1A. Sampling of this well began in March 2004. No detections of carbon tetrachloride were found in this well until December 2005, when it was detected at 1.6 µg/L. In June 2006, 10 µg/L of carbon tetrachloride was detected in this well, and in August 2006 the concentration increased to 40 µg/L. Due to these VOC increases, the monitoring frequency for this well was changed from quarterly to monthly beginning in December 2006. During 2007 a new extraction well RW-6A and five new monitoring wells (800-126, 800-127, 800-128, 800-129, and 800-130) were installed to monitor and capture the contaminants in the vicinity of well 800-96 (**Figure 3.2.10-1**). Well 800-96 has had carbon tetrachloride concentrations close to 100 µg/L throughout 2008. None of the monitoring wells installed downgradient of this area have shown carbon tetrachloride above MCLs.
- As per recommendation in last year's annual report, in February 2009 a vertical profile well (APVP-1-2009) was installed about 200 feet west of well RTW-3A to bound the western edge of the plume in this area. The vertical profile showed low concentrations of TCA (1.3 µg/L at 215 and 225 ft bls). **Table 3.2.10-3** summarizes the vertical profile data. In March 2009, a permanent monitoring well was installed at this location (AP MW-1 2009) that is screened from 215 to 235 ft bls (**Figure 3.2.10-1**). Analytical data from the permanent well were not available in time for this report.

3.2.10.4 System Operations

In 2008, the extraction wells were sampled once per month. The influent, midpoint, and effluent of the carbon units were sampled two times per month. All System samples were analyzed for VOCs. The Airport extraction wells are on a pulse-pumped schedule, being pumped one week per month, except for wells RTW-1A and RW-6A which are pumped on a full-time basis. RW-6A began full-time operations in September 2008.

The following is a summary of the OU III Airport/LIPA System operations for 2008.

January – September 2008

The LIPA System was down in August and September due to communication problems with the BNL Tower. The Airport wells continued normal operations, with wells RTW-1A and RW-6A operating on a full-time basis. RTW-3A began full-time operations in September.

October – December 2008

The system operated normally for the last quarter of 2008 with minimal down time due to scheduled maintenance and carbon change-outs.

Extraction Wells Operational Data

During 2008, approximately 226 million gallons were pumped and treated by the OU III Airport/LIPA System, with an average flow rate of 474 gpm (**Table 3.2.10-2**). **Table F-37** (**Appendix F**) summarizes the System's mass removal. **Table 3.2.10-2** shows the monthly extraction well pumping rates. VOC concentrations for the airport and LIPA extractions wells are provided on **Table F-38** (**Appendix F**). VOC levels in the airport extraction wells were below MCLs, except for well RW-6A and several detections of trichloroethylene above the MCL in well RTW-3A during May and June of 2008. Subsequent results showed VOCs below MCLs.

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations for the carbon influent and effluent in 2008 are summarized on **Tables F-39** and **F-40** (**Appendix F**).

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. 2008 System effluent data were below the analytical method detection limit and below the regulatory limit specified in the SPDES equivalency permit.

Cumulative Mass Removal

The mass of VOCs removed from the aquifer by the OU III Airport/LIPA Treatment System was calculated using the average flow rates for each monitoring period (**Table F-37** in **Appendix F**) in combination with the TVOC concentration in the carbon unit's influent, to calculate the pounds per month removed. The plot of cumulative mass of VOCs removed vs. time (**Figure 3.2.10-4**) shows that 23 pounds of VOCs were removed during 2008, with a total of 260 pounds removed since system start-up.

3.2.10.6 System Evaluation

The Airport Treatment System was designed to capture the leading edge of the OU III and OUI/IV VOC plumes. The newly installed extraction well (RW-6A) has shown carbon tetrachloride above MCLs since it was installed and began operations in November 2007. Some higher concentrations of VOCs have been detected upgradient of these wells. VOC concentrations in the LIPA wells are consistent with the groundwater modeling performed for the design of this system. **Table 3.2.10-1** shows maximum measured values and the values allowed under the SPDES equivalency permit.

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

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

No, there were no unusual or unexpected VOC concentrations observed in the monitoring wells of the LIPA/Airport Treatment System during 2008.

<u>*2. Has the plume been controlled?*</u>

Yes, based on the historical analytical data collected from the monitoring wells and the

Table 3.2.10-1
OU III LIPA/Airport Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.9-7.3 SU
carbon tetrachloride	5	ND
chloroform	7	ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene	5	ND
methylene chloride	5	ND
1,1,1-trichloroethane	5	ND
trichloroethylene	10	ND

Notes:
ND = Not detected above method detection limit of 0.50 µg/L.
Sampling required an a monthly basis

results of the *LIPA/Airport Pump Test Report* (Holzmacher 2004), the plumes are being controlled. The capture zones (**Figure 3.0-1**) clearly show that the capture goal of 50 µg/L TVOC at the LIPA Upper Glacial and Magothy wells is being met. The leading edge of the plume has reached the airport.

3. Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate?
Yes, the system 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, asymptotic concentrations have not been reached.

4b. Is the TVOC concentration in the LIPA core wells less than 50 µg/L?
Yes; however, extraction well EW-4L still shows concentrations greater than 50 µg/L. The extraction well data are utilized to help in tracking the plume.

4c. Are the TVOC concentrations in the Airport core wells less than 10 µg/L ?
No, seven airport core wells (800-63, 800-92, 800-94, 800-95, 800-96, 800-106, and 800-129) had TVOC concentrations greater than 10 µg/L in 2008.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
The intent of the current pulse pumping is not to evaluate for rebound but to monitor for the high-concentration segment as it continues to travel south toward the northern perimeter of the Airport extraction wells.

5. Have the groundwater cleanup goals been met? Have MCLs been achieved?
No, the cleanup goals have not been met. Based on model results, MCLs are expected to be achieved by 2030 for the Upper Glacial aquifer, and in the Magothy aquifer by 2070, as required by the OU III ROD and ESD.

3.2.10.7 Recommendations

The following recommendations are made for the LIPA/Airport Pump and Treat System and groundwater monitoring program:

- Continue the airport extraction wells pulse-pumping schedule of pumping one week per month except for wells RTW-1A and RW-6A, which will continue with full-time operations. Discontinue full-time pumping of well RTW-3A since VOC concentrations in this well are now well below MCLs and have been for over six months. This well will revert back to the one week per month pumping schedule. If concentrations above the capture goal of 10 µg/L TVOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.
- Maintain LIPA wells EW-1L and EW-3L in standby mode. These extraction wells will be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.

3.2.11 Magothy Aquifer

This section provides a brief summary of the Magothy Aquifer Groundwater Monitoring Program and the remedial approach for addressing the VOC contamination. The 41 monitoring wells used to characterize the Magothy are shown on **Figure 3.2.11-1**.

Detailed descriptions of the monitoring well analytical results and remediation progress are presented in the following sections of this report: Western South Boundary, Middle Road, Airport/LIPA, North Street, North Street East, OU III South Boundary, Industrial Park, Industrial Park East, and Central Monitoring. A brief summary of the results is provided on **Table 3.2.11-1**. Further details about these characterization results are in the *Final Magothy Aquifer Characterization Report* (Arcadis Geraghty & Miller 2003).

Table 3.2.11-1. Magothy Aquifer Contamination (Historical and 2008).

Location	Max. TVOC (in µg/L) 2008	Max. TVOC (in µg/L) Historical	Primary VOCs	Results
Western boundary on site	<5.0	<5.0	None	Magothy not impacted. Two monitoring wells serve as adequate outpost/sentinel wells for Suffolk County Water Authority William Floyd Well Field.
Middle Road and south boundary on site	112	340	PCE, CCl_4	VOCs identified in upper 20 to 40 feet of Magothy at Middle Road area where brown clay is absent. A temporary well installed in 2006 did not detect Magothy contamination between the Middle Road and South Boundary. VOCs not detected at South Boundary beneath the clay.
North Street off site	64	50	TCE	Low VOC concentrations have been detected in localized areas in the upper 30 feet of the Magothy aquifer and downgradient near Vita Drive. Leading edge of contamination is around Moriches-Middle Island Road.
North Street East off site	9	30	1,1-DCA; 1,1-DCE	Low VOC concentrations have been detected at the BNL south boundary to North Street below the brown clay at approximately 40 to 150 feet into the upper Magothy.
Industrial Park East off site and south boundary	38	570	TCA, CCl_4	TVOCs currently less than 60 µg/L off site in the Industrial Park, where brown clay is absent. Magothy and Upper Glacial contamination is contiguous in Industrial Park.
South of Carleton Drive off site	26	7,200	CCl_4	Historically high VOC concentrations just south of Carleton Drive where brown clay is absent. Levels of TVOCs are now less than 50 µg/L. Contamination is contiguous between Magothy and Upper Glacial aquifer.

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

1. Continued operation of the five extraction wells as part of the Upper Glacial treatment systems that provide capture of Magothy VOC contamination (Middle Road, South Boundary, Airport, Industrial Park East, and LIPA).

2. Continued evaluation of the monitoring wells' data to ensure protectiveness. **Table 3.2.11-2** describes how each of the Magothy investigation areas is addressed by the DOE's selected Magothy aquifer remedy.
3. Institutional controls and five-year reviews.

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

Table 3.2.11-2. Magothy Remedy.

Area Investigated	Selected Remedy
Western boundary on-site area	Continue monitoring and evaluate data.
Middle Road and South Boundary on-site area	Continue operation of the Magothy extraction well at Middle Road, as well as the two Upper Glacial systems. Continue to monitor the three Magothy monitoring wells at Middle Road and three at the south boundary.
North Street off-site area	Continue operation of the two existing Upper Glacial extraction wells on Sleepy Hollow Drive and North Street until cleanup objectives are met. Continue monitoring and evaluate data.
North Street East off-site area	Continue monitoring and evaluate data.
Industrial Park East off-site area and s. boundary	Continue operation of the Industrial Park East Magothy extraction well until cleanup objectives are achieved. Continue monitoring and evaluate data.
South of Carlton Drive off-site area	Continue operation of the LIPA Magothy extraction well on Stratler Drive until cleanup goals are achieved. This will capture high concentrations of TVOCs identified on Carleton Drive and prevent migration of high concentrations of TVOCs through the hole in the brown clay and into the Magothy aquifer. Continue monitoring and data evaluation.

3.2.11.1 Monitoring Well Results

There are 41 monitoring wells in the Magothy monitoring program (**Figure 3.2.11-1**). **Figure 3.2.11-2** shows trend plots of several of the key monitoring wells. A discussion of some of the key wells follows.

Well 000-130: This well is on Carleton Drive and has historically had the highest concentrations of carbon tetrachloride observed off site related to BNL: over 7,000 µg/L. Concentrations of TVOCs ranged from 16 to 31 µg/L in 2008. The higher concentrations of carbon tetrachloride observed historically in this well are being captured by the LIPA extraction well on Stratler Drive. A more detailed discussion of this is available in **Section 3.2.10**, LIPA/Airport Pump and Treat System.

Wells 000-249 and 000-250: These wells are in the Industrial Park near well UVB-1. Well 000-249 had TVOC concentrations ranging from 75 µg/L in August to 27µg/L in December 2008. Well 000-250 had VOC concentrations below MCLs in 2008. Based on analytical data, the higher levels of contamination observed in well 000-249 are being captured by the UVB wells, even though 000-249 is on the edge of the capture zone for these wells. Any contaminants above the capture goal of 50 µg/L TVOC that migrate beyond the capture of this system will be captured by the Stratler Drive extraction well.

Wells 000-425 and 000-460: These wells are adjacent to the LIPA Stratler Drive Magothy extraction well. Well 000-425 had concentrations of TVOCs ranging from 9 to 23 µg/L during 2008. This well is immediately adjacent to the extraction well. Well 000-460, located east of the extraction well but within the capture zone, had concentrations ranging from 1 to 12 µg/L in 2008.

Well 122-05: This well, located at the eastern edge of the OU III South Boundary System, showed concentrations of TVOCs ranging from 26 to 28 µg/L in 2008.

Well 000-343: Located south and between the OU I and OU III South Boundary systems, this well had TVOC concentrations between 7 and 9 µg/L in 2008.

Well 115-50: Located south and between the OU I and OU III South Boundary systems, this well had VOC concentrations below MCLs in 2008.

Wells 000-427 and 000-429: These wells are located just south of the Industrial Park East System on Carleton Drive. In 2008, well 000-427 had TVOC concentrations ranging from 9 to 28 µg/L,and well 000-429 had concentrations ranging from 3 µg/L in August to 69 µg/L in January.

Well 800-90: This well is located near Moriches-Middle Island Road upgradient of Airport extraction wells 3 and 4. It is screened at about 255 feet below grade. This well is co-located with Well 800-92. TVOC concentrations ranged from 58 to 81 µg/L in 2008.

Well 800-92 (not a Magothy well; screened at a depth of ~200 feet): Located about 2,500 feet north of the Airport System, this well had VOC concentrations ranging from 48 to 89µg/L in 2008. The chemicals in wells 800-90 and 800-92 are similar. This is indicative of contamination that was already past the North Street extraction wells prior to operation, and will eventually be captured by the Airport extraction wells.

3.2.11.2 Recommendations

Continue the current monitoring schedule for the Magothy monitoring program, except for wells 000-428 and 115-50. Well 000-428 will be changed from quarterly to semiannual and well 115-50 from quarterly to annual. This is based upon historically low VOC concentrations in these wells (**Table 1-5**).

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3.2.12 Central Monitoring

The OU III Remedial Investigation (RI) identified several low-level (less than 50 µg/L) TVOC source areas and nonpoint contaminant sources within the developed central areas of the BNL site. These sources include spills within the Alternating Gradient Synchrotron (AGS) Complex, the Bubble Chamber spill areas, and the Building 208 vapor degreaser. Because these sources are not large enough to warrant a dedicated monitoring program, they are monitored under the OU III Central Monitoring Program. In addition, this program includes wells 109-03 and 109-04, located near the BNL western site boundary. These wells were installed by the SCDHS to serve as sentinel wells for the SCWA William Floyd Parkway Well Field.

3.2.12.1 Groundwater Monitoring

Well Network

The monitoring well network is comprised of 20 wells (**Figure 3.2.12-1**). The well locations aid in defining the VOC plumes that extend downgradient from the central areas of the site. This network is also supplemented by data from Facility Monitoring program wells that monitor active research and support facilities (**Table 1-6**). Results from the Environmental Surveillance (ES) programs are provided in **Section 4**.

Sampling Frequency and Analysis

The wells are sampled and analyzed annually for VOCs, and wells 109-03 and 109-04 are analyzed quarterly for VOCs, gamma spectroscopy, tritium, and Sr-90 (**Table 1-5**). Select Facility Monitoring wells in the AGS Complex are typically sampled annually for VOCs in order to complete the northern portion of the OU III VOC plume configuration.

3.2.12.2 Monitoring Well Results

VOC concentrations detected in most of the OU III Central wells are near or below NYS AWQS. In many of the wells in the north-central developed portion of the site, the primary constituent is TCA. A discussion of some of the key wells follows:

- Wells 083-01 and 083-02 are near the intersection of Brookhaven Avenue and Upton Road, and are screened in the Upper Glacial aquifer. These wells consistently have contained 1 to 9 µg/L and 4 to 25 µg/L of chloroform since 1997, respectively. In December 2008, well 083-01 had a detection of chloroform of 8.6 µg/L, exceeding the NYS AWQS of 7.0 µg/L. Well 083-02 had a chloroform detection of 3.9 µg/L in December 2008.
- SCDHS wells 109-03 and 109-04 serve as sentinel wells for the SCWA William Floyd Well Field and are near the western BNL property boundary. There were no detections of VOCs above the NYS AWQS during 2008. Tritium was detected in 109-04 at 1,010 pCi/L in March 2008.

3.2.12.3 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.

<u>1. Was the BNL Groundwater Contingency Plan triggered?</u>
No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2008.

<u>2. Are there potential impacts to the SCWA William Floyd Well Field from on-site contamination?</u>
No. There were no detections of contaminants in the sentinel monitoring wells during 2008, with the exception of low-level (below 0.5 ug/L) chlorinated organic compounds (below NYS AWQS).

3. Are the performance objectives met?
No. Since 1997 the VOC concentrations in the central portion of the site have significantly decreased, as noted in TVOC plume comparison **Figure 3.2-3**. However, during 2008 several individual wells continued to contain VOC concentrations exceeding the NYS AWQS; therefore, the OU III ROD objective of meeting MCLs by 2030 has not yet been met.

4. If not, are observed conditions consistent with the attenuation model?
Yes. The observed VOC concentrations generally agree with the model-predicted concentrations, with respect to both the plume extent and contaminant concentrations.

3.2.12.4 Recommendation

The following is recommended for the OU III Central groundwater monitoring program:

- Based on the lack of VOC detections above standards, wells 064-03, 066-08, 066-09, 075-01, 075-02, 105-05, and 105-06 should be dropped from the sampling program.

3.2.13 Off-Site Monitoring

The OU III Off-Site Groundwater Monitoring Program consists of 12 wells. They were installed to monitor contamination in the southwest portion of the OU III plume or were installed as part of the early BNL hydrogeologic characterization.

3.2.13.1 Groundwater Monitoring

Well Network

The network has 12 wells that monitor the off-site southwest 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. These wells are screened in the deep portions of the Upper Glacial aquifer.

Sampling Frequency and Analysis

The wells were sampled annually and samples analyzed for VOCs (**Table 1-5**). Samples were collected in the fourth quarter of 2008.

3.2.13.2 Monitoring Well Results

The complete results for the monitoring wells in this program can be found in **Appendix C**. The horizontal extent of the off-site segment of the OU III VOC plume is shown on **Figure 3.2-1**.

The monitoring wells in the OU III Off-Site Monitoring Program are perimeter and sentinel wells. In 2008, they continued to have VOC concentrations below the NYS AWQS.

3.2.13.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2008 that would have triggered the BNL Groundwater Contingency Plan. All VOC detections were below NYS AWQS.

3.2.13.4 Recommendation

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

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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 currently migrating off the south section of the BNL site. The sampling was conducted in conjunction with the OU III South Boundary, Western South Boundary, and OU VI Programs. The eastern portions of the site south boundary are monitored for radionuclides as part of the OU I South Boundary and OU V STP groundwater monitoring programs.

3.2.14.1 Groundwater Monitoring

A network of 59 monitoring wells is used to monitor radionuclides from the OU III South Boundary, OU III Western South Boundary, and OU VI programs. The well locations along the southern property boundary are shown on **Figure 3.2.14-1**.

Sampling Frequency and Analysis

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

3.2.14.2 Monitoring Well Results

The radionuclide analytical results for the wells can be found in **Appendix C**. There were no confirmed radionuclide detections during 2008. In July 2008, there was a reported low-level detection of tritium in well 122-04 (300 pCi/L). A data usability review indicates that this result is most likely a false positive. Therefore, the analytical result has been flagged to indicate this conclusion.

3.2.14.3 Groundwater Monitoring Program Evaluation

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

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected results during 2008 to trigger the BNL Groundwater Contingency Plan.

3.2.14.4 Recommendations

The following are recommendations for the OU III South Boundary Radionuclide Groundwater Monitoring program:

- Due to the wells' locations and the lack of detections of radionuclides, it is recommended that the following wells be dropped from the sampling program: 119-03, 124-02, 125-01, and 099-10.
- Due to the lack of detections of radionuclides, it is recommended that gamma and tritium analyses be dropped from the well 107-10 sampling.

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3.2.15 BGRR/WCF Strontium-90 Treatment System

The OU III Brookhaven Graphite Research Reactor (BGRR)/Waste Concentration Facility (WCF) Treatment System addresses the Sr-90 plumes in groundwater downgradient of these facilities. Some of the wells included in the OU III BGRR/WCF network are also monitored as part of the OU III AOC 29 HFBR and Building 801 programs (**Sections 3.2.17** and **4.11**). These wells are sampled concurrently for all of these programs to avoid duplication of effort. The BGRR/WCF remedy consists of:

1. Operation of five extraction wells using ion exchange to remove Sr-90, with on-site discharge of the clean water to injection wells
2. Operation of the system to minimize plume growth and meet DWS by 2070
3. Continued monitoring and evaluation of data to ensure protectiveness
4. Institutional controls and five-year reviews

The analytical results indicate three areas of elevated Sr-90: one from the WCF area, one in an area south of the BGRR Below Ground Ducts (BGD) and Canal House, and one that is south of the former Pile Fan Sump (PFS) area (**Figure 3.2.15-1**).

3.2.15.1 System Description

System operations for this treatment system began in January 2005. There are two extraction wells (SR-1 and SR-2) located south of the WCF and three extraction wells (SR-3, SR-4, and SR-5) located south of the BGRR. The treatment system typically operates at an average rate of 25 gpm total from the five extraction wells.

Groundwater from the five extraction wells is transported through pipelines to an ion exchange treatment system inside Building 855 (within the BNL Hazardous Waste Management complex). The vessels of ion exchange media are designed to treat groundwater contaminated with Sr-90 to below the 8 pCi/L DWS. In addition, the influent is also treated for low-level concentrations (less than 10 µg/L) of TVOCs using liquid-phase activated carbon.

Effluent is recharged to the Upper Glacial aquifer via three drywells approximately 850 feet west of Building 855. A New York SPDES equivalency permit regulates this discharge. A complete description of the system is included in the *Operations and Maintenance Manual for the Sr-90 BGRR/WCF/PFS Groundwater Treatment System* (BNL 2005d).

3.2.15.2 Groundwater Monitoring

Well Network

A network of 86 monitoring wells is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS areas. For the WCF plume in the vicinity of the HFBR, this network is currently being supplemented with temporary wells to monitor the high concentration Sr-90 and tritium (g-2) slugs identified in this area in 2007 and 2008. Most recently, temporary wells were installed in this area during the fourth quarter of 2008 and the first quarter of 2009.

Sampling Frequency and Analysis

In 2008, the sampling frequency for the BGRR and PFS plumes was shifted from a start-up to O&M phase (semiannual to annual) for most wells. The WCF plume remained at a semiannual frequency in order to obtain sufficient data to characterize this plume and support pre-design groundwater modeling for system modification. The well samples are analyzed for Sr-90. As noted on **Table 1-5,** wells also serve dual purposes for other programs.

3.2.15.3 Monitoring Well/Temporary Well Data

The Sr-90 plume distribution map is shown on **Figure 3.2.15-1**. The distribution of Sr-90 throughout the BGRR, WCF, and PFS areas is depicted based on groundwater data obtained from the fourth-quarter 2008 and first-quarter 2009 sampling of the monitoring well network and temporary wells. The following cross-sectional views are also provided:

- **Figure 3.2.15-2** (I–I') for the BGRR plume – A north–south cross section from the BGRR south to Brookhaven Avenue
- **Figure 3.2.15-3** (J–J') for the PFS plume – A north–south cross section from Building 801 south to Cornell Avenue
- **Figure 3.2.15-4** (K–K') for the WCF plume – A north–south cross section from WCF south to Cornell Avenue

In addition, historical Sr-90 concentration trend plots for key wells are plotted on **Figure 3.2.15-5**.

Historically, the highest overall Sr-90 concentration (3,150 pCi/L) occurred in 2003 in a temporary well installed approximately 200 feet south of Building 701 and slightly upgradient of the current location of extraction well SR-3. The highest historical Sr-90 concentration in the WCF area (1,560 pCi/L) occurred in April 2003 in a temporary well installed immediately downgradient of the six former underground storage tanks (USTs A/B) and approximately 25 feet north of the WCF (Building 811). This area within the WCF is upgradient of the current location of extraction well SR-1. The highest historical Sr-90 concentration in the former PFS area (566 pCi/L) occurred in March 1997 in a temporary well installed downgradient of the PFS.

The following is a summary of the 2008 monitoring well data for the three Sr-90 plumes.

WCF Plume

Refer to **Figure 3.2.15-4** for cross-sectional view of the WCF plume.

- In 2008, the highest Sr-90 concentration in all three plumes was 549 pCi/L during October in plume core well 065-175, located immediately south of the WCF yard. The historical high for this well was 821 pCi/L in 2000. **Figure 3.2.15-5** shows an increasing concentration trend in this well over the past two years. This follows a decreasing trend for the previous two years that was most likely the result of a plume shift caused by increased pumping from the eastern supply wells just prior to this time frame. This contamination will be captured by extraction well SR-2.
- Wells 075-47, 075-48, 075-87, and 075-684, located on Temple Place, are sentinel wells for the WCF Sr-90 plume. In well 075-684, the maximum Sr-90 detection was 0.3 pCi/L for 2008.

As recommended in the *2007 Groundwater Status Report* (BNL 2008b), select wells were analyzed for Sr-90 during the installation of temporary wells just northwest of the HFBR. These temporary wells were installed during the fourth quarter of 2008 and first quarter of 2009 as part of the characterization effort for the downgradient portion of the g-2 tritium plume. Most of the samples were collected at locations previously sampled in 2007/2008 using temporary wells. The goal of this characterization was to update the location of both the WCF Sr-90 high concentration slug and the downgradient g-2 tritium slug. The cross section on **Figure 3.2.15-4** shows both plumes and illustrates the relationship between the two plumes. The data from this characterization effort will be used to design the array of additional Sr-90 extraction wells necessary to remediate the high Sr-90 concentrations and enable the OU III ROD cleanup goals to achieved. From September 2008 through March 2009, five sets of east-west temporary well transects were installed and sampled for both tritium and Sr-90. The 29 temporary well locations (i.e., g-2-GP-#) are identified on **Figure 3.2.15-1** and the complete data set is available on **Table 3.2.15-1**. The transects were located as follow:

- A – The northern-most transect situated in the parking lot just south of Rutherford Drive to the east of the BGRR
- B – Approximately 175 feet south of transect A and 250 feet north of the HFBR.
- C – Immediately north of the HFBR
- D – Immediately south of the HFBR
- E – Along Temple Place

The following is a brief summary of the data for the five transects:

- Transect A – The data from the two temporary wells installed in March 2009 shows a slight decrease in the peak Sr-90 concentration from 52 to 46 pCi/L when compared to the 2007 data from this area. The maximum tritium concentration along this transect dropped slightly from 25,100 pCi/L in GP-80 (2007) to 23,200 in GP-79 (2009).
- Transect B – The maximum Sr-90 concentration in the four temporary wells installed in March 2009 was 160 pCi/L in GP-72. This is significantly lower than the 294 pCi/L observed at this location in 2007. The maximum tritium concentration in this area was 38,300 pCi/L in GP-73, which is also substantially lower than the 198,000 pCi/L detection at this location in 2007. The trailing edge of the Sr-90 high concentration slug appears to be approaching this area based on the declining concentrations in upgradient Transect A locations and the declining concentrations along Transect B. The core of the high concentration downgradient segment of the g-2 tritium plume has moved well south of this transect in early 2009, as expected based on tritium transport with groundwater flow.
- Transect C – Nine temporary wells were installed at this transect during March 2009. The maximum Sr-90 concentration was 154 pCi/L in GP-63 (2009), which is significantly lower than the 518 pCi/L detected at that location in 2007. The maximum tritium concentration along this transect was 23,900 pCi/L (2009) in GP-65 as compared to the 53,900 in GP-66 during 2007. In March 2009 an additional location, GP-33, was installed approximately 150 feet south of GP-63. The maximum Sr-90 concentration in that temporary well was 406 pCi/L. Based on the data from Transects C and D, the core of the Sr-90 high concentration slug has shifted south since the 2007 data was collected. The core of the g-2 tritium downgradient slug has largely migrated south of this transect in early 2009.
- Transect D – A total of six temporary wells were installed along this transect in December 2008 and January 2009. The maximum Sr-90 concentration in December 2008 was in GP-93 at 140 pCi/L. This is an increase from the 83 pCi/L detected in early 2008. The maximum tritium concentration in this area during the most recent sampling was 80,700 pCi/L in GP-84 (December 2008) which is comparable to the 83,000 pCi/L detected at this location in early 2008. The core of the g-2 tritium plume downgradient slug appears to be in the vicinity of the front of the HFBR based on the fourth-quarter 2008 data.
- Transect E - Six temporary wells were installed from late September to December 2008. There were only trace detections of Sr-90 along this transect, indicating that the leading edge of the plume remains north of this area. A tritium concentration of 33,300 pCi/L was observed at location GP-94 in September 2008. Based on these data, the leading edge of the g-2 tritium plume is located just south of Temple Place.

BGRR Plume

- The highest Sr-90 concentration in a monitoring well south of the BGRR was 69 pCi/L in the April 2008 sample from well 075-669. Sr-90 concentrations in this well have been declining following a high of 272 pCi/L in 2005. The October 2008 result was 20 pCi/L in this well. This is indicative of a higher concentration slug (that was south of SR-4 and SR-5 prior to the initiation of pumping) moving through this area. This slug of Sr-90 is expected to naturally attenuate on site to below the drinking water standards by 2070.

- The highest Sr-90 concentration downgradient of the BGRR occurred in extraction well SR-3, which reached a peak of 1,650 pCi/L in September 2007. This extraction well showed a steady decline during 2008 to 41 pCi/L in December. It appears that the trailing edge of a high concentration slug may be approaching this extraction well.
- Historic Sr-90 concentrations in plume core well 075-664 (located approximately 50 feet upgradient of SR-3) have not correlated well with the concentrations detected in SR-3. One possibility for the significantly lower concentrations than expected in this well is that it is screened slightly too deep to be in the core of the plume. The installation of a temporary well adjacent to 075-664 will be recommended. Pending the results, this temporary well may be followed up with a permanent monitoring well screened at a shallower depth than 075-664.
- Concentrations of Sr-90 in plume perimeter wells 075-195, 075-196, 075-197, and 075-200, located west of the downgradient portion of the plume, remained below the DWS.
- Sentinel wells 075-670 and 075-671 are north of Brookhaven Avenue on the south side of the NSLS-II. Prior to 2007, these wells were located just downgradient of the leading edge of the plume. In 2008, both wells detected Sr-90 above the DWS, at concentrations between 13 and 38 pCi/L. Based on these data, the leading edge of the plume defined by the 8 pCi/L DWS is located approximately 100 feet south of this location.

Pile Fan Sump Plume

- Plume core well 065-37, located just downgradient of the PFS, detected 47 pCi/L Sr-90 in both April and October 2008. As noted on **Figure 3.2.15-5**, this is a slight decrease from the 2007 data. See **Section 4.11** for further discussion.
- The highest Sr-90 concentration in the PFS plume was 42 pCi/L in core well 075-683, located just south of Cornell Avenue. This well was installed in 2007. This plume is not addressed by active pumping, but will naturally attenuate to below the DWS.
- Plume core wells 075-193, 075-194, 075-674, and 075-675 are located on the south side of Cornell Avenue, and monitor the western perimeter of the leading edge of the plume. The highest 2008 Sr-90 concentration in these wells was 5 pCi/L in well 075-674 during October.

3.2.15.4 System Operations

In accordance with the SPDES equivalency permit, the required frequency for Sr-90 and VOC sampling is monthly and the pH measurement is weekly. However, samples from the influent, effluent, and midpoint locations of the treatment system were collected twice a month throughout 2008 in order to optimize resin usage. All system samples were analyzed for Sr-90 and VOCs. The influent was also analyzed for tritium, and both the influent and effluent were analyzed weekly for pH. Sr-90 concentrations for the extraction wells in 2008 are summarized on **Table F-41** (**Appendix F**). System influent and effluent concentrations are summarized on **Tables F-42** and **F-43**. **Table F-44** contains the monthly Sr-90 removal totals for the system.

Operation details are given in the O&M manual for this system (BNL 2005d). Below is a summary of the system operations for 2008.

January – September 2008

Well SR-1 was off from January to May and well SR-3 was off February through April due to electrical and mechanical problems. The entire system was off from August 11 to 26 due to damage from a lightning strike. A resin vessel change-out was performed from July 11 to August 6, during which time the system was down. A second resin change-out was performed in February 2008.

October – December 2008

The treatment system ran normally for the entire period.

Extraction Well Operational Data

During 2008, approximately 8.5 million gallons were pumped and recharged by the OU III BGRR/WCF SR-90 Treatment Systems, with an average flow rate of 16 gpm. **Table 3.2.15-3** shows the monthly extraction well pumping rates while **Table F-41** shows Sr-90 concentrations.

3.2.15.5 System Operational Data

During 2008, influent concentrations of Sr-90 ranged from 26 to 137 pCi/L, with the highest concentration observed in January. The highest influent tritium concentration during 2008 was 324 pCi/L in April. During 2008, Sr-90 was detected once in the effluent samples, at a concentration of 1.7 pCi/L in January. This detection was below the limit of 8.0 pCi/L (**Table 3.2.15-2**). There were no VOCs detected above the SPDES Equivalency Permit discharge limits in the 2008 influent or effluent samples. During 2008, approximately 8.8 million gallons of groundwater were processed through the system.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 influent concentrations, to calculate the number of milliCuries (mCi) removed. During 2008, the flow averaged 17 gpm. Approximately 2.7 mCi of Sr-90 was removed during 2008, for a total of 16.9 mCi removed since system start-up in 2005 (**Figure 3.2.15-6**). Cumulative mass removal of Sr-90 is shown on **Figure 3.2.15-7**.

Table 3.2.15-2
BGRR Sr-90 Treatment System
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range	5.5–8.5 SU	5.8–7.7 SU
Sr-90	8.0 pCi/L	1.69
Chloroform	7.0 µg/L	<0.5
1,1,1-Trichloroethane	5.0 µg/L	<0.5

Notes:
ND = Not detected above minimum detectable activity.
SU = Standard Units
Required sampling frequency is monthly for Sr-90 and VOCs, and weekly for pH.

Extraction Wells

Maximum Sr-90 concentrations in each of the extraction wells during 2008 were as follows:

- SR-1 113 pCi/L in January
- SR-2 146 pCi/L in October
- SR-3 269 pCi/L in January
- SR-4 23 pCi/L in January
- SR-5 116 pCi/L in January

During 2008, no VOCs were detected above the drinking water standard in the extraction wells. **Figure 3.2.15-6** shows the influent Sr-90 concentrations for individual extraction wells over time.

3.2.15.6 System Evaluation

The OU III BGRR/WCF Strontium-90 Pump and Treat System and 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?

WCF Plume: No. There were no unusual or unexpected concentrations in the monitoring wells associated with this program during 2008.

BGRR Plume: No.

PFS Plume: No.

2. Has the plume been controlled?

WCF Plume: No. Based on the monitoring well data, the area of high Sr-90 contamination near the WCF is controlled and captured by extraction wells SR-1 and SR-2. However, based on the additional temporary well data collected in the vicinity of the HFBR in 2007 through early 2009, there are high Sr-90 concentrations that are not actively controlled. Preliminary groundwater modeling of the recent data indicates that if left untreated, the OU III ESD cleanup objective of meeting the DWS by 2070 would not be met.

BGRR Plume: Yes. Based on the monitoring well data, the high concentration portion of the plume is being captured by extraction wells SR-3, SR-4, and SR-5.

PFS Plume: Yes. Based on the monitoring well data, the high concentration portion of the plume is expected to attenuate to below DWS.

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

WCF Plume: The hydraulic capture performance of the system is operating as modeled in the system design. The system has been removing Sr-90 from the aquifer and the resin is effectively treating the Sr-90 to below MCLs. However, based on current model projections on the long-term restoration of the aquifer, the elevated Sr-90 concentrations identified just north of the HFBR indicate that the ESD cleanup objective of meeting DWS by 2070 may not be met. Additional extraction wells will be necessary to reduce the high concentration slug (identified as part of the recent characterization effort) to levels that will attenuate in accordance with the cleanup goal. A complication to addressing the high concentration slug is that it is co-located with tritium from the g-2 plume, well in excess of the DWS. This will not permit for pumping of the Sr-90 high concentration slug for the next six months to a year. The g-2 tritium slug has been well defined, and is moving in the aquifer at a rate five to 10 times faster than Sr-90. Once the tritium slug has moved south of this area it will be possible to pump and treat this segment of the plume.

BGRR Plume: The hydraulic capture performance of the system is operating as modeled in the system design, and the system has been removing Sr-90 from the aquifer. The resin is effectively treating the Sr-90 to below DWS. The ESD objectives are expected to be met.

PFS Plume: Based on the Sr-90 concentrations detected in 2008, the plume it is attenuating as projected.

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

WCF Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met. However, the system is minimizing plume growth of the higher concentrations of Sr-90 near the WCF. Based on the temporary well data from 2007 through March 2009, the OU III cleanup goal will not be met if the high concentration areas of the plume near the HFBR are not actively addressed.

BGRR Plume: No. The cleanup goal of achieving the DWS in the aquifer has not been met, but the system is preventing and minimizing plume growth of the higher concentrations of Sr-90.

PFS Plume: No. The cleanup goal of meeting the DWS in the aquifer has not yet been met. The plume is not being actively remediated.

3.2.15.7 Recommendations

The following are recommendations for the BGRR/WCF Groundwater Treatment System and Monitoring Program:

- Perform groundwater modeling for modifying the system to address the high concentration Sr-90 area in the vicinity of the HFBR. Utilize the fourth-quarter 2008 permanent and temporary well data and the first-quarter 2009 temporary well data for model initialization. Determine the number and placement of extraction wells necessary to remediate this area and reduce Sr-90 concentrations to levels that will allow for achievement of OU III ROD cleanup goals.
- Install additional extraction wells to address the Sr-90 hot spot identified in the WCF plume. The modification to the existing Sr-90 treatment system will consist of several new extraction wells. The location and exact number of wells will depend on the distribution of the hot spot following the departure/attenuation of the g-2 tritium slug from this area. It is currently estimated that the modification will be implemented in 2010.
- For the BGRR Sr-90 plume, install temporary wells near 075-670 and 075-671 to determine the width of the downgradient portion of the plume.
- Install a temporary well adjacent to monitoring well 075-664 to determine if a permanent well screened at a shallower depth is necessary at this location.
- Eliminate sampling at monitoring wells 065-11 and 065-177. These wells are significantly outside of the current plume position and have not detected more than trace levels of Sr-90 over a number of years.
- Install a temporary well approximately 75 feet north of monitoring well 075-86 at the corner of Cornell Avenue to characterize the centerline of the PFS plume.

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3.2.16 Chemical/Animal Holes Strontium-90 Treatment System

This section summarizes the operational data from the OU III Chemical/Animal Holes Strontium-90 Treatment System for 2008, and gives conclusions and recommendations for future operation. This system began operation in February 2003.

3.2.16.1 System Description

The Chemical/Animal Holes were located in the south-central portion of the BNL property (**Figure 1-1 and 3.2.16-1**). The area consisted of 55 pits east of the Former Landfill that were used for the disposal of a variety of laboratory chemicals and animal remains. The buried waste was excavated in 1997.

Following the excavation, a Sr-90 plume was characterized. As discussed in the *2006 Groundwater Status Report*, 17 temporary wells were installed between April 2006 and February 2007 to collect additional data as a result of increasing Sr-90 concentrations downgradient of EW-1. In addition, as discussed below and based on the recommendations of the *2007 Groundwater Status Report*, eight temporary wells were installed in the upgradient portion of the plume in 2008. Based on the data from the temporary and program monitoring wells, the plume (as defined by the 8 pCi/L isocontour) is now approximately 700 feet long and 65 feet wide, with a maximum thickness of 15 feet. It is approximately 22 to 45 feet below ground surface. To date, the highest Sr-90 concentration observed in groundwater in this area was 4,720 pCi/L at well 106-99 in March 2005. The areas of higher concentrations (>100 pCi/L) occur in very narrow bands. The first is an area at and immediately upgradient of EW-1. The second area, approximately 20 feet wide, begins just south of the Princeton Avenue firebreak and continues south for approximately 250 feet just upgradient of EW-3 (**Figure 3.2.16-1).**

The elements of the Sr-90 remediation at the Chemical/Animal Holes are:

1. Three extraction wells pumping into an ion exchange treatment system to remove Sr-90 from the extracted groundwater, and on-site discharge of the clean water into two drywells. Extraction wells EW-2 and EW-3 became operational in November 2007. Extraction Well EW-1 is now in a pulse-pumping phase and run on a one-month-on/one-month off schedule.
2. Operation of the system to minimize plume growth and meet DWS within 40 years.
3. Continued monitoring and evaluation of the data to ensure protectiveness.

Details of operations are provided in the *Chemical/Animal Holes Strontium-90 Groundwater Treatment System Operation and Maintenance Manual* (BNL 2008d). This manual was updated to reflect the additional extraction wells (EW-2 and EW-3).

3.2.16.2 Groundwater Monitoring

Well Network

As recommended in the *2007 Groundwater Status Report*, monitoring wells 106-20, 106-21, 106-43, 106-44, 106-45, and 106-64, located significantly west of the Chemical/Animal Holes plume, were transferred to the Former Landfill groundwater monitoring program in 2008. The data for these wells are discussed in the annual *2008 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2009b). With the transfer of the six wells, the Chemical/Animal Holes monitoring network now consists of 35 wells. **Figure 1-2** shows the monitoring well locations.

Sampling Frequency and Analysis

The monitoring wells are sampled in accordance with the O&M phase (semiannual and annual) frequency. As recommended in the *2007 Groundwater Status Report*, the sampling frequency for the five monitoring wells installed in 2007 was changed from quarterly to semiannually. Also, the sampling frequency for well 106-99 changed from annual to semiannual. Fourteen of the 35 monitoring wells were sampled semiannually for Sr-90; the remaining wells were sampled annually. As recommended in the *2007 Groundwater Status Report*, VOC analysis was dropped from the monitoring program starting in the fourth quarter of 2008 since VOCs have not been detected above the DWS since 2004.

3.2.16.3 Monitoring Well Results

Figure 3.2.16-1 shows the Sr-90 plume distribution. The plume depiction is derived from the fourth quarter monitoring well data and supplemented with the eight temporary wells.

A summary of key monitoring well data for 2008 follows.

- The highest Sr-90 concentration observed in 2008 was 859 pCi/L in plume core well 106-16. This well is approximately 50 feet upgradient of EW-1 and began to rebound in late 2006 following two previous years of lower values (<250 pCi/L). However, Sr-90 concentrations in plume core well 106-99, slightly downgradient of 106-16, have remained low over the past three years despite reaching a historical high concentration for the entire plume of 4,720 pCi/L in 2005.
- Plume core wells 106-103 and 106-105, located immediately downgradient of EW-1, only detected up to 4 pCi/L in 2008. This is the first year that a break in the plume downgradient of EW-1 was observed.
- Except for one detection in 2003 (11 pCi/L), SR-90 concentrations in plume perimeter well 106-48 have been below the DWS. However, in 2008 Sr-90 was detected twice above the DWS with a maximum of 32 pCi/L. This resulted in a slight shifting of the western portion of the plume below Princeton Avenue. Plume perimeter well 106-50 continues to bound the plume to the east since it has been below the DWS since 2006.
- Plume core well 106-49, located in the centerline of the plume approximately 170 feet downgradient of extraction well EW-1, detected Sr-90 at 146 pCi/L in January and 42 pCi/L in July 2008. As shown on **Figure 3.2.16-2,** the 2008 data for this well are the lowest since 1999. This indicates that the trailing edge of the high Sr-90 portion of the plume is now moving through the well 106-49 area. This is also supported by the declining trends in upgradient wells 106-103 and 106-105.
- Plume core well 106-125, approximately 100 feet downgradient of well 106-49 and just upgradient of EW-2, is picking up the leading edge of the higher concentration portion of the plume. This well detected 498 pCi/L of Sr-90 in October 2007 and dropped off to 94 pCi/L in July 2008. Plume core well 106-119, located upgradient of the southern-most extraction well EW-3, detected a maximum Sr-90 concentration of 62 pCi/L in July 2008. This is consistent with 2007 data.
- Bypass wells 106-120, 106-121, and 106-122 are approximately 100 feet south of EW-3. The only detection of Sr-90 in these wells in 2007 and 2008 was 1.02 pCi/L in well 106-122 in July 2008.

As noted previously in **Section 3.2.16.1**, eight temporary wells were installed in the upgradient portion of the plume in 2008. These wells were installed to determine if there is a continuing source of Sr-90 contamination upgradient of monitoring well 106-16. The highest Sr-90 concentration in these wells was 190 pCi/L in B-2. The data are presented on **Table 3.2.16-1**. Based on a review of the data, there doesn't appear to be a continuing source, and a permanent monitoring well was not installed.

All monitoring wells in this program were also analyzed annually for VOCs to monitor low-level VOC contamination originating from the Chemical/Animal Holes area. There were no detections of VOCs above the DWS in 2008 in any of the program well. The complete results are in **Appendix C**.

3.2.16.4 System Operations

The Chemical/Animal Holes Strontium-90 Treatment System influent, effluent, and midpoint locations were sampled once a week. These samples were analyzed for Sr-90. In addition, the influent and effluent samples were analyzed for pH on a monthly basis (**Table 3.2.16-2**). The SPDES Equivalency Permit, which expired in January 2008, was renewed in February 2008 and the Sr-90 sampling frequency was changed from weekly to monthly. As per the recommendations in the *2007 Groundwater Status Report*, well EW-1 was placed in a pulse-pumping mode in 2008 on a schedule of one month on and one month off. Sr-90 concentrations for the system influent and effluent in 2008 are summarized on **Tables F-45** and **F-46** in **Appendix F**. **Table F-47** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2008. Details for this system are given in the O&M manual.

Table 3.2.16-2.
OU III Chemical/Animal Holes Sr-90 Treatment System
2008 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range (SU)	5.0–8.5	5.2–7.7
Sr-90 (pCi/L)	8.0	0.786J

Notes:
pCi/L = pico Curies per liter
SU = Standard Units
J = Estimated value
Required sampling frequencies are monthly for Sr-90 and pH.

January – September 2008

For this period the system operated the majority of the time. The system was off from July 7 to 14 and September 23 to 29 due to electrical problems. From January through September, the treatment system pumped a total of 4.4 million gallons of water.

October – December 2008

The system operated normally for this quarter, with the exception of being off for a couple of days in October and December due to electrical problems. The system pumped and treated a total of 1.6 million gallons of water this quarter.

3.2.16.5 System Operational Data

Sr-90 concentrations in EW-2 and EW-3 have decreased as expected since these wells became operational in November 2007. Upon start-up EW-2 detected up to 139 pCi/L of Sr-90, but the Sr-90 concentration has steadily dropped to 20 pCi/L in late 2008. When EW-3 became operational, concentrations were already low at 13 pCi/L, and they remained close to the DWS for 2008. Concentrations of Sr-90 spiked up and down several times in EW-1, but averaged approximately 45 pCi/L for the year. However, in late 2008 a maximum of 86 pCi/L Sr-90 was detected in EW-1. The spikes may be attributable to the pulse pumping. **Figure 3.2.16-3** presents the extraction well influent data over time. The 2008 analytical data show that influent Sr-90 concentrations ranged from 12 to 51 pCi/L. Effluent samples were well below the SPDES equivalency permit level of 8 pCi/L for Sr-90. During 2008, approximately 6 million gallons of groundwater were processed through the system.

Cumulative Mass Removal

Average flow rates for each monitoring period were used, in combination with the Sr-90 concentration, to calculate the number of mCi removed. Flow averaged 11 gpm during 2008. **Table 3.2.16-3** shows the monthly extraction well pumping rates. The cumulative total mass of Sr-90 removed was approximately 0.74 mCi during 2008, with a total of approximately 3.33 mCi removed since 2003 (**Figure 3.2.16-4**).

3.2.16.6 System Evaluation

The Chemical/Animal Holes Treatment System performance can be evaluated based on the four major decisions identified for this system as part of the DQO process.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected Sr-90 concentrations in the monitoring wells or extraction wells associated with the Chemical/Animal Holes Treatment System during 2008.

2. Has the plume been controlled?
The monitoring data indicate that the plume is controlled by the three extraction wells pumping at 6 gpm. Monitoring of the three plume bypass wells will continue to provide verification. The travel time from EW-3 to these wells is approximately three years (**Figure 3.2.16-1**). Based on the eight temporary wells installed in the upgradient portion of the plume, there doesn't appear to be a continuing source of contamination present.

3. *Is the system operating as planned? Specifically, is the aquifer being restored at the planned rate identified in the Explanation of Significant Differences to the OU III Record of Decision?*
The system was designed to meet the ROD and ESD cleanup goal of reaching the MCL by 2040. The original system design was for one extraction well operating for approximately 10 years to actively treat the Sr-90 plume, followed by 30 years of natural attenuation and radioactive decay. Based on increased Sr-90 concentrations identified in monitoring wells further downgradient, two additional extraction wells were installed in 2007 to ensure the cleanup goals would be met. The additional two extraction wells are also expected to operate approximately 10 years.

4. *Have the cleanup goals been met? Can the groundwater treatment system be shut down?*
No. Based on groundwater monitoring data discussed in **Section 3.2.16.3**, significant contamination remains upgradient of extraction wells EW-1, EW-2, and EW-3. If this were left untreated, the cleanup goal of meeting the MCL within 40 years would not be met.

3.2.16.7 Recommendations

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

- Due to the low influent concentrations, continue pulse pumping of EW-1 (one month on, one month off). If concentrations in this extraction well increase significantly, then EW-1 will be put back into full-time operation. Continue to operate extraction wells EW-1, EW-2 and EW-3 between 5 and 7 gpm.
- Maintain the operations and maintenance phase monitoring well sampling frequency started in 2007.
- Drop well 114-01 from the monitoring program since there have been no historical detections of Sr-90 in this well.
- Install temporary wells adjacent to monitoring well 106-48 to determine the extent of the Sr-90 contamination detected in this well. Following review of the temporary well data, a monitoring well may be installed.

3.2.17 HFBR Tritium Pump and Recharge System

In late 1996, tritium was detected in monitoring wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed and the spent fuel pool was drained. In May 1997, a three-well groundwater pump and recharge system was constructed on the Princeton Avenue firebreak road approximately 3,700 feet downgradient of the HFBR to capture tritium and assure that the plume would not move off site. Extracted water was recharged at the RA V recharge basin. Groundwater modeling projected that the tritium plume would attenuate naturally to below DWS (20,000 pCi/L) before reaching the site boundary. The extraction system was placed on standby status in September 2000, as groundwater monitoring data demonstrated that the plume was attenuating to concentrations well below DWS in the vicinity of the Pump and Recharge System.

As described in the OU III ROD, the selected remedy to address the HFBR tritium plume included implementing monitoring and low-flow extraction programs to prevent or minimize the plume's growth. Beginning in June 2000 and ending April 2001, 20 low-flow extraction events removed 95,000 gallons of tritiated water with concentrations greater than 750,000 pCi/L. This water was sent off-site for disposal.

The OU III ROD contingencies are defined as either a detection of tritium above 25,000 pCi/L in monitoring wells at the Chilled Water Facility Road, or above 20,000 pCi/L in monitoring wells along Weaver Drive. The OU III ROD contingency of exceeding 20,000 pCi/L at Weaver Drive was triggered with a detection of 21,000 pCi/L in GP-297 in November 2006. In 2007, new extraction well EW-16 was installed to supplement the three existing extraction wells and the system was restarted in November 2007 as per the ROD contingency.

Groundwater flow in the vicinity of the HFBR is primarily to the south (**Figures 2-2** and **2-3**). Evaluation of groundwater flow and quality data indicates that the downgradient portion of the tritium plume (south of Brookhaven Avenue) has shifted east since 1997 in response to decreased cooling water discharges to the HO recharge basin and the OU III recharge basin. The eastward shift is also demonstrated by observing the sharp declines in tritium concentration for monitoring wells 075-294, 075-418, 085-287, and 085-78 shown on **Figure 3.2.17-3**.

3.2.17.1 System Description

As a result of the implementation of the ROD contingency described above, operation of the system resumed in November 2007 and included the pumping of wells EW-16 and EW-11. Extraction well EW-16 was installed approximately 400 feet north of the existing pump and recharge wells located on Princeton Avenue (**Figure 3.2.17-1**). Extraction wells EW-9, EW-10, and EW-11 are being sampled quarterly and EW-16 is being sampled at a weekly frequency. A pre-startup sample obtained on November 28, 2007 showed tritium at 6,580 pCi/L. Since that time, the tritium concentrations in EW-16 have ranged from 970 to 2,950 pCi/L.

For a complete description of the HFBR Tritium Pump and Recharge System, see the *Operations and Maintenance Plan for the High Flux Beam Reactor Tritium Plume Pump and Recharge System* (BNL 2009c).

3.2.17.2 Groundwater Monitoring

Well Network

A monitoring well network of 116 wells is used to evaluate the extent of the plume, monitor the source area, and verify the predicted attenuation of the plume (**Figure 1-2**). The permanent monitoring well network is being supplemented with a semiannual temporary well characterization. A total of 37 temporary wells were installed and sampled in April 2008 to the first quarter of 2009. Eighteen temporary wells were installed between January 14 and March 25, 2008, four were installed between April 29 and May 19, 2008, and fifteen were installed between December 8, 2008 and March 17, 2009 (**Figure 3.2.17-1** and **Table 3.2.17-1)**. In 2008, a total of six wells were abandoned in preparation for NSLS-II Facility construction activities . Due to the eastward shift of the plume over the past 5 to 10 years, the abandoned wells are all currently located outside of the core of the plume. The loss of these wells should have no impact on the effectiveness of the groundwater monitoring program, as these areas are supplemented with temporary wells as needed.

Sampling Frequency and Analysis

Sampling details for the well network are provided on **Table 1-5**. Select wells are also analyzed for VOCs as part of the Carbon Tetrachloride and Middle Road programs.

3.2.17.3 Monitoring Well Data

The extent of the tritium plume is shown on **Figure 3.2.17-1**. This figure summarizes data collected from monitoring wells during the fourth quarter of 2008, supplemented with data obtained from 15 temporary wells installed from December 2008 through March 2009. The temporary wells were installed to fill in data gaps along key segments of the plume. Specifically, the temporary wells were installed on Temple Place and along four transects from the area immediately north of EW-16 to approximately 1,000 feet north where the high concentration segment of the plume is currently located (**Figure 3.2.17-1**). **Appendix C** contains the complete set of monitoring well data. Data from temporary wells installed from April 2008 through March 2009 are summarized on **Table 3.2.17-1**. A north–south cross-sectional view of the plume centerline is shown on **Figure 3.2.17-2**. Tritium concentration trends for key monitoring wells are shown on **Figure 3.2.17-3**.

Background

Samples are collected from a network of seven monitoring wells north of the HFBR. These wells serve as early detection points if groundwater flow shifts to a more northerly direction and toward supply wells 10, 11, and 12. Groundwater flow during 2008 was consistently to the south. Supply well 10 was not operated during 2008, while wells 11 and 12 provided approximately 10% of the lab's water supply. The g-2 plume is present in the vicinity of the HFBR, approximately 10 to 20 feet deeper than the HFBR plume. A characterization of the downgradient extent of the g-2 tritium plume was conducted again in 2008 and is summarized in **Section 4.2**.

HFBR to Brookhaven Avenue

Tritium concentrations directly downgradient from the HFBR have been observed to correlate with peak water-table elevations in response to water-table flushing of the unsaturated zone beneath the HFBR. There has been a steady decline in water-table elevations since the middle of 2007, which has minimized water-table flushing beneath the HFBR during that time, and is at least partially contributing to the declining tritium trends over the same period (**Figure 3.2.17-4)**. Based on the current trend, it is anticipated that peak tritium concentrations in these wells will be less than the 20,000 pCi/L DWS within the next several years.

The peak tritium concentration in this area was 103,000 pCi/L in well 075-240 (located on Cornell Avenue) in June 2008 (**Figure 3.2.17-5**). The tritium concentrations in this well declined to 2,490 pCi/L by December of 2008. The peak tritium concentration in this area was 200,000 pCi/L in well 075-240 during 2007. Decreasing tritium concentrations in this area were expected based on the declining water-table elevation from late 2007 through 2008. The HFBR tritium plume as depicted on **Figure 3.2.17-1** now consists of several discontinuous segments. The segment south of Temple Place is the result of periodic flushing of the remaining tritium inventory in the unsaturated zone beneath the HFBR.

Brookhaven Avenue to Weaver Drive

The monitoring well network in this area was supplemented with six temporary wells during 2008/2009. The plume in this area has become discontinuous as defined by the 20,000 pCi/L contour. There is now a break of approximately 500 feet in length to the north and south of Brookhaven Avenue and another east of the Chilled Water Facility (**Figure 3.2.17-1)**. These breaks were created by the intermittent nature of tritium flushing in the vadose zone beneath the HFBR over the past several years.

In the first quarter of 2009, the highest concentration segment of the HFBR tritium plume was located between the Chilled Water Facility Road and Weaver Drive. The highest tritium concentration detected during 2008 was 113,000 pCi/L in temporary well GP-282 in January 2008. The concentration at this location in December 2008 was 18,900 pCi/L. The leading edge of the higher concentration slug should be approaching the Weaver Drive area. Wells in this area are scheduled for sampling again in July 2009. The trailing edge of the high concentration downgradient slug is now south of the Chilled Water Facility Road area based on the tritium concentrations in that area decreasing to less than 20,000 pCi/L during the latest sampling round.

Weaver Drive to Princeton Avenue Firebreak Road

During 2008 and the first quarter of 2009, 11 temporary wells were installed in this area to supplement the monitoring well network. The highest detection observed south of Weaver Drive was 82,300 pCi/L in GP-349 in March 2008. The concentration at this location decreased to 3,700 pCi/L in January 2009. Temporary well GP-340, located approximately 100 feet north of EW-16, detected 10,000 pCi/L in March 2008. First-quarter 2009 data from temporary wells GP-340 (17,600 pCi/L), GP-338 (23,200 pCi/L), and permanent well 096-117 (27,800 pCi/L), located immediately north of EW-16, indicate that the leading edge of the plume, as defined by concentrations greater than 20,000 pCi/L, is approaching this vicinity. EW-16 is being sampled on a weekly basis, and concentrations to date have shown a slight increase with a maximum tritium concentration of 2,950 pCi/L in 2008. Tritium has not been detected in perimeter monitoring well 096-118, located approximately 200 feet east of EW-16, which confirms that the plume is within the capture zone of the extraction well. **Table F-48** (**Appendix F**) presents the VOC and tritium detections in the extraction wells for 2008.

3.2.17.4 System Operations

Extraction wells EW-9, EW-10, and EW-11 were sampled quarterly, whereas EW-16 was sampled quarterly for VOCs and weekly for tritium in 2008. The influent, midpoint, and effluent of the carbon units were sampled twice per month, along with weekly pH readings. These samples were analyzed for VOCs and tritium. However, the weekly EW-16 sample was only analyzed for tritium. Extraction wells EW-11 and EW-16 are in full-time operation, while EW-9 and EW-10 are in standby mode. **Table 3.2.17-2** shows the 2008 SPDES parameter levels.

The following is a summary of the OU III HFBR Tritium System operations for 2008:

January – September 2008

The system operated normally during this period, with some down time in January due to routine testing and maintenance while flow rates were being set. Normal down time was experienced due to scheduled maintenance and alarm testing. During the first three quarters of 2008 approximately 61 million gallons of groundwater were pumped and recharged.

Table 3.2.17-2
OU III HFBR Tritium System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–8.5 SU	5.6-7.4 SU
Carbon tetrachloride	5	ND
Chloroform	7	ND
1,1-Dichloroethane	5	ND
1,2-Dichloroethane	0.6	ND
1,1-Dichloroethene	5	ND
Cis-1,2-Dichloroethylene	5	ND
Trans-1,2-Dichloroethylene	5	ND
Tetrachloroethylene	5	ND
1,1,1-Trichloroethane	5	ND
Trichloroethylene	5	ND

Note:
ND = Not detected above method detection limit of 0.50 µg/L.
SU = Standard Units

October – December 2008

The system operated normally during the last quarter of 2008 with some down time due to NSLS-II electrical construction activities. Approximately 24 million gallons of groundwater were pumped and recharged.

Extraction Well Operational Data

During 2008, approximately 86 million gallons of groundwater were pumped and recharged by the OU III HFBR Tritium System, with an average flow rate of 163 gpm. **Table 3.2.17-3** shows the monthly extraction well pumping rates while **Table F-48** (**Appendix F**) shows VOC and tritium concentrations.

3.2.17.5 System Evaluation

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

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unusual or unexpected concentrations of contaminants observed in the monitoring wells or the extraction wells associated with the HFBR Tritium Pump and Recharge System during 2008. EW-16 was installed and the Pump and Recharge system restarted in November 2007 in response to triggering the ROD contingency of 20,000 pCi/L at Weaver Drive in 2006.

2. Is the tritium plume growing?

No. Based on the position of the 20,000 pCi/L isocontour line, the high concentration segment of the plume has migrated to EW-16, which is positioned to capture the plume. See **Figure 3.2.17-6** for the plume distribution comparison between 1997 and 2008.

3. Are observed conditions consistent with the attenuation model?

Yes. The BNL HFBR groundwater model 2003 update predicted that the remnants of the hot spot would reach Weaver Drive in late 2005 (approximately) at concentrations between 30,000 and 60,000 pCi/L. Observed conditions with respect to both tritium concentrations and hot-spot position matched the model predictions reasonably well. The observed concentration of 82,300 pCi/L between Weaver Drive and EW-16 in 2008 is slightly higher than the model predicted concentration (30,000 – 60,000 pCi/L), but within an acceptable error range for a 5-year prediction.

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

No. Groundwater flow from this area was to the south during 2008 (**Figure 2-2**).

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

No. The plume is monitored by a combination of permanent wells supplemented with temporary wells, where necessary, to ensure that the plume extent is characterized.

3.2.17.6 Recommendations

The following are recommendations for the HFBR Tritium Pump and Recharge System and monitoring program:

- Reduce the sampling frequency for 11 wells along Cornell Avenue (075-225, 075-228, 075-231, 075-234, 075-237, 075-240, 075-244, 075-42, 075-43, 075-44, and 075-45) from monthly to quarterly. The sampling frequency for these wells was increased during the fall of 2006 in response to a water leak in the HFBR building. There is no need to continue data collection at a monthly frequency as this leak has had no impact on groundwater.

- Reduce the sampling frequency for tritium for a number of wells as noted on **Table 5-1**. It is now well documented that these wells are outside the plume perimeter and, in most cases, there is another well located between these wells and the plume.
- Continue to install and sample temporary wells twice per year over the next several years to characterize the location of the high tritium concentration area approaching EW-16. Results will be communicated to the regulators via the IAG conference call and quarterly/annual reports.
- Continue operating EW-16 and EW-11 in 2009. Monitor tritium concentrations in EW-16 on a weekly basis.
- The pump and recharge well(s) will be operated until the tritium concentrations from Weaver Drive to EW-16 drop below 20,000 pCi/L. The estimated operational duration of 2 to 4 years (2011 to 2013) is based on the length of the high concentration area slug and the time it would take to be completely captured by EW-16. The decision to turn the wells back to standby will be based on:
    - concentrations of tritium decreasing to less than 20,000 pCi/L in the monitoring wells at Weaver Drive as well as the extraction wells, and
    - verification that the new extraction well has captured concentrations of tritium in this area greater than 20,000 pCi/L. A decision to turn the wells back to standby will be supported with data from additional permanent and temporary wells, as needed.

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3.3 OPERABLE UNIT IV

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

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

A *Five-Year Review Report for OU IV* was submitted to the regulators in June 2002. A final report was approved in September 2003. This report included changes to the continued groundwater monitoring program.

3.3.1.1 Groundwater Monitoring

Well Network

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

Monitoring wells 076-18 and 076-19 continue to be monitored under the BNL Facility Monitoring Program for the Central Steam Facility. The remaining monitoring wells were either included under the radionuclide monitoring under the Building 650 and Sump Outfall Strontium-90 Monitoring Program (**Section 3.3.2**) or abandoned as per the final report (BNL 2003b) **(Figure 1-2).**

Sampling Frequency and Analysis

As per the *2007 Groundwater Status Report* (BNL 2008b), the sampling frequency for VOCs and SVOCs in these wells was reduced to annually. Since the recommendation was not implemented until the fourth-quarter 2008, more than one sample was collected from each well in 2008.

3.3.1.2 Monitoring Well Results

Post-closure sampling of monitoring wells was conducted for 2008. The complete groundwater data are given in **Appendix C**. There were no detections of SVOCs above reporting limits in any of the samples collected. Well 076-06 had detections of 7 µg/L 1,2,4-trimethylbenzene and 6 µg/L 1,3,5-trimethylbenzene in the January sampling event. These are above the NYS AWQS of 5 µg/L for each of these compounds. Two subsequent sampling events showed concentrations below 1 µg/L for these analytes. Well 076-185 had detections of 10 µg/L cis-1,2-dichloroethylene and 9.1 µg/L tetrachloroethylene in the October 2008 sampling round. These are above the NYS AWQS of 5 µg/L for each of these compounds. This contamination most probably originated from spills at the Central Steam Facility.

3.3.1.3 Post-Closure Monitoring Evaluation

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

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

No. There were no unexpected VOC concentrations in groundwater during 2008.

3.3.1.4 Recommendation

The following is recommended for the OU IV AS/SVE Post Closure Monitoring program:

- Collect a sample from well 076-185 for VOC analyses during the second-quarter 2009 to confirm the detections of cis-1,2-dichloroethylene and tetrachloroethylene.

3.3.2 Building 650 and Sump Outfall Strontium-90 Monitoring Program

The Building 650 and Sump Outfall Strontium-90 Monitoring Program monitors a Sr-90 plume emanating from a remediated source area known as the former Building 650 Sump Outfall Area. This former source consisted of a depression at the terminus of a discharge pipe from the building. The pipe conveyed discharges from a concrete pad located approximately 1,200 feet to the west, where radioactively contaminated clothing and equipment were decontaminated beginning in 1959.

Remediation (by excavation) of the contaminated soils associated with the Building 650 sump outfall and removal of the pipe leading to the outfall, as well as soil, concrete, and asphalt associated with the former decontamination pad behind Building 650, were completed in 2002.

3.3.2.1 Groundwater Monitoring

Well Network

The network consists of 29 wells used to monitor the Sr-90 concentrations originating from the former Building 650 sump outfall area (**Figure 1-2**).

Sampling Frequency and Analysis

During 2008, the wells were monitored either annually or semiannually, and the samples were analyzed for Sr-90 (**Table 1-5**).

3.3.2.2 Monitoring Well Results

The complete results of the radionuclide sampling can be found in **Appendix C**. The Sr-90 plume originating from the Building 650 sump outfall continues to migrate slowly southward away from the former sump outfall area. The leading edge of the plume is presently located to the southwest of well 076-24. The trailing edge of the plume appears to be migrating away from the sump outfall area as evidenced by the steadily declining Sr-90 concentrations in well 076-169 over the previous two years (**Figure 3.3.2-1**). During 2008, the highest Sr-90 concentration (19 pCi/L) was detected in well 076-24 in January.

Sr-90 concentrations in well 076-28 are shown on **Figure 3.3.2-2**. This well is immediately north of Building 650, adjacent to the former decontamination pad where contaminated soils were removed in 2002. Fluctuations in Sr-90 concentrations have been observed in this well over the past several years. The Sr-90 data from this well, which dates back to 1997, was compared to water-table elevation data to identify whether the Sr-90 increases may be in response to periodic water table rises that flush out residual Sr-90 residing in the unsaturated zone in the vicinity of the pad/building. This water-table flushing process of contaminants in the vadose zone has been observed in several former source areas across the site, including the HFBR, BGRR, and g-2. Based on an analysis of the data, there does not appear to be a direct correlation between water-table elevation and Sr-90 concentration in this well. Sr-90 concentrations were also compared to available precipitation data over the history of the well with no observable correlation.

3.3.2.3 Groundwater Monitoring Program Evaluation

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

1. Was the BNL Groundwater Contingency Plan triggered?

No. There were no unexpected Sr-90 concentrations detected in groundwater during 2008.

2. Were performance objectives met?

No. The performance objective for this project is to achieve Sr-90 concentrations below the DWS of 8 pCi/L. There were four monitoring wells exceeding this limit in 2008. Therefore, the performance objectives have yet to be achieved. The removal of contaminated soils in 2002 addressed the predominate source of groundwater contamination. The groundwater plume continues to degrade due to natural attenuation (i.e., radioactive decay).

3. If not, are observed conditions consistent with the attenuation model?
Yes. The observed data are consistent with the attenuation model in terms of the extent of Sr-90 contamination.

3.3.2.4 Recommendations

The following recommendations are made for the Building 650 and Sump Outfall Strontium-90 Groundwater Monitoring Program:

- Reduce the sampling frequency for monitoring wells 076-167, 076-183, 076-20, and 076-262 from semiannual to annual. These are all perimeter wells that have not been detecting Sr-90 over the past several years. Eliminate sampling of monitoring wells 076-10, 076-182, 076-264, 076-265, and 076-27. After approximately ten years of monitoring these wells, BNL has established that they are outside of the plume and are no longer providing useful data. The sampling of wells can be resumed and sampling frequencies increased if warranted by future changes in groundwater flow conditions.
- Install two to three temporary wells approximately 150 feet south of monitoring well 076-24 to a depth of 60 feet bls. The data will help in characterizing the leading edge of the plume and the width of the plume in this area. A permanent monitoring well may be installed pending the results.

3.4 OPERABLE UNIT V

3.4.1 Sewage Treatment Plant Monitoring Program

The Sewage Treatment Plant (STP) processes sanitary wastewater from BNL's research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit. Historically, BNL's STP received discharges of contaminants from routine operations. Releases of low-level contaminants to groundwater (in particular, VOCs, metals, and radionuclides) occurred via the STP sand filter beds and discharges to the Peconic River. The OU V project monitors the identified groundwater contamination downgradient of the STP. Groundwater quality in the immediate vicinity of the STP is being monitored under the Facility Monitoring Program, which is discussed in **Section 4.6** of this document.

3.4.2 Groundwater Monitoring

Well Locations

A network of 34 monitoring wells was designed to track groundwater contamination downgradient of the STP, at the site boundary, and off site (**Figure 1-2**).

Sampling Frequency and Analysis

All 34 wells are sampled annually for VOCs and tritium, and eight wells are sampled for perchlorate as per **Table 1-5**. As recommended in the *2007 Groundwater Status Report* (BNL 2008b), due to low concentrations of perchlorate being detected, the frequency of this analysis for the eight monitoring wells was reduced from semiannual to annual.

3.4.3 Monitoring Well Results

The OU V wells were sampled once during 2008. **Appendix C** contains the complete data. The VOC plume extends from south and east of the STP to the vicinity of the Long Island Expressway (**Figure 3.4-1**). During 2008, the highest TVOC concentration was 7 µg/L in well 061-05, located along the Peconic River in the vicinity of the site boundary. VOC concentrations in on-site plume core wells continued to decline. The TVOC concentrations in off-site plume core well 000-122 have shown a decreasing trend since early 2005 (**Figure 3.4-2)**. It appears that this plume has reached an equilibrium state in the aquifer with the leading edge attenuating in the vicinity of 000-122. There were no individual VOCs detected at levels exceeding NYS AWQS. There have been no significant changes to the VOC plume over the past several years, other than the gradual decline in concentrations (**Figure 3.4-2**). A comparison of the plume from 1997 to 2008 is shown on **Figure 3.4-3**.

In August 2004, the 34 OU V monitoring wells were sampled and analyzed for perchlorate in response to a request from the SCDHS. In June of that year, perchlorate had been detected in SCDHS monitoring well EG-A (off site and east of BNL) in a sample from the deep section of the Upper Glacial aquifer. Perchlorate was detected during the August 2004 sampling event in four of the 34 BNL wells (049-06, 050-02, 061-04, and 061-05), with concentrations ranging between 5.0 and 12.7 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L. The EPA published a Drinking Water Equivalent Level for perchlorate of 24.5 µg/L in January 2006. However, in December 2008 EPA established an Interim Drinking Water Health Advisory for perchlorate of 15 µg/L.

Since 2004, BNL has been monitoring eight of the monitoring wells for perchlorate (000-122, 000-123, 049-05, 049-06, 050-01, 050-02, 061-04, and 061-05). During 2008, the wells were analyzed for perchlorate during the third quarter sampling round. The compound was detected in wells 049-06, 061-04 and 061-05, which monitor the deep portion of the Upper Glacial aquifer. Well 049-06 is near the eastern firebreak road and wells 061-04 and 061-05 are at the eastern site boundary. The maximum perchlorate concentration was 5.4 µg/L detected in well 061-05. This concentration is significantly below the NYSDOH action level. The same eight OU V wells will be sampled for perchlorate again in 2009.

Tritium has historically been detected at low concentrations in monitoring wells 049-06, 050-02, and 061-05. During 2008, the maximum tritium concentration detected was 1,060 pCi/L in well 049-06; this is approximately one-twentieth the DWS of 20,000 pCi/L. Tritium was not detected in the off-site monitoring wells.

3.4.4 Groundwater Monitoring Program Evaluation

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unexpected contaminant concentrations in groundwater from the OU V Monitoring Program during 2008.

2. Were the performance objectives met?
Yes. The performance objective for this program is to attain NYS AWQS for VOCs in groundwater in the Upper Glacial aquifer within 30 years through monitored natural attenuation. VOCs were below NYS AWQS in the program monitoring wells in 2008.

3. Is the extent of the plume still defined by the existing monitoring well network?
Yes. The leading edge of the plume is in the vicinity of well 000-122 (south of the Long Island Expressway). Currently, two well clusters serve as sentinel wells for this plume along South Street and Wading River Road.

3.4.5 Recommendations

The following recommendation is made for the OU V plume groundwater monitoring program:

- It appears that the OU V VOC plume has largely attenuated. No individual VOC exceeded the NYS AWQS in 2008. It is recommended that the monitoring well network be sampled on an annual basis for one more year. If individual VOC concentrations and tritium remain below NYS AWQS during 2009, BNL may recommend reducing the number of wells being monitored.

3.5 OPERABLE UNIT VI EDB PUMP AND TREAT SYSTEM

The OU VI EDB Program monitors the extent of an ethylene dibromide (EDB) plume in groundwater extending from just south of the Long Island Expressway for approximately 4,000 feet. 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. Currently, only trace levels of EDB are detected on the site property.

3.5.1 System Description

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

3.5.2 Groundwater Monitoring

Well Locations

A network of 30 wells monitor the EDB plume from the former source area in the Biology Department's agricultural fields to locations on private property south of North Street (**Figure 3.5-1**).

Sampling Frequency and Analysis

The OU VI EDB plume monitoring program is in the O&M phase (**Table 1-7**). The sampling frequency for most of the plume core and perimeter wells (**Table 1-5**) is semiannual. As per the recommendation in the *2007 Groundwater Status Report* (BNL 2008b), the sampling frequency for on-site wells 058-02, 089-13, 089-14, 099-06, 099-10, 099-11, 100-12, 100-13, and 100-14 were changed to annual, since there have been no detections of EDB above the federal DWS since mid 2003. Also, the frequency for well 000-498 changed to semiannual (O&M phase). The exception to this was core well 000-178 and bypass detection well 000-508, which remained at a quarterly sampling frequency for the year. The wells are analyzed for EDB according to EPA Method 504. Samples are also analyzed annually for VOCs. Several wells are incorporated into the OU III South Boundary Radionuclide monitoring program and analyzed for tritium annually. The inclusion of these wells allows for radionuclide monitoring across the entire downgradient site boundary (**Table 1-5**).

3.5.3 Monitoring Well Results

Appendix C contains the complete analytical results of the OU VI EDB monitoring well sampling program. The distribution of the EDB plume is shown for the fourth quarter of 2008 (**Figure 3.5-1**). The leading edge of the plume is being captured by extraction wells EW-1E and EW-2E. The plume is located in the deep Upper Glacial aquifer and is generally moving horizontally, as depicted on cross section M–M' (**Figure 3.5-2)**. A summary of key monitoring well data for 2008 follows:

- During 2008, the highest EDB concentration observed in the plume was 1.5 µg/L in core well 000-283. The 2007 maximum concentration in the plume was 2.3 µg/L in well 000-283. As seen in trend **Figure 3.5-3**, the EDB concentrations in wells 000-283 and 000-284 have been declining over the past several years. The federal DWS for EDB is 0.05 µg/L.
- The trailing edge of the EDB plume is moving south, as evidenced by the reduction in concentrations over the past several years in upgradient plume core wells 000-110, 000-175, and 000-209.

- Well 000-178, installed in 1998, is upgradient of EW-2E. As shown on **Figure 3.5-3**, increased EDB values have been detected in this well since late 2006, indicating movement of the plume south.
- Plume perimeter well 000-500, installed in 2004 in the eastern portion of the plume, has shown increased EDB levels to above the DWS since 2007. The maximum EDB detection well 000-500 in 2008 was 0.49 µg/L. Prior to this, the last detection that exceeded the DWS in this well was 0.087 µg/L in 2005. This portion of the plume is downgradient of well 000-178 and will be captured by EW-2E.
- Core well 000-507 has detected gradually increasing levels of EDB above the DWS since it was installed in 2005. This well is immediately upgradient of the extraction wells.
- Plume bypass well 000-508 has not contained any EDB since it was installed in 2004, except for one detection in 2005.
- As recommended in the *2007 Groundwater Status Report*, in March 2009 another plume bypass well was installed east of well 000-508 and slightly deeper, to verify that EDB is being captured by extraction well EW-2E.

As noted above, the southward migration of the plume can be observed by analyzing the trends on **Figure 3.5-3**. Over the past three years, the EDB concentration has increased in well 000-178, indicating that the core of the plume is located between the extraction wells and wells 000-283 and 000-284. Comparing the plume's distribution from 1999 to 2008 (**Figure 3.5-4**), as well as the EDB concentrations in monitoring wells just south of North Street**,** helps to illustrate the southward movement of the plume. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 (in well 000-283) to 1.5 µg/L in 2008 (also in well 000-283).

EDB was the only VOC detected above the MCL in any OU VI well in 2008 (**Appendix C**).

3.5.4 System Operational Data

The extraction wells are currently sampled monthly. In conformance with the SPDES equivalency permit, the sampling frequency for the influent and effluent is also monthly. All OU VI system samples were analyzed for VOCs and EDB, and the effluent sample was analyzed weekly for pH. **Table 3.5-1** provides the effluent limitations for meeting the requirements of the SPDES permit equivalency.

Table 3.5-1
OU VI EDB Pump & Treat System
2008 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Measured Value
pH (range)	5.0 – 8.5 SU	5.6 – 7.9 SU
ethylene dibromide	5.0 µg/L	<0.50 µg/L
chloroform	7.0 µg/L	1.4 µg/L
1,1-dichloroethene	5.0 µg/L	<0.50 µg/L
1,1,1-trichloroethane	5.0 µg/L	<0.50 µg/L

Notes:
Required sampling frequency is monthly for VOCs and weekly for pH.
SU = Standard Units

January – September 2008

The system operated with EW-1E and EW-2E running at 180 and 150 gpm, respectively, for almost this entire period. In June the system was down for part of the month due to a lightning strike. The system was off again from July 24 to 31 due to electrical problems. From January through September approximately 113 million gallons of water were pumped and treated.

October – December 2008

EW-1E was off from November 12 to December 1 for repairs. The system operated normally for the remainder of this period. Approximately 40 million gallons of water were pumped and treated this quarter.

Extraction Wells

During 2008, 153 million gallons were pumped and treated by the OU VI EDB System, with an average flow rate of approximately 330 gpm. **Table 2-3** contains the monthly pumping data for the two extraction wells, and **Table 3.5-2** shows the pumping rates. VOC concentrations for EW-1E (000-503) and EW-2E (000-504) are provided on **Table F-49** in **Appendix F**. Low levels of EDB were detected monthly in extraction well EW-1E during 2008, with a maximum of 0.06µg/L in July. Only two of the detections of EDB in EW-1E (0.054 and 0.06 µg/L) were above the federal DWS of 0.05 µg/L. There were two EDB detections in EW-2E in 2008, with a maximum concentration of 0.14 µg/L. No other VOCs were detected in the extraction wells above the MCLs.

System Influent and Effluent

During 2008, OU VI EDB system discharge parameters were below the regulatory limit specified in the SPDES equivalency permit. Influent and effluent results are reported on **Tables F-50** and **F-51**, respectively. EDB was detected monthly in the influent throughout 2008, with a maximum concentration of 0.042 µg/L.

Cumulative Mass Removal

No cumulative mass calculations were performed, based on the low detections of EDB below the federal DWS in the system influent. Several low-level VOCs not attributable to BNL were detected; the results are potentially due to analytical lab contamination and were all below the DWS.

3.5.5 System Evaluation Data

The OU VI EDB System was designed to capture and remediate the EDB plume as it travels off site south of BNL with the regional groundwater flow. Start-up of the system was initiated in August 2004, and it is planned to run for approximately 10 years. The system is operating as designed; no operating difficulties were experienced beyond normal maintenance, and no permit equivalencies have been exceeded.

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

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

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

<u>2. If not, has the plume been controlled?</u>

Yes. An analysis of data from the plume perimeter and bypass wells shows no detections of EDB above the DWS in 2008 except in perimeter well 000-500, located just upgradient and slightly east of extraction well EW-2E. As noted above, this well had two detections of EDB in 2008, with a maximum of 0.49 µg/L. Extraction well EW-2E is expected to capture this portion of the plume.

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

The hydraulic capture of the system is operating as designed. In 2007 and 2008 EDB was detected in the system influent monthly. These detections were at concentrations just below the federal DWS. Based on the location of the trailing edge of the plume, the aquifer is being restored at the planned rate.

<u>4. Can the groundwater treatment system be shut down?</u>

No, the system has not met all shutdown requirements.

<u>4a. Have asymptotic EDB concentrations been reached in plume core wells?</u>

No. Asymptotic conditions have not yet been achieved.

4b. Are there individual plume core wells above 0.05 µg/L EDB ?
In the fourth quarter of 2008, seven of eight plume core wells had concentrations greater than the 0.05 µg/L federal DWS.

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

4d. Have the groundwater cleanup goals been met? Are MCLs expected to be achieved by 2030?
No. The federal DWS has not been achieved for EDB in plume core wells. It is expected to be achieved by 2030, as required by the OU VI ROD.

3.5.6 Recommendations

The following recommendations are made for the OU VI EDB Pump and Treat System and groundwater monitoring program:

- Maintain routine operations of the treatment system.
- Since there have been no historical detections of EDB above the DWS, except on one occasion for well 000-180 in 2001, sampling of monitoring wells 000-180, 000-285, 058-02, 089-13, 089-14, 099-06, 099-10, and 100-14 will be eliminated.
- For the remainder of the wells, maintain the routine operation and maintenance monitoring frequency.

3.6 SITE BACKGROUND MONITORING

Background water quality has been monitored since 1990. Historically, low levels of VOCs were routinely detected in several background wells that are screened in the deeper portions of the Upper Glacial aquifer.

3.6.1 Groundwater Monitoring

Well Network

The 2008 program included 10 wells in the northwestern portion of the BNL property (**Figure 1-2**). Background quality is defined as the quality of groundwater that is completely unaffected by BNL operations.

Sampling Frequency and Analysis

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

3.6.2 Monitoring Well Results

The complete groundwater analytical data for 2008 are provided in **Appendix C**. There were detections of low levels of several VOCs in the site background wells, all of which were below NYS AWQS. The highest concentration detected was 2.3 μg/L of methyl tertiary-butyl ether 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.

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

No. There were no VOCs detected in site background wells above NYS AWQS during 2008. Based on these results, there is no current impact to BNL groundwater quality from upgradient contaminant sources.

3.6.4 Recommendation

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

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

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

Note:
<MDA = Less than minimum detectable activity

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 2008 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2009a). 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. By the end of 2008, the landfill had been capped for 13 years. Groundwater quality has been slowly improving. The trend in the data suggests that the cap is effective in mitigating contamination. The following is a summary of the results from the samples collected during 2008:

- VOCs, such as benzene and/or chloroethane, continue to be detected in downgradient wells 087-11, 087-23, 088-109, and 088-110 at concentrations above groundwater standards (**Figure 3.2-1**). The maximum chloroethane concentration was 80.8 µg/L in well 088-109. Benzene was detected at a maximum of 3.02 µg/L in well 088-110. TVOC concentrations in these four wells have ranged from 1.5 to 90 µg/L over the past several years indicating that low-level VOCs continue to emanate from the landfill. However, an analysis of the trends of VOCs indicated the concentrations are stable to decreasing.
- Landfill water chemistry parameters and metals evaluated during the year suggest that leachate continues to emanate from the landfill, but at low levels.
- Tritium and Sr-90 continue to be detected in the wells downgradient of the Current Landfill, but at concentrations well below groundwater standards. These concentrations were consistent with those observed in 2007.
- Since 1998, there have been no detections of VOCs, water chemistry parameters, or radionuclides exceeding groundwater standards in wells 087-24, 088-22, and 088-23. These wells are all screened in the mid to deep Upper Glacial aquifer to monitor the vertical extent of contamination from the Current Landfill.
- Although low levels of contaminants continue to be detected, the landfill controls are effective as evidenced by the improving quality of groundwater downgradient of the landfill.

3.7.2 Current Landfill Recommendations

The following recommendations are made for the Current Landfill groundwater monitoring program:

- The sampling frequency for organic and inorganic compounds be reduced from quarterly to semiannual, except for VOCs in wells 088-22 and 088-23. Based on the lack of VOC detections in these wells, the VOC analyses in wells 088-22 and 088-23 should be reduced from semiannual to annual. Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium, and gamma spectroscopy will continue on an annual basis.

3.7.3 Former Landfill Summary

Data show that contaminant concentrations have been decreasing following the capping of the landfill in 1996. Contaminant concentrations downgradient of this landfill were relatively low prior to capping, primarily due to it being approximately 50 years old. The trend in the data suggests that the cap is effective in mitigating the remaining contamination from entering the groundwater. Based on the declining VOC and Sr-90 concentration trends in downgradient wells, it appears that the landfill cap is performing as planned. The following is a summary of the results from the samples collected during 2008:

- The Former Landfill Area is not a significant source of VOC contamination. No VOCs were detected above groundwater standards in 2008. VOC concentrations in the downgradient wells were at or near the method detection limits.
- Landfill-leachate indicators in downgradient wells were detected at concentrations approximating those in the background monitoring wells, indicating that leachate generation is minimal to nonexistent.
- The Former Landfill Area no longer appears to be a source of Sr-90 contamination. Only trace amounts of Sr-90 were detected near the Former Landfill Area (well 097-64). The Sr-90 detected in wells 106-43, 106-44, 106-45, and 106-64 have been decreasing with time and are currently not above groundwater standards.
- The implemented landfill controls are effective, as evidenced by the improving quality of groundwater downgradient of the landfill.

3.7.4 Former Landfill Recommendations

The following recommendations are made for the Former Landfill groundwater monitoring program:

- Based on the lack of detections above background levels, the monitoring frequency of all non-radiological parameters will be reduced from semiannual to annual.
- Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium, and/or gamma spectroscopy will continue.

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4.0 FACILITY MONITORING PROGRAM SUMMARY

During 2008, the Facility Monitoring Program at BNL monitored the groundwater quality at 10 active research and support facilities. New York State operating permits require groundwater monitoring at two support facilities (the Major Petroleum Facility and the Waste Management Facility); the remaining eight research and support facilities are monitored in accordance with DOE Order 450.1, *Environmental Protection Program*. This Order requires the Laboratory 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 uses these data to determine whether current engineered and administrative controls effectively protect groundwater quality and whether additional corrective actions are needed.

During 2008, approximately 240 individual samples were collected from 125 groundwater monitoring wells. BNL also installed 29 temporary wells to supplement the network of permanent monitoring wells. Information on groundwater quality at each of the monitored research and support facilities is described below. **Table 1-6** summarizes the Facility Monitoring Program by project. Complete analytical results from groundwater samples collected in 2008 can be found in **Appendix D**.

4.1 Alternating Gradient Synchrotron (AGS) Complex

The structures that constitute the AGS Complex include the AGS Ring, Linear Accelerator (Linac), Building 912, AGS Booster Beam Stop, 914 Transfer Tunnel, g-2 experimental area, E-20 Catcher, former U-Line Beam Target, and the J-10 Beam Stop. Activated soil has been created near a number of these areas as the result of secondary particles (primarily neutrons) produced at beam targets and beam stops. A number of radionuclides can be produced by the interaction of secondary particles with the soil that surrounds these experimental areas. Once produced in the soils, some of these radionuclides can be leached from the soils by rainwater, and carried to the groundwater. Of the radionuclides formed in the soil, only tritium (half-life = 12.3 years) and sodium-22 (half-life = 2.6 years) are detected in groundwater. Of these two radionuclides, tritium is more easily leached from the activated soils by rainwater and does not bind to soil particles. When tritium enters the water table, it migrates at the same rate as groundwater flow (approximately 0.75 feet per day). Sodium-22 does not leach out of the soil as readily as tritium, and migrates at a slower rate in the aquifer. The drinking water standard (DWS) for tritium is 20,000 pCi/L, and for sodium-22 is 400 pCi/L.

To prevent rainwater from leaching these radionuclides from the soil, impermeable caps have been constructed over many of the soil activation areas. Specifications for evaluating potential impacts to groundwater quality and the need for impermeable caps over beam loss areas are defined in the Standards Based Management System (SBMS) subject area entitled *Accelerator Safety*. BNL uses 56 groundwater monitoring wells to evaluate the impact of current and historical operations at the AGS beam stop and target areas. The locations of permanent monitoring wells are shown on **Figure 4-1**. During 2008, all 56 AGS monitoring wells were used to evaluate groundwater quality within the AGS Complex. The wells are routinely monitored for tritium.

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 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 beam stop and E-20 Catcher areas. As discussed below, tritium concentrations greater than 20,000 pCi/L continue to be detected downgradient of the g-2 (VQ-12 magnet) soil activation area (**Section 4.2**).

Historical surface spills and discharges of solvents to several cesspools and recharge basins near the AGS contaminated the groundwater with VOCs. VOC contaminated groundwater within the AGS complex is monitored under the CERCLA Monitoring Program's Operable Unit III Central Monitoring Program (**Section 3.2.12**).

4.1.1 AGS Building 912

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

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

4.1.1.1 AGS Building 912 Groundwater Monitoring

Well Network

Seventeen shallow Upper Glacial aquifer wells are positioned upgradient and downgradient of Building 912 (**Figure 4-1**). Upgradient wells are positioned to monitor potential tritium contamination from sources such as the g-2 area and the former U-Line experimental area. The downgradient wells are positioned to monitor significant beam stop and target areas in Building 912. Six of the downgradient wells are also used to track a section of the g-2 tritium plume that has migrated underneath Building 912 (**Section 4.2**).

Sampling Frequency and Analysis

During 2008, the six Building 912 wells that are used to track the g-2 tritium plume were sampled two times, whereas the remaining wells were sampled annually. The groundwater samples were analyzed for tritium (**Table 1-6**).

4.1.1.2 AGS Building 912 Monitoring Well Results

Other than low-level tritium contamination that is traceable to the g-2 source area, groundwater monitoring data for 2008 indicate that tritium is not being released from activated soil beneath the experimental floor of Building 912. The g-2 tritium plume has been tracked from the VQ-12 magnet source, beneath a portion of Building 912, to the HFBR facility (**Figure 4-8**). Tritium from this plume was detected in five wells downgradient of Building 912, with a maximum concentration of 16,500 pCi/L found in a sample from well 065-122. As described in **Section 4.2**, remedial actions for the g-2 source area and tritium plume are described in the ROD signed in May 2007 (BNL 2007b).

4.1.1.3 AGS Building 912 Groundwater Monitoring Program Evaluation

As noted above, in areas not impacted by the g-2 tritium plume, only low levels of tritium were detected in the Building 912 area groundwater monitoring wells. These results indicate that the building and associated stormwater management operations are effectively preventing rainwater from infiltrating activated soil below the experimental hall.

4.1.1.4 AGS Building 912 Recommendations

The following is recommended for the AGS Building 912 groundwater monitoring program.

- For 2009, the Building 912 wells used to track the g-2 tritium plume will continue to be sampled semiannually, whereas the remainder of the Building 912 monitoring wells will continue to be sampled annually.

4.1.2 AGS Booster Beam Stop

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

Although internal shielding around the beam stop was designed to keep secondary particle interactions with the soil to very low levels, a landfill-type geomembrane cap was constructed over the original beam stop region to prevent stormwater infiltration into the activated soil. When the beam stop was repositioned to the 6 o'clock region of the Booster, a coated concrete cap was constructed over the new beam stop area to prevent stormwater infiltration.

4.1.2.1 AGS Booster Groundwater Monitoring

Well Network

Two shallow Upper Glacial aquifer monitoring wells (064-51 and 064-52) are used to monitor the Booster beam stop area (**Figure 4-1**).

Sampling Frequency and Analysis

The Booster area wells were sampled one time during 2008, and the samples were analyzed for tritium (**Table 1-6**).

4.1.2.2 AGS Booster Monitoring Well Results

Tritium has not been detected in the Booster area wells since 2002 (**Figure 4-2**).

4.1.2.3 AGS Booster Groundwater Monitoring Program Evaluation

The low levels of tritium detected during 2001 and 2002 near the Booster beam stop were related to a short-term uncovering of activated soil shielding near the former booster beam stop area during the construction of the tunnel leading from the Booster to the NSRL facility. This work, which began in September 1999 and was completed by October 1999, allowed rainwater to infiltrate the low-level tritium activated soil shielding.[1] Tritium has not been detected in the Booster area monitoring wells since 2003.

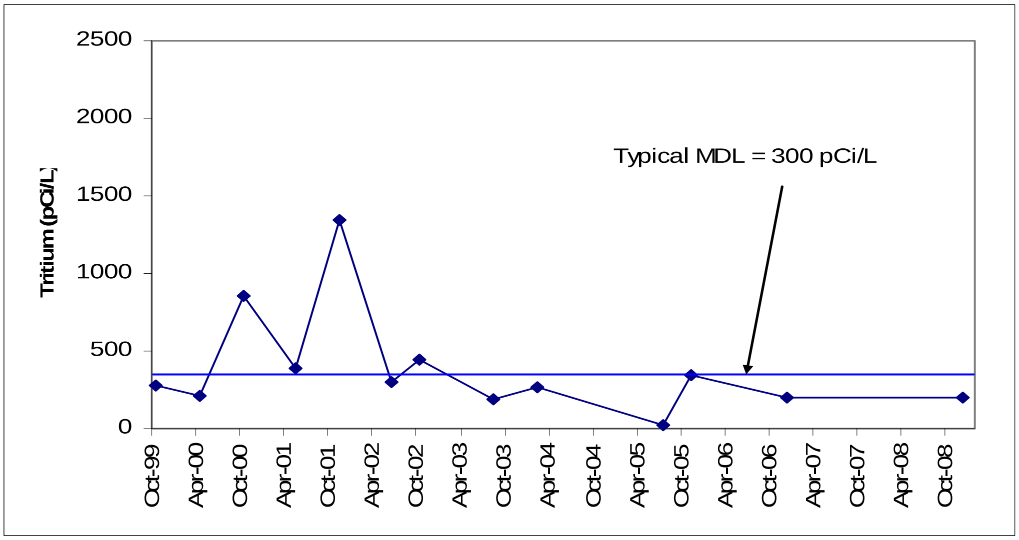
4.1.2.4 AGS Booster Recommendation

The following is recommended for the AGS Booster groundwater monitoring program:

- For 2009, the monitoring frequency for the Booster beam stop monitoring wells will continue to be annually.

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

Figure 4-2.
AGS Booster Beam Stop
Maximum Tritium Concentrations in Downgradient Wells 064-51 and 064-52



4.1.3 NASA Space Radiation Laboratory Facility (NSRL)

The NSRL is jointly managed by the U.S. Department of Energy's Office of Science and NASA's Johnson Space Center. The NSRL employs beams of heavy ions extracted from Brookhaven's Booster accelerator for radiobiology studies. NSRL became operational during summer 2003. Although the secondary particle interactions with the surrounding soil shielding are expected to result in only a minor level of soil activation, geomembrane caps were constructed over the entire length of the beam line and the beam stop region to prevent stormwater infiltration into potentially activated soil.

4.1.3.1 NSRL Groundwater Monitoring

Well Network

This facility is monitored by two shallow Upper Glacial aquifer monitoring wells (054-08 and 054-191) located immediately downgradient of the NSRL (**Figure 4-1**).

Sampling Frequency and Analysis

The NSRL area wells were monitored one time during 2008, and the samples were analyzed for tritium (**Table 1-6**).

4.1.3.2 NSRL Monitoring Well Results

Groundwater monitoring at the NSRL facility began in late 2002. Since that time, tritium has not been detected in any of the groundwater samples.

4.1.3.3 NSRL Groundwater Monitoring Program Evaluation

Based on monitoring conducted to date, NSRL beam line operations have not impacted groundwater quality.

4.1.3.4 NSRL Recommendation

The following is recommended for the NSRL groundwater monitoring program:

- For 2009, the monitoring frequency for the NSRL wells will continue to be annually.

4.1.4 AGS E-20 Beam Catcher

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

Like other beam loss areas in the AGS complex, the soil surrounding the E-20 Catcher became activated by the interaction with secondary particles. In late 1999 and early 2000, tritium and sodium-22 levels in groundwater 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. Tritium and sodium-22 concentrations dropped to below their applicable DWS soon after the cap was installed.

4.1.4.1 AGS E-20 Catcher Groundwater Monitoring

Well Network

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

Sampling Frequency and Analysis

During 2008, the E-20 Catcher wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.4.2 AGS E-20 Catcher Monitoring Well Results

Following the installation of the cap in 2000, tritium and sodium-22 concentrations decreased to levels below applicable DWS (**Figure 4-3**). During 2008, the maximum observed tritium concentration was 430 pCi/L, detected in well 064-80.

4.1.4.3 AGS E-20 Catcher Groundwater Monitoring Program Evaluation

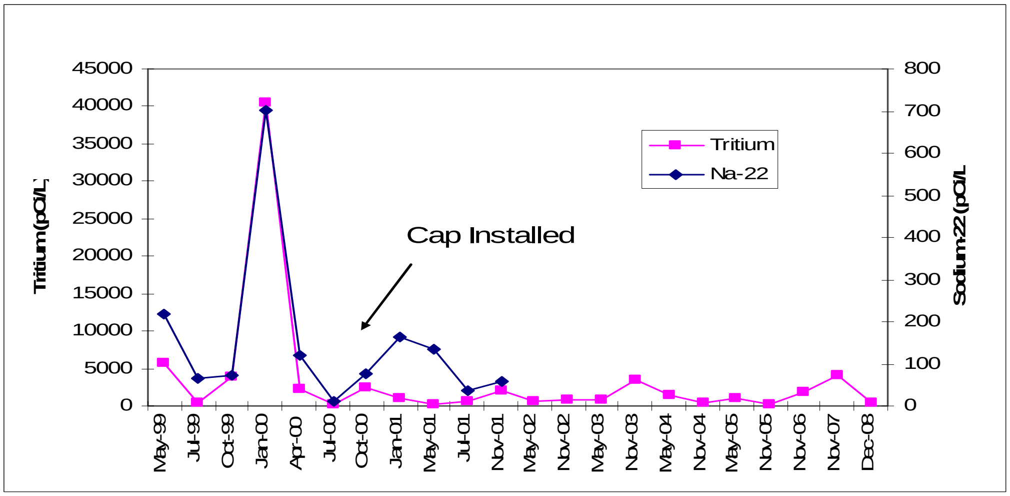
The reduction in tritium concentrations since the impermeable cap was constructed over the E-20 Catcher area in 2000 indicates that the cap has been effective in preventing rainwater infiltration into the activated soil that surrounds this portion of the AGS tunnel.

4.1.4.4 AGS E-20 Catcher Recommendation

The following is recommended for the AGS E-20 Catcher groundwater monitoring program:

- For 2009, the monitoring frequency for the E-20 Catcher wells will continue to be annually.

Figure 4-3.
AGS E-20 Catcher
Maximum Tritium and Sodium-22 Concentrations in Downgradient Temporary and Permanent Monitoring Wells.



4.1.5 AGS Building 914

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

4.1.5.1 AGS Building 914 Groundwater Monitoring

Well Network

Groundwater quality downgradient of the AGS Building 914 transfer line area is monitored by shallow Upper Glacial aquifer wells 064-03, 064-53, and 064-54 (**Figure 4-1**).

Sampling Frequency and Analysis

During 2008, the AGS Building 914 area wells were monitored one time and samples were analyzed for tritium (**Table 1-6**).

4.1.5.2 AGS Building 914 Monitoring Well Results

Low levels of tritium were detected intermittently in groundwater downgradient of the AGS Building 914 transfer tunnel during 2000 through 2005 (**Figure 4-4**). Although tritium was not detected in any of the groundwater samples during 2006 and 2007, in 2008 low-level tritium was once again detected in well 064-03 at a concentration of 620 pCi/L.

4.1.5.3 AGS Building 914 Groundwater Monitoring Program Evaluation

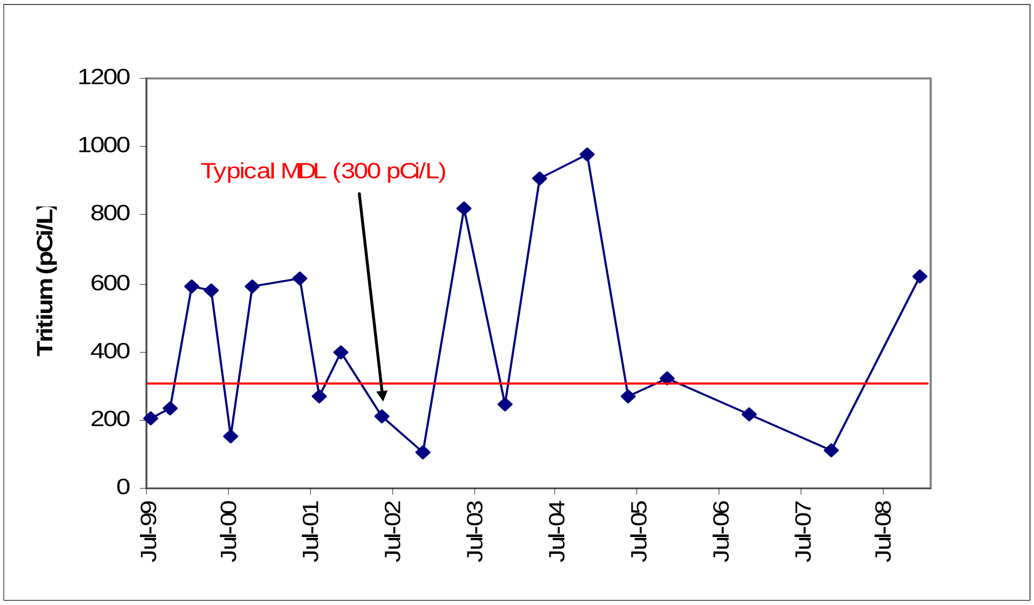
Groundwater monitoring downgradient of AGS Building 914 continues to indicate that the building structure and associated stormwater controls are effectively preventing significant rainwater infiltration into activated soil below the building. However, the periodic detection of trace levels of tritium since 2000 suggests that some rainwater may be infiltrating the activated soil. Continued monitoring is required.

4.1.5.4 AGS Building 914 Recommendation

The following is recommended for the AGS Building 914 groundwater monitoring program:

- For 2009, the monitoring frequency for the AGS Building 914 area wells will continue to be annually.

Figure 4-4.
AGS Building 914 Transfer Tunnel
Maximum Tritium Concentrations in Downgradient Wells 064-03, 064-53, and 064-54



4.1.6 AGS g-2 Beam Stop

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

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

Following the discovery, an investigation into the source of the contamination revealed that the tritium originated from activated soil shielding adjacent to the g-2 experiment's VQ-12 Magnet. There was no evidence that any of the tritium originated from the beam stop area. The VQ-12 magnet section of the beam line was not a designed beam loss area, and the gunite cap installed over the nearby beam stop did not protect the VQ-12 area. In December 1999, an impermeable cap was installed over the VQ-12 soil activation area. This cap was joined to the existing beam stop cap. In September 2000, the activated soil shielding and associated tritium plume were designated as new sub-Area of Concern 16T. The selected remedial actions for the g-2 tritium source area and plume are documented in a ROD which was signed in May 2007 (BNL 2007b). The monitoring program for the VQ-12 source area and g-2 tritium plume are described in **Section 4.2**.

4.1.6.1 AGS g-2 Beam Stop Groundwater Monitoring

Well Network

Groundwater quality downgradient of the g-2 beam stop is monitored using wells 054-67, 054-68, 054-124, 054-125, and 054-126 (**Figure 4-1**). These wells are located immediately north, and cross gradient, of the VQ-12 source area monitoring wells described in **Section 4.2**..

Sampling Frequency and Analysis

During 2008, the g-2 beam stop wells were monitored annually, and the samples were analyzed for tritium (**Table 1-6**).

4.1.6.2 AGS g-2 Beam Stop Monitoring Well Results

During 2008, trace levels of tritium were detected in three of the four monitoring wells located downgradient of the g-2 beam stop: 290 pCi/L in well 054-125, 310 pCi/L in well 054-126, and 690 pCi/L in well 054-124.

4.1.6.3 AGS g-2 Beam Stop Groundwater Monitoring Program Evaluation

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

4.1.6.4 AGS g-2 Beam Stop Recommendation

The following is recommended for the AGS g-2 Beam Stop groundwater monitoring program:

- During 2009, the g-2 beam stop area wells will continue to be monitored on an annual basis.

4.1.7 AGS 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**). The J-10 beam stop is subject to the same injection, transition, ejection, and studies losses that occurred at the former E-20 Catcher (**Section 4.1.4**). The J-10 stop area of the AGS Ring is covered by layers of soil-crete (a sand and concrete mixture), which reduce the ability of rainwater to infiltrate the potentially activated soil. BNL also constructed a gunite cap over a small section of the J-10 region that did not have a soil-crete cover before beam stop operations began.

4.1.7.1 AGS J-10 Beam Stop Groundwater Monitoring

Well Network

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

Sampling Frequency and Analysis

During 2008, the three J-10 beam stop wells were monitored one time and the samples were analyzed for tritium (**Table 1-6**).

4.1.7.2 AGS J-10 Beam Stop Monitoring Well Results

Since 2001, low levels of tritium have been routinely detected in groundwater downgradient of the J-10 beam stop (**Figure 4-5**). During 2008, these tritium concentrations were less than the MDA.

4.1.7.3 AGS J-10 Beam Stop Monitoring Program Evaluation

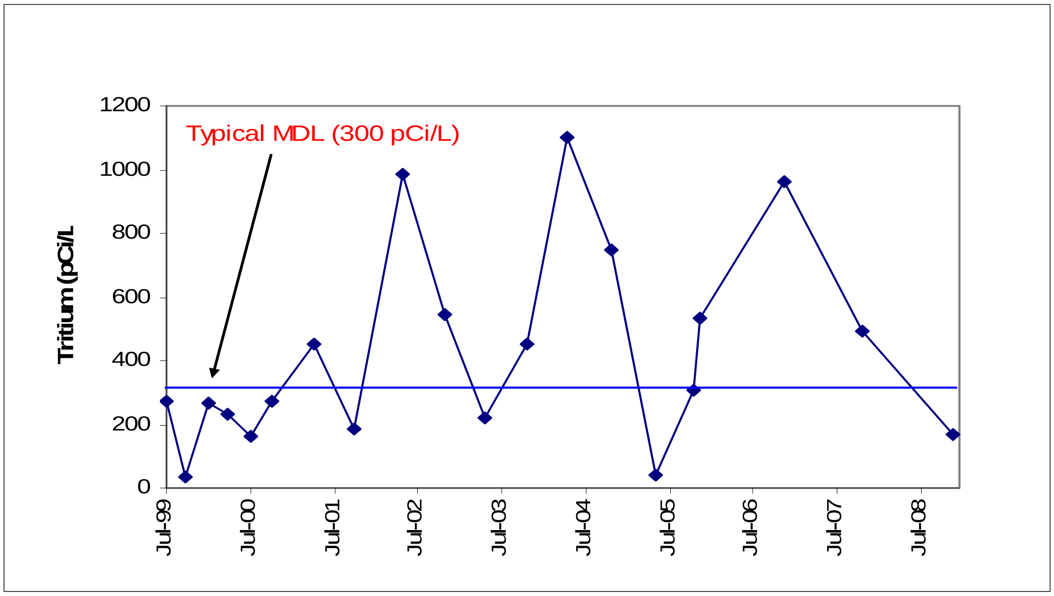
Groundwater monitoring data suggest that the engineered controls in place at J-10 are preventing significant rainwater infiltration into the activated soil shielding. However, the occasional detection of low levels of tritium (up to 1,000 pCi/L), suggests that some rainwater may be infiltrating the activated soil.

4.1.7.4 AGS J-10 Beam Stop Recommendation

The following is recommended for the AGS J-10 Beam Stop groundwater monitoring program:

- During 2009, the monitoring frequency for the J-10 Beam Stop area wells will continue to be annual.

Figure 4-5.
AGS J-10 Beam Stop
Maximum Tritium Concentrations in Downgradient Wells 054-63 and 054-64



4.1.8 Former AGS U-Line Beam Target and Stop Areas

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

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

4.1.8.1 Former AGS U-Line Groundwater Monitoring

Well Network

The former U-Line area is monitored by upgradient well 054-127 and downgradient wells 054-66, 054-128, 054-129, 054-130, 054-168, and 054-169. Three of the downgradient wells monitor the target area, and three wells monitor the beam stop area (**Figure 4-1**).

Sampling Frequency and Analysis

During 2008, the former U-Line area wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**).

4.1.8.2 Former AGS U-Line Groundwater Monitoring Well Results

U-Line Target Area

Low levels of tritium have been routinely detected in wells downgradient of the former U-Line beam target since monitoring began in 2000 (**Figure 4-6**). During 2008, the highest tritium concentration detected was 400 pCi/L in well 054-129, located approximately 200 feet downgradient of the target area.

U-Line Beam Stop Area

Since the cap was installed over the former U-line beam stop in 2000, tritium concentrations in downgradient wells have been well below the 20,000 pCi/L DWS (**Figure 4-7**). During 2008, only a trace level of tritium (670 pCi/L) was detected in one well downgradient of the U-Line target area.

4.1.8.3 Former AGS U-Line Groundwater Monitoring Program Evaluation

The significant decrease in tritium concentrations since 2000 indicates that the impermeable cap has been effective in stopping rainwater infiltration into the residual activated soil.

4.1.8.4 Former AGS U-Line Recommendation

The following is recommended for the Former AGS U-Line groundwater monitoring program:

- For 2009, the U-line area wells will continue to be sampled for tritium on an annual basis.

Figure 4-6.
Former AGS U-Line Beam Target
Maximum Tritium Concentrations in Downgradient Well 054-129

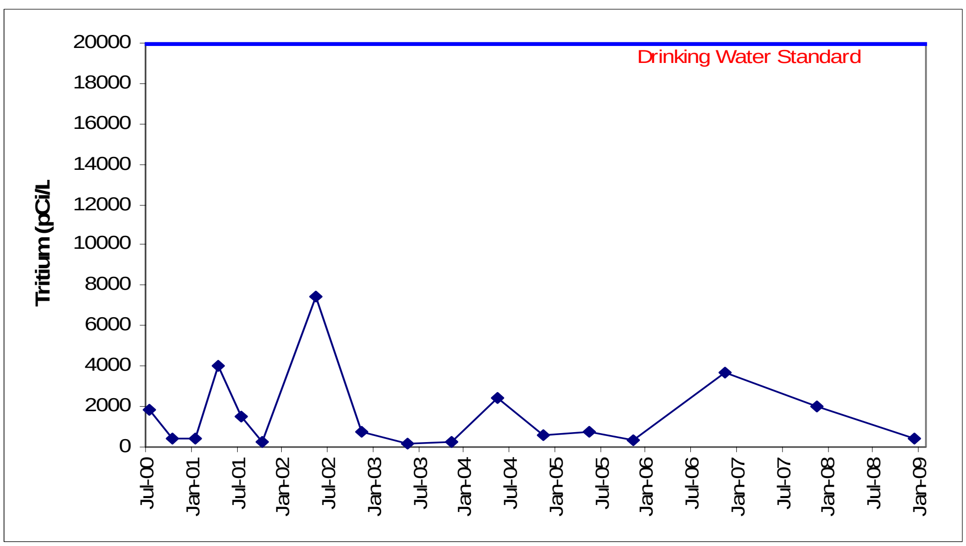
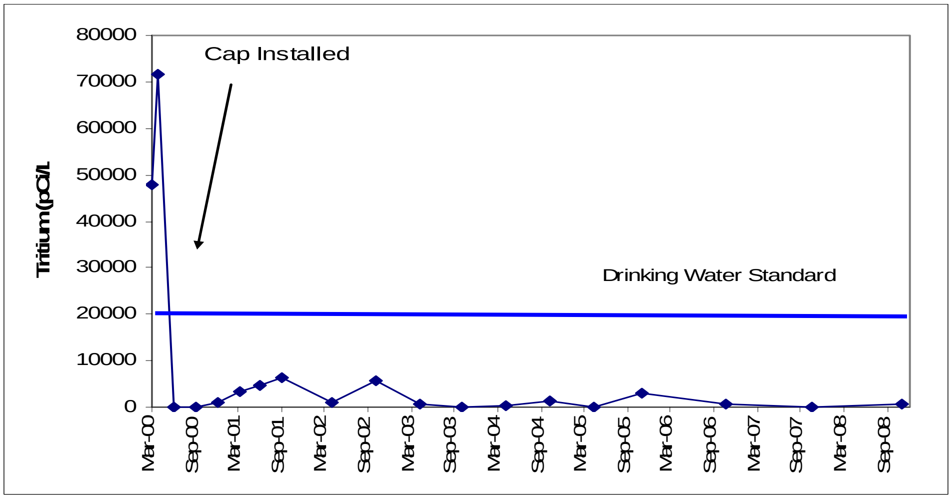


Figure 4-7.
Former AGS U-Line Beam Stop
Maximum Tritium Concentrations in Downgradient Temporary and Permanent Wells



4.2 g-2 Tritium Source Area and Groundwater Plume

In November 1999, tritium was detected in the groundwater near the g-2 experiment at concentrations above the 20,000 pCi/L DWS. Sodium-22 was also detected in the groundwater, but at concentrations well below the 400 pCi/L DWS. An investigation into the source of the contamination revealed that the tritium and sodium-22 originated from activated soil shielding located adjacent to the g-2 target building, where approximately 5 percent of the beam was inadvertently striking one of the beam line magnets (magnet VQ-12). Rainwater was able to infiltrate the activated soils and carry the tritium and sodium-22 into the groundwater. To prevent additional rainwater infiltration into the activated soil shielding, a concrete cap was constructed over the area in December 1999. Other corrective actions included refocusing the beam and improved beam loss monitoring to reduce additional soil activation, stormwater management improvements, and additional groundwater monitoring.

Following the concurrence from the NYSDEC, a ROD was signed by the DOE and EPA in early 2007 (BNL 2007b). This ROD requires continued routine inspection and maintenance of the impermeable cap, groundwater monitoring of the source area to verify the continued effectiveness of the stormwater controls, and monitoring the tritium plume until it attenuates to less than the 20,000 pCi/L DWS. Monitoring of the source area will continue for as long as the activated soils remain a threat to groundwater quality. Contingency actions have been developed if tritium levels exceeding 1,000,000 pCi/L are detected within the plume, or if the tritium plume does not attenuate as predicted by the groundwater model.

4.2.1 g-2 Tritium Source Area and Plume Groundwater Monitoring

Well Network

The g-2 tritium plume is currently monitored in two general areas: the source area (including the area to the east of Building 912), and the downgradient segments of the plume. Monitoring of the source area is accomplished using six wells immediately downgradient of the VQ-12 source and 12 wells east of Building 912. Monitoring of the downgradient sections of the tritium plume located in the vicinity of the HFBR is accomplished using a combination of permanent and temporary wells (**Figures 4-8 and 4-9**).

Sampling Frequency and Analysis

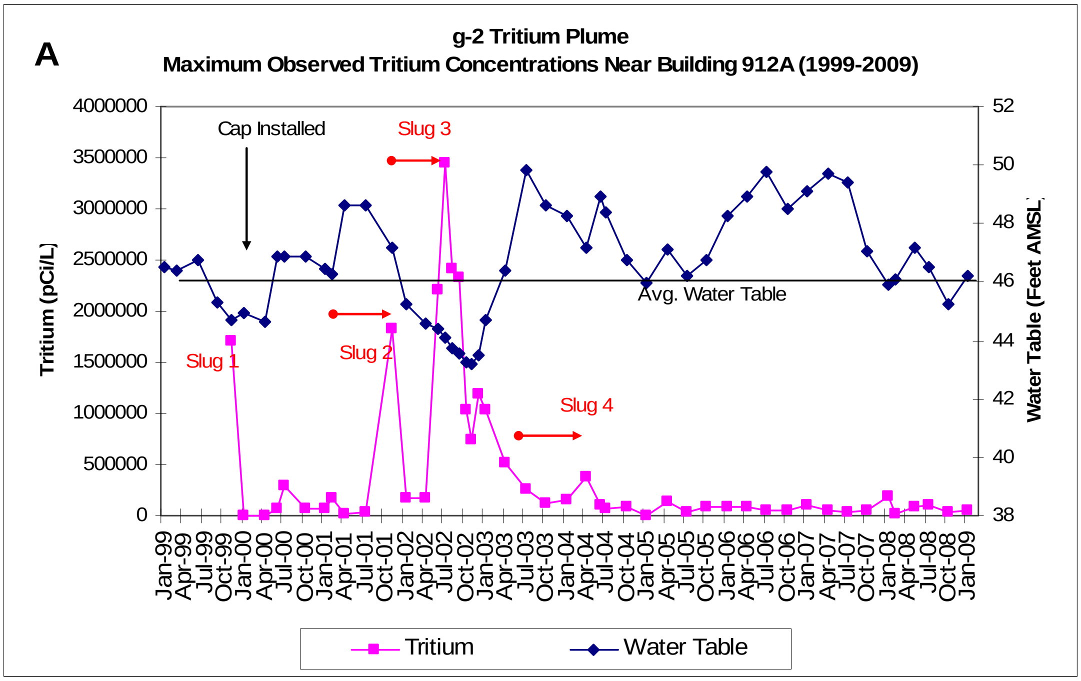
During 2008, the g-2 VQ-12 source area monitoring wells were monitored quarterly, and the samples were analyzed for tritium (**Table 1-6**). One set of quarterly samples was also analyzed for sodium-22. The wells located east of Building 912 were sampled two times during the year. From September 2008 to March 2009, 29 temporary wells were installed along five east-west transects to track the leading edge of the g-2 tritium plume (**Figure 4-8**). Sample results for the temporary wells are summarized on **Tables 4.2-1** through **4.2-5**.

4.2.2 g-2 Tritium Source Area and Plume Monitoring Well Results

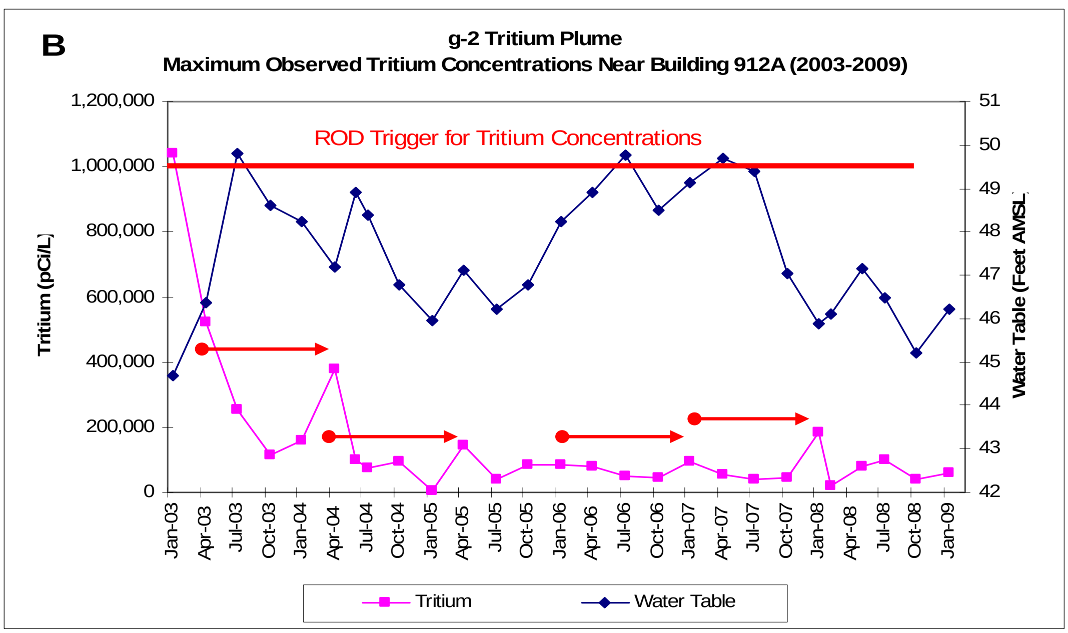
Source Area Monitoring Results

Monitoring data indicate that the high levels of tritium have entered the groundwater as a series of slug releases (**Figure 4-10**). Following the initial releases of tritium that occurred prior to cap installation in December 1999, subsequent periodic slug releases, characterized by short-term spikes in tritium concentrations, appear to be related to changes in the water-table elevation. As the water table rises, residual tritium is flushed from the vadose (unsaturated) zone close to the water table. Water levels in the central BNL area in mid-2000, mid-2001, and mid-2003 were near the highest observed in almost 50 years of record for the BNL site, to a level of approximately 49 feet above mean sea level. Approximately one year after each of these periods of high water-table elevations, elevated tritium concentrations were observed in the first set of source area monitoring wells (e.g., tritium concentrations increased to 1.8 million pCi/L in November 2001, and 3.4 million pCi/L in July 2002). Over time, the amount of tritium remaining in the vadose zone near the water table is expected to decrease by this flushing mechanism and by natural radioactive decay. Although the water table increased to nearly 49 feet above mean sea level during two periods since 2003, tritium levels in all but three sets of quarterly samples from source area monitoring wells have been less than 100,000 pCi/L. During this time period, tritium concentrations increased to a maximum 186,000 pCi/L in January 2008 (**Figure 4-10**). The overall reductions in tritium concentrations suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing. Samples were analyzed for sodium-22 during the fourth-quarter 2008. The maximum sodium-22 concentration was 74 pCi/L detected in the sample from well 054-185. The DWS for sodium-22 is 400 pCi/L.

Figure 4-10. g-2 Tritium Source Area
Maximum Tritium Concentrations in Downgradient Wells
A: Maximum tritium concentrations observed from 1999 through January 2009 in groundwater downgradient of the VQ-12 source area. Red arrows represent approximately 1 year of travel time from the source area to the first set of downgradient monitoring wells.



B: Comparison of January 2003–January 2009 results to the ROD trigger level. Red arrows represent approximately 1 year of travel time from the source area to the first set of downgradient monitoring wells.



Downgradient Areas of the Plume

The extent of the g-2 tritium plume during the first quarter of 2009 is depicted on **Figure 4-8**. **Figure 4-9** provides a cross-sectional view of the plume. Monitoring of the downgradient areas of the plume is accomplished using a combination of permanent and temporary wells. Since June 2007, 39 temporary well locations have been established along five east–west transects (Transects A, B, C, D and E). Over this period, 18 temporary wells have been installed at the same locations twice to evaluate changes in tritium concentrations over time; with the most recent wells installed between September 2008 and April 2009 (**Tables 4.2-1** through **4.2-.5**). During the September 2008 through April 2009 sampling events, samples were also collected for Sr-90 to assist in defining the extent of the WCF Sr-90 Plume (**Section 3.2.15**). The downgradient segment of the tritium plume (as defined by concentrations >20,000 pCi/L) appears to be breaking up into discrete segments. Based upon the most recent sampling of the temporary wells, the downgradient portion of the g-2 plume extends from the Building 801 parking lot (Transect A) to Temple Place (Transect E). The highest tritium concentrations were observed along Transect D, located immediately south of the HFBR, where a maximum concentration of 80,700 pCi/L was detected in temporary well G2-GP-84. The southernmost extent of the tritium plume extends to the Temple Place area (Transect E), where a maximum tritium concentration of 33,300 pCi/L was detected in temporary well G2-GP-94. The observed tritium concentrations have been consistent with g-2 Engineering Evaluation/Cost Analysis (EE/CA) model predictions of decay and dispersion effects on the high concentration plume segments (i.e., slugs) with distance from the source area.

4.2.3 g-2 Tritium Source Area and Plume Groundwater Monitoring Program Evaluation

Although tritium continues to be detected in the groundwater downgradient of the g-2 (VQ-12) source area at concentrations that exceed the 20,000 pCi/L DWS, the reduction in tritium concentrations since 2003 indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding. As discussed previously, a comparison of tritium levels in the source area monitoring wells and water-table elevation data suggests that the periodic natural fluctuations in the water table have released residual tritium from the deep vadose zone (i.e., unsaturated soil immediately above the water table). It is believed that this tritium was mobilized to the soil close to the water table before the cap was constructed in December 1999. Once the cap was in place, the lack of additional rainwater infiltration kept the tritium in the vadose zone from migrating into the groundwater until the significant rise in water table mobilized it. There appears to be good correlation between high tritium concentrations detected in monitoring wells immediately downgradient of the source area, and the water-table elevation about one year before the sampling (**Figure 4-10**). Over time, the amount of tritium remaining in the vadose zone near the water table is expected to decrease by this flushing mechanism and by natural radioactive decay. To fulfill the monitoring requirements defined in the ROD, BNL will continue to monitor groundwater quality in the source area until the activated soils are no longer a threat to groundwater quality.

4.2.4 g-2 Tritium Source Area and Plume Recommendations

The following are recommended for the g-2 Tritium Source Area and Plume groundwater monitoring program:

- During 2009, the source area monitoring wells will continue to be sampled quarterly, and the downgradient sections of the tritium plume will continue to be monitored using a combination of permanent and temporary wells.
- During the summer/fall of 2009, additional temporary wells will be installed along Transect D and Transect E to track the leading edge of the g-2 plume.
- To fulfill the monitoring requirements defined in the ROD, BNL will continue to track the plume until the tritium concentrations drop below the 20,000 pCi/L DWS.

4.3 Brookhaven Linac Isotope Producer (BLIP)

When the Brookhaven Linac Isotope Producer (BLIP) is operating, the Linac delivers a beam of protons that strike a series of targets in the BLIP target vessel, positioned at the bottom of a 30-ft underground tank. The targets rest inside a water-filled, 18-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 soil immediately outside the tank is activated by the production of secondary particles at the target.

As part of a 1985 redesign of the vessel, leak detection devices were installed and the open space between the water-filled shaft and the vessel's outer wall became a secondary containment system for the primary vessel. The BLIP target vessel system conforms to Suffolk County Article 12 requirements, and is registered with the SCDHS. The BLIP facility also has a 500-gallon UST for storing 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 the groundwater approximately 50 feet downgradient of the BLIP target vessel. Due to the activation of the soil shielding surrounding the BLIP target vessel and the detection of tritium and sodium-22 in groundwater, the BLIP facility was designated as sub-AOC 16K under the IAG.

In 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent additional rainwater infiltration into the activated soil below the building. The BLIP building's roof drains were redirected away from the building, existing paved areas on the south side of the building were resealed, and a gunite cap was installed on the remaining three sides of the building. In May and June 2000, BNL undertook additional protective measures by injecting colloidal silica grout (also known as a Viscous Liquid Barrier) into the activated soil. The grout reduces the permeability of the soil, thus further reducing the ability of rainwater to leach tritium and sodium-22 from the activated soils should the stormwater controls fail.

In late 2004, BNL also constructed a new protective cap over the beam line that runs from the Linac to the BLIP facility. The new cap was installed because direct soil measurements and beam loss calculations indicated that the tritium and sodium-22 concentrations in soils surrounding these beam lines could result in stormwater leachate concentrations that exceed the "5 percent" criteria described in the *Accelerator Safety* SBMS (Standards Based Management System) subject area.[2]

Following concurrence from the NYSDEC, a ROD was signed by the DOE and EPA in early 2007 (BNL 2007b). This ROD requires continued routine inspection and maintenance of the impermeable cap, and groundwater monitoring to verify the continued effectiveness of the stormwater controls. Maintenance of the cap and groundwater monitoring will continue for as long as the activated soils remain a threat to groundwater quality.

4.3.1 BLIP Groundwater Monitoring

Well Network

The monitoring well network for the BLIP facility consists of two upgradient and five downgradient wells. These wells provide a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality (**Figure 4-1**).

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[2] The BNL *Accelerator Safety* SBMS subject area requires stormwater controls where rainwater infiltration into activated soil shielding could result in leachate concentrations that exceed 5 percent of the drinking water standard (i.e., >1,000 pCi/L for tritium and 20 pCi/L for sodium-22).

Sampling Frequency and Analysis

During 2008, the three wells located immediately downgradient of BLIP were monitored quarterly (064-47, 064-48, and 064-67). The two upgradient wells and remaining two downgradient wells were sampled semiannually. All BLIP groundwater samples were analyzed for tritium, and one set of samples from the three immediately downgradient wells were analyzed for sodium-22 by gamma spectroscopy (**Table 1-6**).

4.3.2 BLIP Monitoring Well Results

Monitoring data collected from January 1999 to July 2000 indicated that the initial corrective actions taken during 1998 were highly effective in preventing the release of tritium and sodium-22 from the activated soil surrounding the BLIP target vessel. Prior to May 2000, tritium and sodium-22 concentrations in wells directly downgradient of BLIP were <3,000 pCi/L and <5 pCi/L, respectively. However, significant increases in tritium concentrations were observed in groundwater samples collected after the silica grout injection took place in late May and early June 2000 (**Figure 4-11**). It was determined that tritium in the soil pore water near the target vessel was displaced by the grout. Tritium concentrations in the groundwater immediately downgradient of BLIP increased to 56,500 pCi/L by October 2000. By December 2000, tritium concentrations dropped to below 20,000 pCi/L, and remained below this level throughout 2001 and 2002. From 2003 through 2006, there were several short-duration periods when tritium concentrations once again exceeded 20,000 pCi/L (**Figure 4-12**). Since January 2006, tritium levels have remained below the 20,000 pCi/L DWS. During 2008, the maximum tritium concentration was 5,630 pCi/L. Sodium-22 was not detected in the samples collected from downgradient wells 064-47, 064-48, and 064-67 during the third quarter 2008.

Figure 4-11.
BLIP Target Vessel
Maximum Tritium Concentrations in Wells 40 feet Downgradient

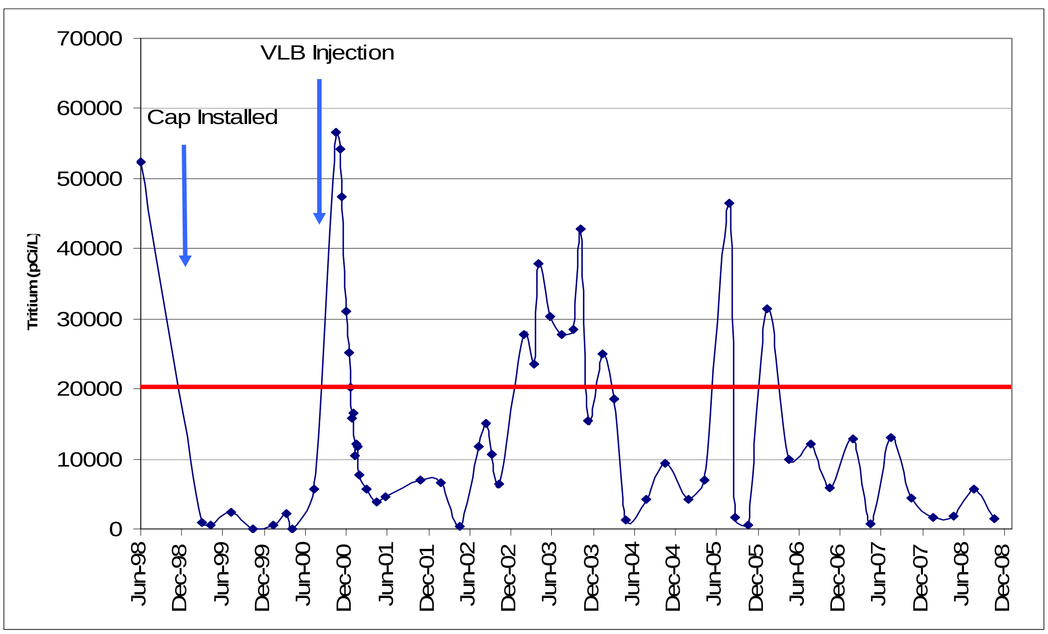
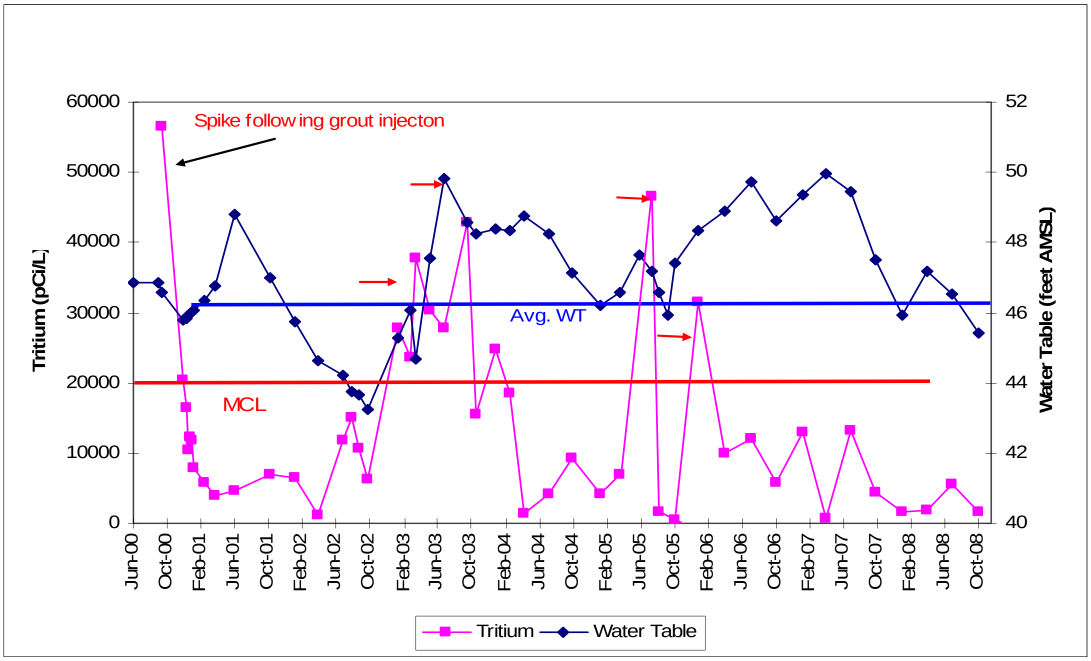


Figure 4-12.
BLIP Target Vessel
Tritium Concentrations vs. Water-Table Position, in Wells 40 Feet Downgradient,



Note 1: Arrows indicate approximate groundwater travel time from directly below the BLIP target to the first set of monitoring wells (e.g., well 064-67). Travel time is approximately 89 days, based on a distance of 40 feet and groundwater velocity of 0.45 ft/day.

4.3.3 BLIP Groundwater Monitoring Program Evaluation

The BLIP cap is in good condition, and is effectively controlling stormwater infiltration. Although direct inspection of the silica grout is not possible, it is expected to be in good condition and would be effective in preventing significant leaching of tritium from the activation zone should the primary stormwater controls fail. A comparison of tritium concentrations to changes in water-table position suggests that the periodic increases in tritium concentrations are probably associated with increases in water-table elevation (**Figure 4-12**). As the water table rises, older tritium that had leached from the soil before the cap was installed in 1998 or that was released during the grout injection project is flushed from the soil close to the water table. The amount of tritium remaining in the vadose zone close to the water table is expected to decline over time, due to this flushing mechanism and by natural radioactive decay. The short-term concentration increases observed in 2005 and 2006 also appear to be correlated to increases in the elevation of the water table.

4.3.4 BLIP Recommendation

As required by the ROD, BNL will continue to conduct routine inspections of the cap, and to monitor groundwater quality downgradient of the BLIP facility. The following is recommended for the BLIP groundwater monitoring program:

- Because tritium levels in groundwater have been continuously below the 20,000 pCi/L DWS since January 2006, BNL proposes reducing the monitoring frequency for the downgradient monitoring wells 064-47, 064-48, and 064-67 from quarterly to semiannually starting in 2009.
- Sampling frequency for the two upgradient and two downgradient wells will be changed from semiannual to annual.

4.4 Relativistic Heavy Ion Collider (RHIC)

Beam line interaction with the Relativistic Heavy Ion Collider (RHIC) collimators and beam stops produces secondary particles that interact with soil surrounding the 8 o'clock and 10 o'clock portions of the RHIC tunnel and the W-Line stop (**Figure 4-13**). These interactions result in the production of tritium and sodium-22, which can be leached out of the soil by rainwater. Although the level of soil activation was expected to be minor, before RHIC operations began in 2000 BNL installed impermeable caps over these beam loss areas to prevent potential impact to groundwater quality.

4.4.1 RHIC Groundwater Monitoring

Well Network

Thirteen shallow wells are used to verify that the engineered 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 are in the collimator area, and one well is downgradient of the W-Line beam stop (**Figure 4-13**). As an extension to the groundwater monitoring program, surface water samples are also collected from the Peconic River, both upstream (location HY) and downstream (location HV) of the beam stop area, to verify that potentially contaminated groundwater is not being discharged into the Peconic River stream bed during high water-table conditions.

Sampling Frequency and Analysis

During 2008, groundwater samples were collected from the RHIC monitoring wells on a semiannual schedule, and the samples were analyzed for tritium (**Table 1-6**). Routine analysis for sodium-22 was dropped from the groundwater monitoring program in 2002 because tritium is the best indicator of possible cap failure (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater). Surface water samples were collected quarterly and analyzed for tritium and sodium-22.

4.4.2 RHIC Monitoring Well Results

As in past years, no tritium was detected in the RHIC groundwater samples. No tritium or sodium-22 was detected in surface water samples from downstream location HV.

4.4.3 RHIC Groundwater Monitoring Program Evaluation

Groundwater and surface water monitoring data continue to demonstrate that the impermeable caps installed over the RHIC beam stop and collimator areas are effectively preventing rainwater infiltration into the activated soil shielding.

4.4.4 RHIC Recommendation

The following is recommended for the RHIC groundwater monitoring program:

- During 2009, groundwater samples will continue to be collected on a semiannual basis. Surface water samples will also continue to be collected as part of the monitoring program.

4.5 Brookhaven Medical Research Reactor (BMRR)

The Brookhaven Medical Research Reactor (BMRR) was a 3-megawatt light water reactor that was used for biomedical research. Research operations at the BMRR stopped in December 2000. All spent fuel was removed in 2003 and the primary cooling water system has been drained. BNL is preparing plans to permanently decommission the facility.

The BMRR primary cooling water system consisted of a recirculation piping system that contained 2,550 gallons of water. The cooling water contained approximately 5 Curies (Ci) of tritium. Unlike the HFBR, the BMRR does not have a spent fuel storage canal or pressurized imbedded piping systems that contained radioactive liquids. Historically, fuel elements that required storage were either stored within the reactor vessel, or they were transferred to the HFBR spent fuel canal. The BMRR primary cooling water system piping is fully exposed in the containment structure and is accessible for routine visual inspections. When the BMRR was operational, excess heat was transferred by means of heat exchangers with once-through (secondary) cooling water, which was obtained from nearby process supply wells or the BNL Chilled Water System. This secondary water was discharged to recharge basin HP, 800 feet south of the Medical Department complex, and was monitored as part of the SPDES program. All cooling water discharges from the BMRR stopped in December 2000.

In 1997, tritium was detected in wells installed directly downgradient (within 30 feet) of the BMRR. The maximum tritium concentration observed during 1997 was 11,800 pCi/L, almost one-half of the 20,000 pCi/L DWS. The highest observed tritium concentration since the start of groundwater monitoring was 17,100 pCi/L in October 1999. The tritium currently detected in groundwater is believed to have originated from the historical discharge of small amounts of BMRR primary cooling water to a basement floor drain and sump system that may have leaked. Although the last discharge of primary cooling water to the floor drain system occurred in 1987, the floor drains continued to be used for secondary (non-radioactive) cooling water until 1997. The infiltration of this water may have promoted the movement of residual tritium from the soil surrounding the floor drain piping system to the groundwater. The floor drains were permanently sealed in 1998 to prevent any accidental future releases to the underlying soil.

4.5.1 BMRR Groundwater Monitoring

Well Network

The monitoring well network for the BMRR facility consists of one upgradient and three downgradient wells (**Figure 4-14**). Samples collected from the four groundwater monitoring wells are used to determine whether residual tritium in the soils below the BMRR is impacting groundwater quality.

Sampling Frequency and Analysis

Starting in 2007, the sampling frequency for the BMRR wells was changed from annual to once every two years. One set of samples was collected in 2008, and the samples were analyzed for tritium, gamma emitting radionuclides, gross alpha, and gross beta (**Table 1-6**).

4.5.2 BMRR Monitoring Well Results

Monitoring results for 2008 indicated that tritium concentrations continued to be well below the 20,000 pCi/L DWS. Detectable levels of tritium were observed in all three downgradient wells, with the maximum value of 1,130 pCi/L detected in well 084-27 (**Figure 4-15**). As in past years, gamma, gross alpha, and gross beta analyses did not indicate the presence of any other reactor-related radionuclides.

4.5.3 BMRR Groundwater Monitoring Program Evaluation

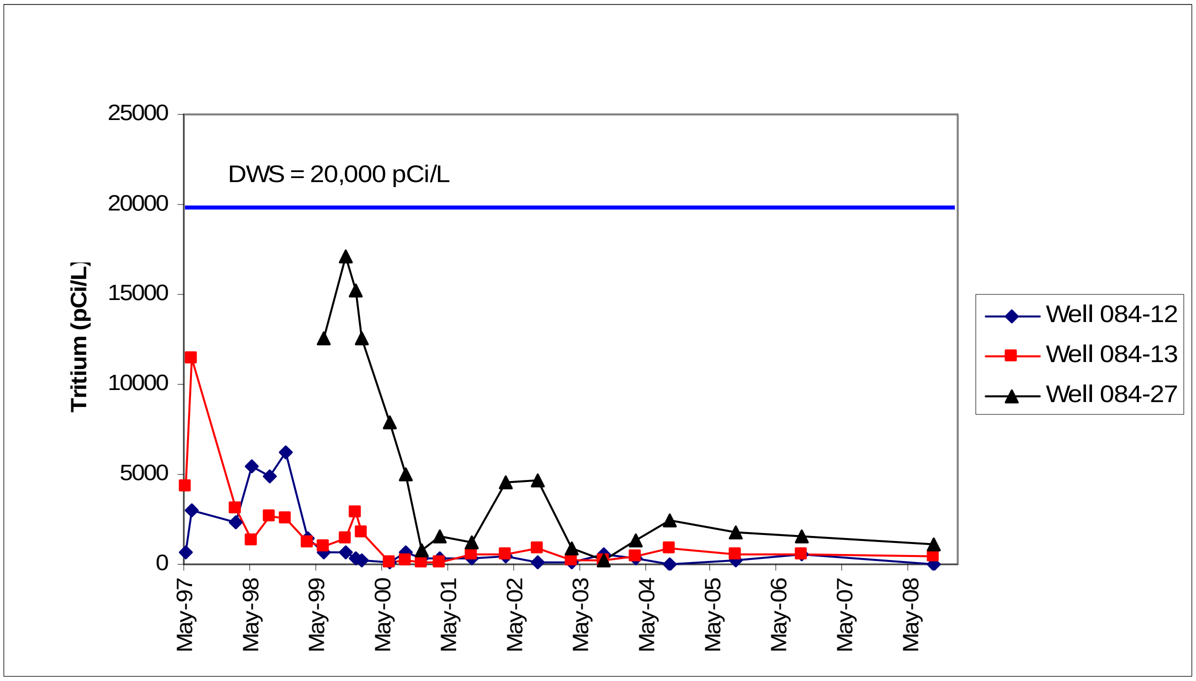
Tritium concentrations in groundwater from the BMRR well network have never exceeded the 20,000 pCi/L DWS, and have remained <5,000 pCi/L since September 2000. The BMRR structure is effectively preventing rainwater infiltration into the underlying soils, and therefore reducing the movement of any residual tritium from the soil to the groundwater.

4.5.4 BMRR Recommendation

The following is recommended for the BMRR groundwater monitoring program:

- The monitoring frequency for the BMRR wells will continue to be once every two years, with the next set of samples being collected in 2010.

Figure 4-15.
BMRR
Tritium Concentrations in Downgradient Wells



4.6 Sewage Treatment Plant (STP)

The STP processes sanitary wastewater from BNL research and support facilities. Treated effluent from the STP is discharged to the Peconic River under a NYSDEC SPDES permit (NY-0005835). On average, 1.25 million gallons per day (MGD) are processed during the summer and 0.72 MGD are processed daily during the rest of the year. Before discharge into the Peconic River, the sanitary waste stream is fully treated by 1) primary clarification to remove settleable solids and floatable materials, 2) aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia, 3) secondary clarification, 4) sand filtration for final effluent polishing, and 5) ultraviolet disinfection for bacterial control. Oxygen levels are regulated during the treatment process to remove nitrogen biologically, using nitrate-bound oxygen for respiration.

Wastewater from the STP clarifier is released to the sand filter beds, where water percolates through 3 feet of sand before being recovered by an underlying clay tile drain system, which transports the water to the discharge point at the Peconic River (SPDES Outfall 001). Approximately 15 percent of the water released to the filter beds is either lost to evaporation or to direct groundwater recharge. At the present time, six sand filter beds are used in rotation.

Two emergency hold-up ponds are located east of the sand filter bed area. The hold-up ponds are used to store sanitary waste in the event of an upset condition or if the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The hold-up ponds have a combined holding capacity of nearly 8 million gallons of water, and provide BNL with the ability to divert all sanitary system effluent for approximately one week. The hold-up ponds are equipped with fabric-reinforced plastic liners that are heat-welded along all seams. As part of the Phase III Sewage Treatment Plant Upgrades project in 2001, the liners were enhanced by the addition of new primary liners and a leak detection system. The older liners now serve as secondary containment.

4.6.1 STP Groundwater

Well Network

In addition to the comprehensive influent and effluent monitoring program at the STP, the 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 4-16**).

Sampling Frequency and Analysis

During 2008, the six STP filter bed area wells were monitored semiannually and the three holding pond area wells were sampled annually. The samples were analyzed for VOCs, anions, metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-6**).

4.6.2 STP Monitoring Well Results

Radiological Analyses

During 2008, radioactivity levels in samples collected from most of the STP wells were generally typical of ambient (background) levels. As in previous years, the samples from filter bed area monitoring well 038-02 had higher than normal gross alpha and gross beta levels, with maximum concentrations of 24 pCi/L and 110 pCi/L, respectively. This well is screened in fine-grained material above a localized low permeability (silt and clay) deposit, and the elevated gross alpha and gross beta values are believed to be related to the naturally occurring radionuclides common to these deposits. Tritium was not detected in any of the STP area wells. No BNL-related gamma emitting radionuclides were detected in any of the STP groundwater monitoring wells.

Non-Radiological Analyses

During 2008, all water quality and most metals concentrations were below the applicable NYS AWQS or DWS. In filter bed area well 039-86, sodium was detected at a concentration of 27 milligrams per liter (mg/L), slightly above the 20 mg/L NYS AWQS. In four of six filter bed area wells, iron and aluminum exceeded applicable standards, with the highest levels of 7.4 mg/L and 5.8 mg/L, respectively, detected in well 038-02. The NYS AWQS for iron is 0.3 mg/L, and the DWS (secondary MCL for aesthetic quality) for aluminum is 0.2 mg/L. Low levels of nitrates continue to be detected in many of the STP filter bed area wells, with a maximum concentration of 5.2 mg/L detected in filter bed area monitoring well 039-08. The NYS AWQS for nitrate is 10 mg/L. No VOCs were detected above the NYS AWQS in any of the STP monitoring wells.

4.6.3 STP Groundwater Monitoring Program Evaluation

Monitoring results for 2008 indicate that STP operations are not having a significant impact on groundwater quality, and that the BNL administrative and engineered controls designed to prevent the discharge of chemicals and radionuclides to the sanitary system continues to be effective.

4.6.4 STP Recommendation

No changes to the monitoring frequency are proposed for 2009.

4.7 Motor Pool Maintenance Area

The Motor Pool (Building 423) and Site Maintenance facility (Building 326) are attached structures located along West Princeton Avenue (**Figure 4-17**). The Motor Pool area consists of a five-bay automotive repair shop, which includes office and storage spaces. The Site Maintenance facility provides office space, supply storage, locker room, and lunchroom facilities for custodial, grounds, and heavy equipment personnel. Both facilities have been used continuously since 1947.

Potential environmental concerns at the Motor Pool include 1) the historical use of USTs to store gasoline, diesel fuel, and waste oil, 2) hydraulic fluids used for lift stations, and 3) the use of solvents for parts cleaning. In August 1989, the gasoline and waste oil USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000-gallon USTs used to store unleaded gasoline, one 260-gallon above ground storage tank used for waste oil, and one 3,000-gallon UST for No. 2 fuel oil. The Motor Pool facility has five vehicle-lift stations. The hydraulic fluid reservoirs for the lifts are located above ground.

Since 1996, several small-scale hydraulic oil and diesel oil spills have been remediated at the Motor Pool. The only known environmental concern associated with the Site Maintenance facility (Building 326) was the December 1996 discovery of an old oil spill directly south of the building. In an effort to investigate the potential impact that this spill had on groundwater quality, four wells were installed downgradient of the spill site. Although the solvent TCA was detected in the groundwater at concentrations above NYS AWQS, petroleum hydrocarbons were not detected.

4.7.1 Motor Pool Maintenance Area Groundwater Monitoring

Well Network

The Motor Pool facility's groundwater monitoring program for the UST area is designed to confirm that the engineered and institutional controls are effective in preventing contamination of the aquifer, and to evaluate continued impacts from historical spills. Two shallow Upper Glacial aquifer wells (102-05 and 102-06) are used to monitor for potential contaminant releases from the UST area (**Figure 4-17**).

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 2008, the UST area wells were monitored semiannually and the samples were analyzed for VOCs (**Table 1-6**). The wells were also checked for the presence of floating petroleum hydrocarbons during these sample periods. The Building 423/326 area wells were monitored annually, and the samples were analyzed for VOCs.

4.7.2 Motor Pool Monitoring Well Results

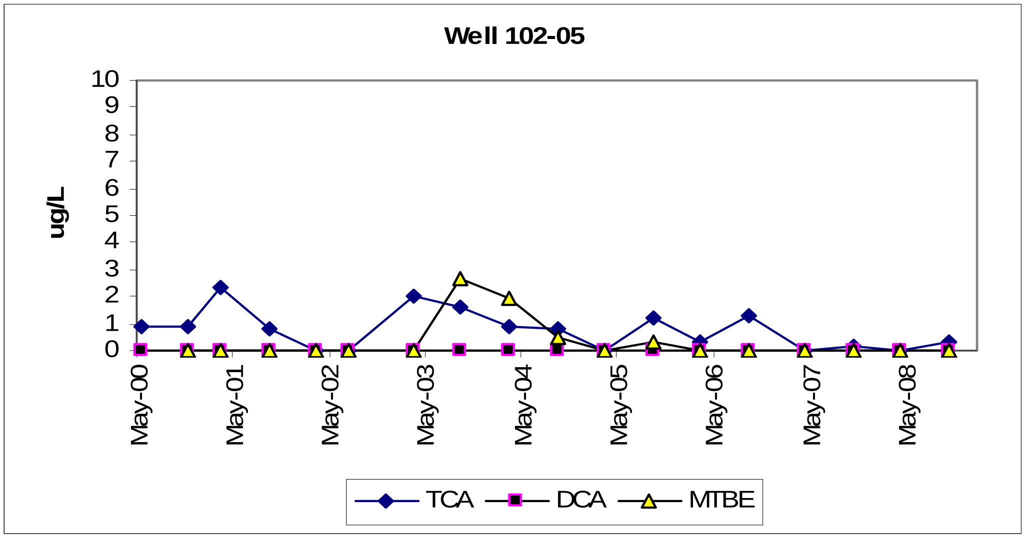
Underground Storage Tank Area

During 2008, no gasoline-related products were detected in groundwater downgradient of the gasoline UST area (**Figure 4-18**). Although the former gasoline additive MTBE concentrations had reached a maximum of nearly 34 µg/L (NYS AWQS is 10 µg/L) in 2003, MTBE has not been detected in any samples since 2006. As in past years, trace levels of the solvent TCA were also detected, but at concentrations that continued to be well below the NYS AWQS of 5 µg/L. Wells 102-05 and 102-06 were also tested for the presence of floating petroleum hydrocarbons. As in previous years, no floating product was observed.

Building 423/326 Area

During 2008, the solvent TCA was detected in well 102-12 at a concentration of 6.7 µg/L, slightly above the 5 µg/L NYS AWQS (**Figure 4-19**). As in 2007, DCA levels remained less than the 5 µg/L standard. Although trace levels (< 0.3 µg/L) of the former gasoline additive MTBE continue to be occasionally detected in some of the Motor Pool wells, the MTBE levels have been less than the 10 µg/L NYS AWQS since 2005. It is believed that the TCA, DCA, and MTBE originated from historical vehicle maintenance operations.

Figure 4-18.
Motor Pool Gasoline UST Area
VOC Concentration Trends in Downgradient Wells



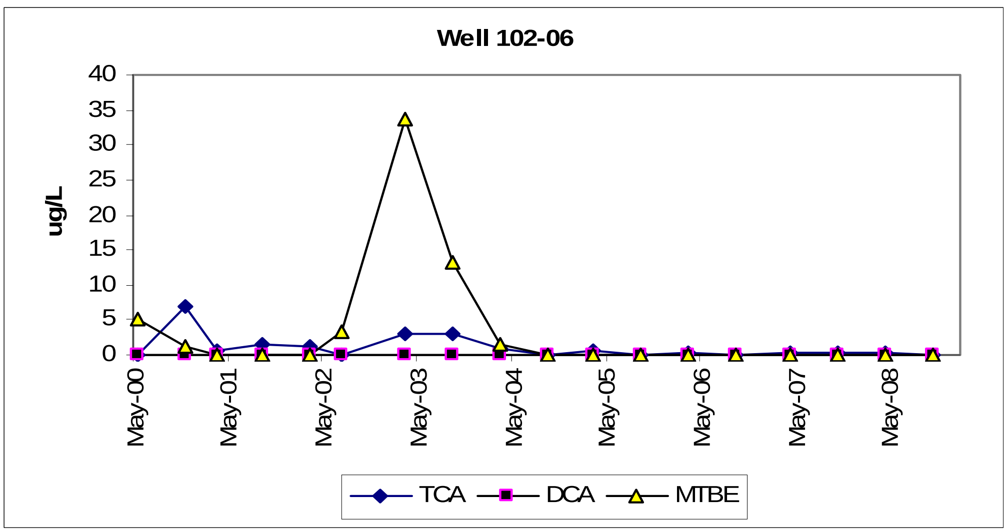
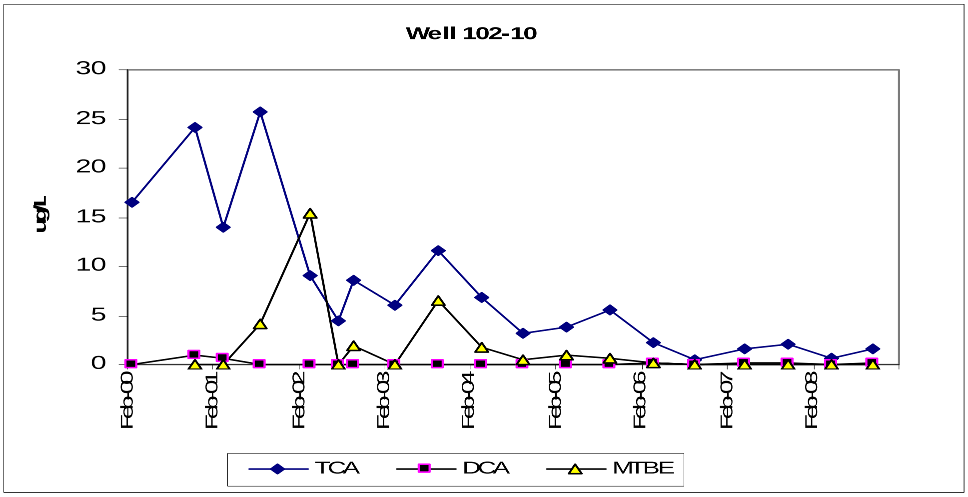
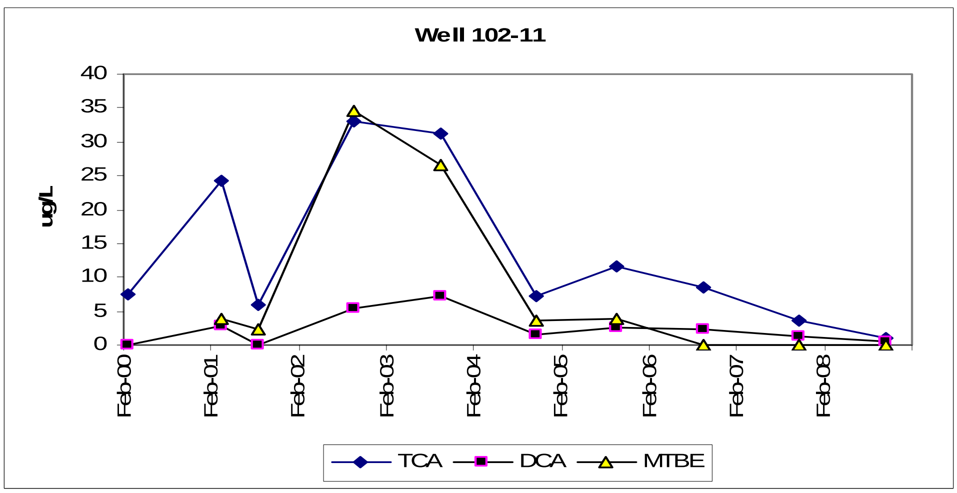
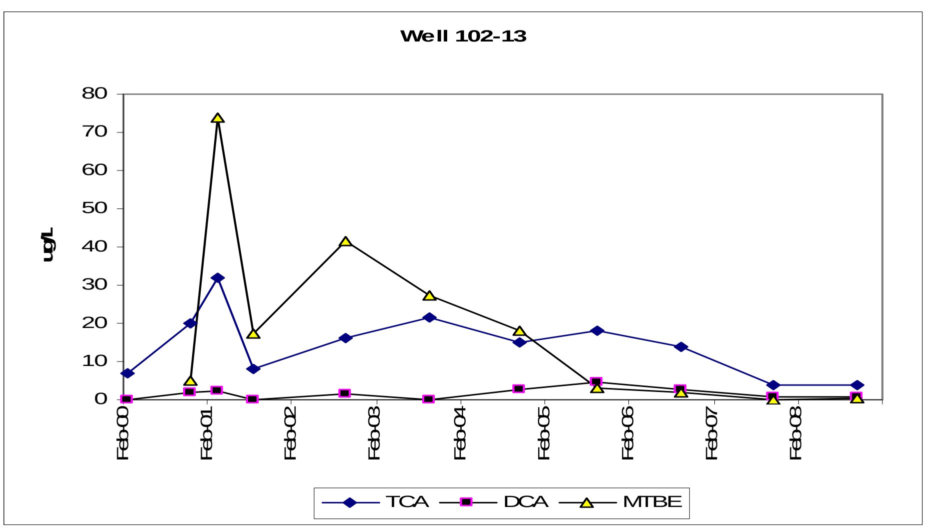


Figure 4-19.
Motor Pool Building 423/326 Area
VOC Concentration Trends in Downgradient Wells







4.7.3 Motor Pool Monitoring Program Evaluation

Although small-scale solvent and gasoline releases from vehicle maintenance operations have impacted groundwater quality in the Motor Pool area, there has been a steady decrease in VOC concentrations over the past several years. During 2008 there were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). The MTBE and TCA that is periodically detected in the groundwater near the UST area are likely to have originated from historical spills.

4.7.4 Motor Pool Recommendation

No changes to the monitoring program are proposed for 2009.

4.8 On-Site Service Station

Building 630 is a commercial automobile service station, privately operated under a contract with BNL. The station was built in 1966, and is used for automobile repair and gasoline sales.

Potential environmental concerns at the service station include the historical use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. When the service station was built in 1966, the UST inventory consisted of one 6,000-gallon and two 8,000-gallon tanks for storing gasoline, and one 500-gallon tank for used motor oil. In August 1989, the USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. During the removal of the old USTs, there were no obvious signs of soil contamination.

The current tank inventory includes three 8,000-gallon USTs for storing unleaded gasoline, and one 500-gallon UST used for waste oil. The facility has three hydraulic vehicle-lift stations.

Groundwater quality in the service station area has been impacted by historical small-scale spills of oils, gasoline, and solvents, and by carbon tetrachloride contamination associated with a nearby UST that was used as part of a science experiment conducted in the 1950s. In April 1998, BNL removed a UST from an area approximately 200 feet northwest (upgradient) of the service station. Although there are indications that the tank was releasing small quantities of carbon tetrachloride before its removal, a significant increase in carbon tetrachloride concentrations in groundwater indicated that additional amounts of this chemical were inadvertently released during the excavation and removal process. BNL started to remediate the carbon tetrachloride plume in October 1999 (**Section 3.2.1**).

4.8.1 Service Station Groundwater Monitoring

Well Network

The service station's groundwater monitoring program is designed to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer and to evaluate continued impacts from historical spills. Five wells are used to monitor for potential contaminant releases (**Figure 4-20**).

Sampling Frequency and Analysis

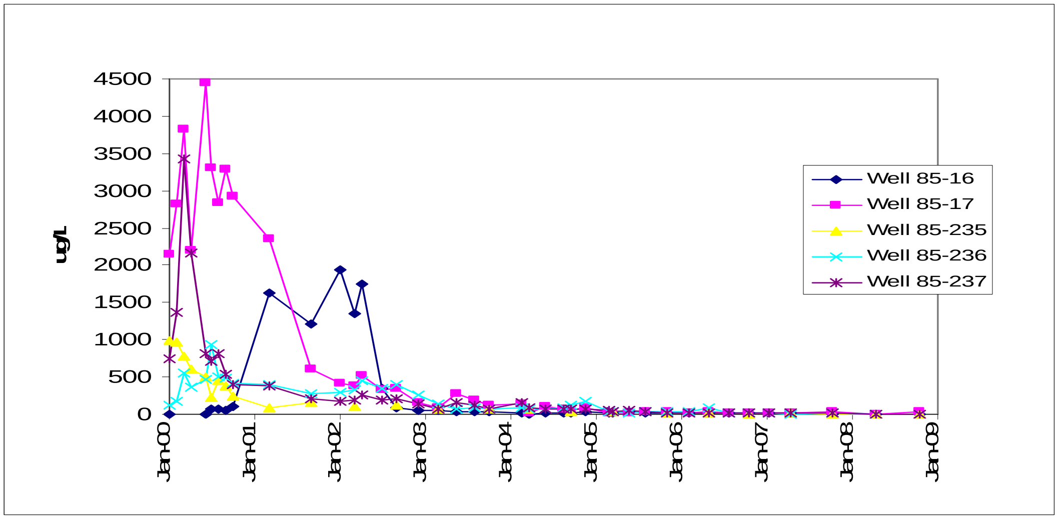
During 2008, the service station facility wells were monitored two times, primarily by the CERCLA program as part of the Carbon Tetrachloride plume monitoring project. The samples were analyzed for VOCs (**Tables 1-5** and **1-6**). Three of the wells near the gasoline USTs were also checked semiannually for the presence of floating petroleum hydrocarbons.

4.8.2 Service Station Monitoring Well Results

During 2008, carbon tetrachloride (and its breakdown product, chloroform) continued to be detected in the service station monitoring wells (**Figure 4-21**). The maximum carbon tetrachloride and chloroform concentrations were 36 µg/L and 5.9 µg/L, respectively. The levels of carbon tetrachloride currently detected in the groundwater are considerably less than those observed during 2000, when carbon tetrachloride concentrations approached 4,500 µg/L. The reduction in carbon tetrachloride levels reflects the effectiveness of the groundwater remediation system, which achieved its cleanup objectives and was shut down and placed in standby mode in August 2004 (**Section 3.2.1**).

Historically, groundwater quality at the Service Station has been affected by a variety of VOCs that appeared to be related to historical service station operations. During 2008, high levels of VOCs (with a TVOC concentration of 1,575 µg/L) continued to be detected in well 085-17. The contamination consisted primarily of xylenes (total) at 720 µg/L, ethylbenzene at 29 µg/L, 1,2,4-trimethylbenzene at 250 µg/L, 1,3,5-trimethylbenzene at 93 µg/L, and the solvent PCE at a concentration of 35 µg/L (**Figure 4-22**). For the past two years, VOC concentrations in wells 085-235, 085-236, and 085-237 have remained at low to trace levels (**Figures 4-23** and **4-24**). As in previous years, no floating product was detected in the wells. It is important to note that the petroleum-related compounds detected in the Motor Pool wells have not been detected in Carbon Tetrachloride project wells located downgradient of the facility. This is consistent with studies that have demonstrated that many petroleum-related compounds breakdown in aquifer systems within a short distance from a source area.

Figure 4-21.
Service Station
Carbon Tetrachloride Concentration Trends in Monitoring Wells.



4.8.3 Service Station Groundwater Monitoring Program Evaluation

Analysis of groundwater samples collected at the service station facility during 2008 indicates that VOCs continue to be detected at concentrations greater than the applicable NYS AWQS. There were no reported gasoline or motor oil losses or spills that could affect groundwater quality, and all waste oils and used solvents generated from current operations are being properly stored and recycled. The gasoline USTs have electronic leak detection systems, and there is a daily product reconciliation (i.e., an accounting of the volume of gasoline stored in USTs and volume of gasoline sold). It is believed that the petroleum hydrocarbon-related compounds and solvents that have been detected in groundwater originated from historical vehicle maintenance operations before improved chemical storage and handling controls were implemented in the 1980s.

Figure 4-22.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-17
Carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.

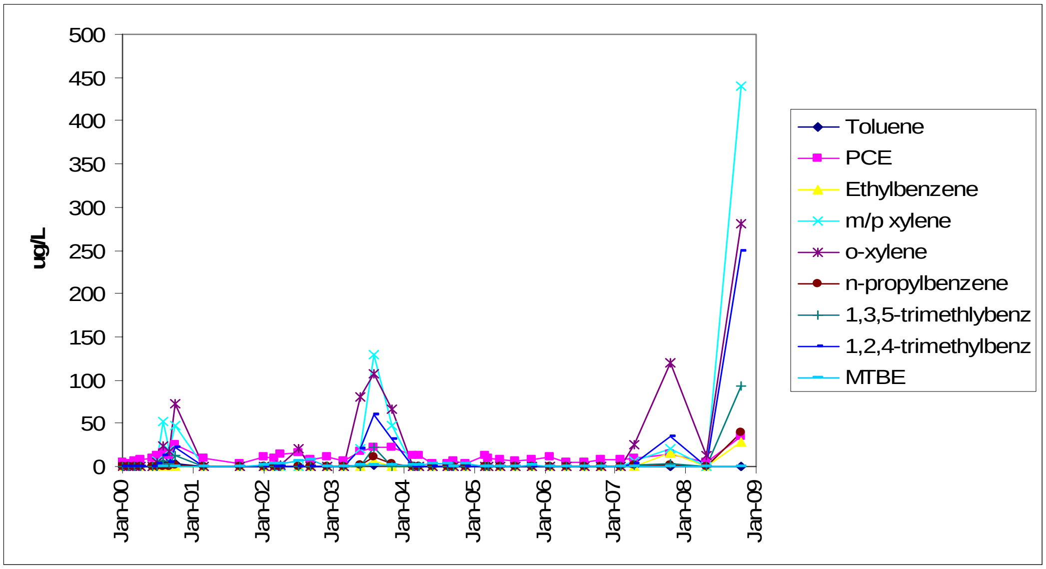
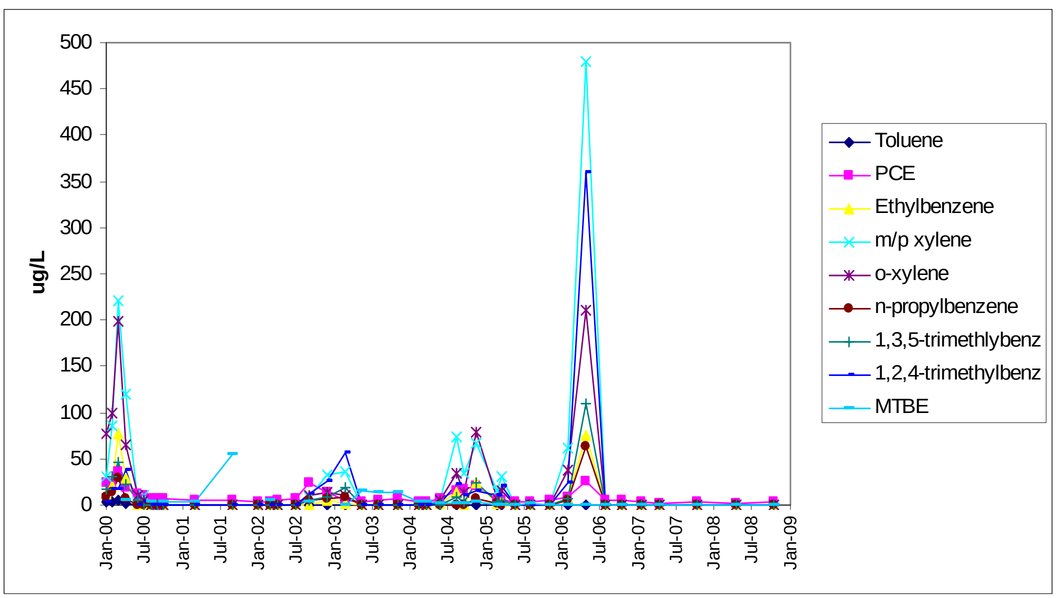


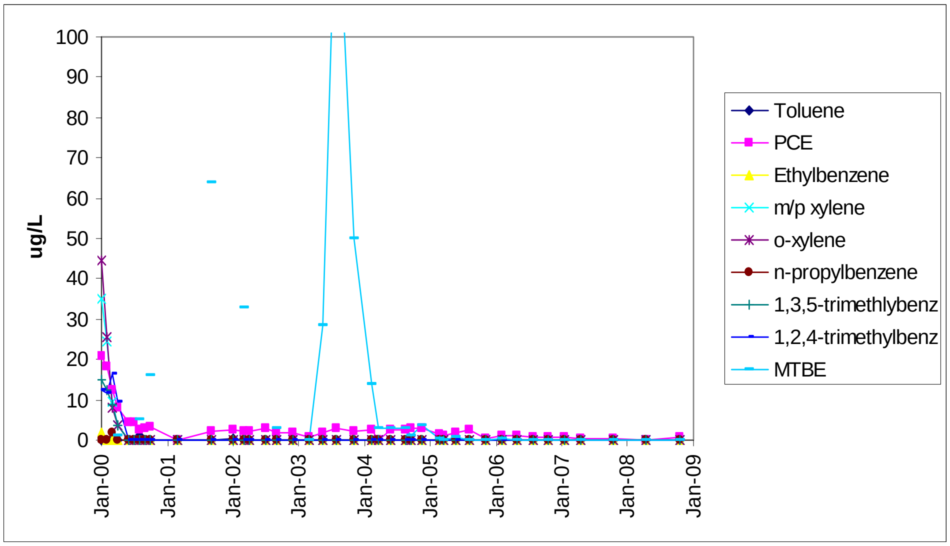
Figure 4-23.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-236
Carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.



4.8.4 Service Station Recommendation

No changes to the monitoring program are proposed for 2009.

Figure 4-24.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-237
Carbon tetrachloride originating from the upgradient carbon tetrachloride UST source area is not included.



4.9 Major Petroleum Facility (MPF) Area

The MPF is the holding area for fuel oil used at the Central Steam Facility (CSF). The fuel oil is held in a network of seven above ground storage tanks, which have a combined capacity of up to 1.7 million gallons of No. 6 fuel oil and 60,000 gallons of No. 2 fuel oil. The tanks are connected to the CSF by above ground pipelines that have secondary containment and leak detection devices. The fuel storage tanks are positioned in bermed containment areas that have a capacity to hold >110 percent of the volume of the largest tank located there. The bermed areas have bentonite clay liners consisting of either Environmat™ (bentonite clay sandwiched between geotextile material) or bentonite clay mixed into the native soil to form an impervious soil/clay layer. As of December 1996, the fuel-unloading operations were consolidated to one centralized building that has secondary containment features. The MPF is operated under NYSDEC Permit #1-1700 and, as required by law, a Spill Prevention Control and Countermeasures (SPCC) Plan and a Facility Response Plan have been developed for the facility. Groundwater quality near the MPF has been impacted by several oil and solvent spills: 1) the 1977 fuel oil/solvent spill east of the MPF that was remediated under the IAG (**Section 3.3.1**); and 2) solvent spills near the CSF.

4.9.1 MPF Groundwater Monitoring

Well Network
Eight shallow Upper Glacial aquifer wells are used to confirm that the engineered and institutional controls in place are effective in preventing contamination of the aquifer (**Figure 4-25**).

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 Facility Monitoring Program. In 2002, NYSDEC expanded the required list of routine analyses to include VOCs, including testing for

MTBE (**Table 1-6**). MTBE was a common gasoline additive until January 2004, and it was occasionally introduced to fuel oil as a contaminant during the storage and transportation process.

4.9.2 MPF Monitoring Well Results

The MPF wells were sampled in April and October 2008. The wells were also tested monthly for the presence of floating petroleum. The samples were tested for SVOCs and VOCs. As in the past, no SVOCs were detected, and no floating product was observed. A number of VOCs not associated with fuel storage activities continued to be detected in the MPF area wells. Low levels of TCA (up to 0.6 μg/L), PCE (up to 3.2 μg/L), and chloroform (up to 0.9 μg/L) were detected in upgradient well 076-25. These compounds are related to historical spills near building 650. In the downgradient wells, the highest VOC concentrations continue to be detected in well 076-380, where PCE was detected at concentrations up to 66 μg/L, well above the NYS AWQS of 5 μg/L. Low levels of TCE (7.7 μg/L) and TCA (up to 3.5 μg/L) were also detected in this well. Levels of the PCE breakdown product trans-1,2-dichloroethylene dropped to non-detectable levels by the end of 2005, and was only detected at a trace level during 2008 (**Figure 4-26**). Elevated levels of VOCs were also detected in OU IV monitoring well 076-185, located approximately 300 feet downgradient of well 076-380, with PCE concentrations of 9 μg/L and PCE breakdown product cis-1,2-DCE at a concentration of 10 μg/L. These solvents are believed to have originated from documented historical spills near the CSF building; their presence in groundwater is not the result of recent CSF or MPF operations.

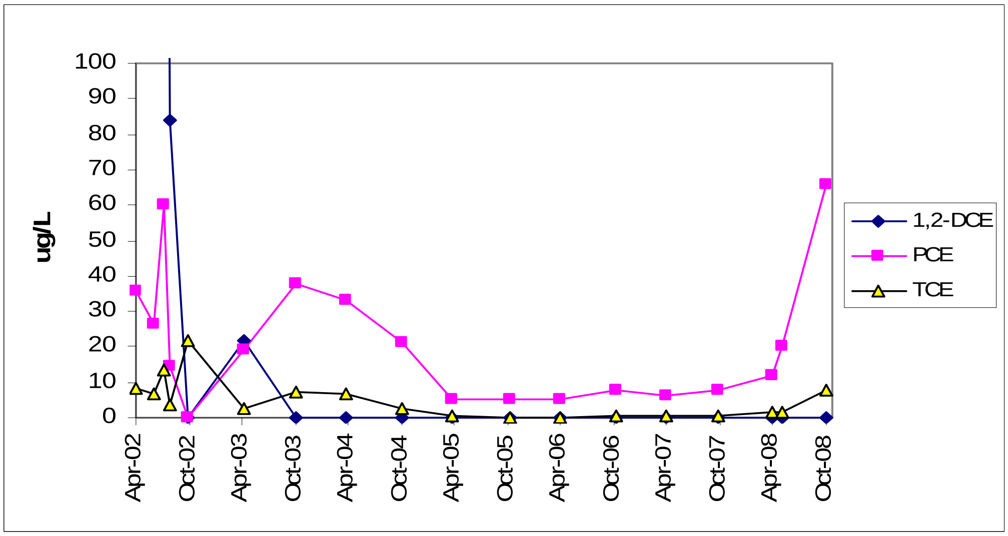
4.9.3 MPF Groundwater Monitoring Program Evaluation

Groundwater monitoring at the MPF continues to show that fuel storage and distribution operations are not impacting groundwater quality. The low levels of PCE and TCE detected in the groundwater in 2008 originated from historical solvent spills near Building 610. The historical nature of this contamination is supported by: 1) degreasing agents such as PCE have not been used at the CSF in many years, 2) PCE has been detected in several MPF area wells since the early 1990s, and 3) breakdown products of PCE have been detected. A number of historical spill sites near the CSF were identified in the late 1990s, and the contaminated soil was excavated in accordance with regulatory requirements.

4.9.4 MPF Recommendation

For 2009, monitoring will continue as required by the NYS operating permit.

Figure 4-26.
Major Petroleum Facility
VOC Concentrations in Downgradient Well 076-380.



4.10 Waste Management Facility (WMF)

The WMF is designed to safely handle, repackage, and temporarily store BNL-derived wastes prior to shipment to off-site disposal or treatment facilities. The WMF is a state-of-the-art facility, with administrative and engineered controls that meet all applicable federal, state, and local environmental protection requirements. The WMF consists of four buildings: the Operations Building, Reclamation Building (for radioactive waste), RCRA Waste Building, and the Mixed Waste Building.

Groundwater monitoring is a requirement of the RCRA Part B permit issued for WMF operations. The groundwater monitoring program for the WMF is designed to supplement the engineered and institutional controls by providing additional means of detecting potential contaminant releases from the facility. Because of the close proximity of the WMF to BNL potable supply wells 11 and 12, it is imperative that the engineered and institutional controls implemented at the WMF are effective in ensuring that waste handling operations do not degrade the quality of the soil and groundwater in this area.

4.10.1 WMF Groundwater Monitoring

Well Network

Groundwater quality at the WMF is currently monitored using seven shallow Upper Glacial aquifer wells. Five new downgradient monitoring wells were installed in late 2007 and incorporated into the monitoring program in February 2008. The new wells were positioned downgradient of the buildings based on the current southeast groundwater flow direction. Two wells (055-03 and 055-10) are used to monitor background water quality, and the five newly installed wells monitor groundwater quality downgradient of the three main waste handling and storage facilities. Wells 066-220 and 066-221 are located downgradient of the RCRA Building, wells 066-222 and 066-223 are located downgradient of the Reclamation Building, and well 066-224 is located downgradient of the Mixed Waste Building. The rest of the older wells are being maintained for the collection of water-level data, and the possible future collection of groundwater samples. Locations of the monitoring wells are shown on **Figure 4-27**.

Sampling Frequency and Analysis

During 2008, the WMF wells were sampled in February and August. Groundwater samples were analyzed twice for VOCs, tritium, gamma spectroscopy, gross alpha, and gross beta, and one time for metals and anions (e.g., chlorides, sulfates, and nitrates) (**Table 1-6**). A complete set of monitoring data and groundwater flow maps were provided to the NYSDEC in the *2008 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2009d).

4.10.2 WMF Monitoring Well Results

Radiological Analyses

Gross alpha and beta levels in samples from both upgradient and downgradient monitoring wells were consistent with background concentrations, and no BNL-related, gamma-emitting radionuclides were identified. Tritium was not detected in any of the WMF wells during 2008.

Non-radiological Analyses

The anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS. Sodium was detected at a concentration of 44 mg/L in downgradient well 066-220, above the 20 mg/L NYS AWQS. The elevated sodium concentrations detected in both upgradient and downgradient wells since 1999 are likely due to nearby road salting operations. No VOCs were detected at concentrations above NYS AWQS during 2008. However, as in past years, trace levels of chloroform were detected in some of the upgradient and downgradient monitoring wells, with a maximum concentration of 0.57 μg/L detected in upgradient well 055-03. Trace levels of methyl chloride were also reported for some of the upgradient and downgradient wells, at concentrations up to 0.14 μg/L. This compound is infrequently detected in WMF area monitoring wells.

4.10.3 WMF Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2008 were consistent with previous years' monitoring, and continued 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 elevated levels of sodium, the concentrations of chemicals and radionuclides analyzed were below NYS AWQS. Although there continue to be periodic detections of trace levels of tritium in the groundwater, a thorough review of waste management operations suggests that the tritium was not released from the WMF.

4.10.4 WMF Recommendation

For 2009, monitoring will continue as required by the RCRA Part B Permit.

4.11 Building 801

In early December 2001, approximately 8,000 gallons of stormwater seeped into the basement of Building 801. Analysis of the floodwater indicated that the water contained Cs-137 (up to 784 pCi/L), Sr-90 (594 pCi/L), and tritium (25,000 pCi/L). It is believed that the floodwater became contaminated when it came into contact with the basement floor, which contains significant residual contamination from historical radiological spills. When the floodwater was pumped from the basement on March 8, 2002, approximately 4,950 gallons of contaminated water were removed. Taking into account possible losses due to evaporation, estimates were that between 1,350 and 2,750 gallons of contaminated floodwater might have seeped into the soil below Building 801. To evaluate the potential impact of such a release to groundwater quality, BNL installed a new monitoring well immediately downgradient of the building and monitored several nearby wells.

4.11.1 Building 801 Groundwater Monitoring

Well Network

Four downgradient wells are used to evaluate potential impacts to groundwater from the 2001 floodwater event. Well 065-169 is approximately 10 feet south of Building 801, whereas wells 065-37 and 065-170 are approximately 80 feet downgradient of the building (**Figure 3.2.15-1**). These wells were installed in 1999 to monitor historical releases from the Waste Concentration Facility and the former Pile Fan Sump area. Well 065-37 is screened close to the water table, whereas wells 065-169 and 065-170 are screened approximately 10 feet below the water table. In order to monitor groundwater quality at the water table directly downgradient of Building 801, well 065-325 was installed in October 2002.

Sampling Frequency and Analysis

During 2008, Building 801 monitoring well 065-325 was sampled two times under the Facility Monitoring Program (**Table 1-6**). The samples were analyzed for gross alpha, gross beta, Sr-90, Cs-137, and tritium. Monitoring wells 065-37, 065-169, and 065-170 were sampled one to two times under the CERCLA program, and the samples were analyzed for Sr-90 and Cs-137 (**Table 1-5**).

4.11.2 Building 801 Monitoring Well Results

The April and October 2008 samples from well 065-325 had Sr-90 concentrations of 42 pCi/L and 34 pCi/L, respectively (**Figure 4-28**). As in previous years, tritium and Cs-137 were not detected in this well. Sr-90 concentrations in well 065-37 decreased from a high of 73.3 pCi/L in October 2007 to a maximum of 47 pCi/L in 2008. Tritium was detected in well 065-37 at a concentration of 5,700 pCi/L, which is well below the 20,000 pCi/L standard. Tritium has not been detected in this well since 1997. As in previous years, only low levels of Sr-90 were detected in deeper wells 065-169 and 065-170, with maximum concentrations of 0.8 pCi/L and 1.1 pCi/L, respectively. Cs-137 was not detected in any of the wells.

4.11.3 Building 801 Groundwater Monitoring Program Evaluation

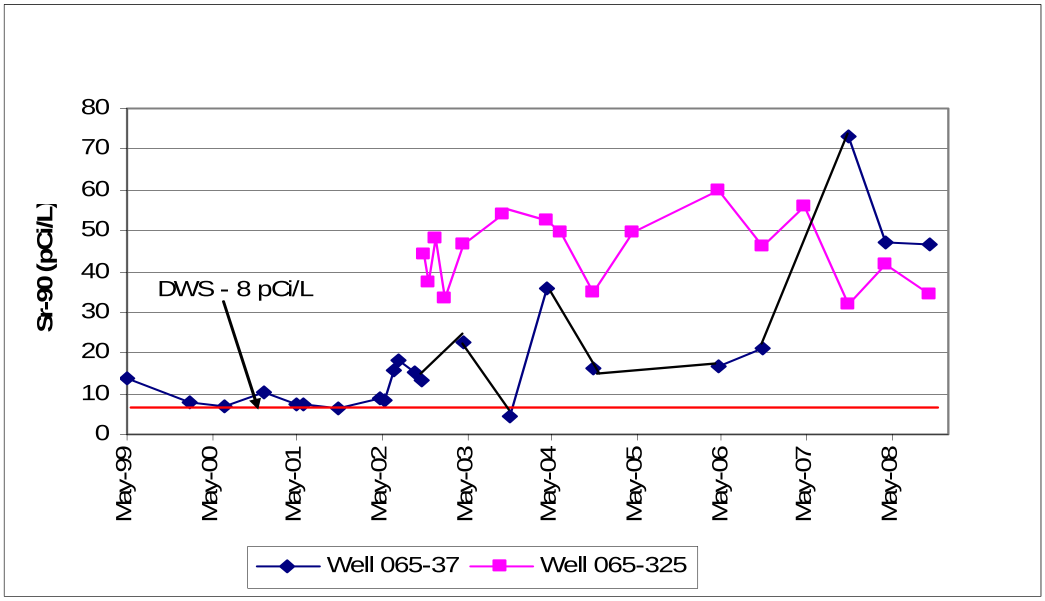
During 2008, Sr-90 concentrations in samples collected from shallow groundwater well 065-325 are consistent with pre-December 2001 values. Additionally, Cs-137 has not been detected in any of the groundwater samples since the floodwater event. It is estimated that from the December 2001 Building 801 floodwater release, it could take approximately 3 to 8 years for Sr-90 and approximately 100 years for Cs-137 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 from Building 801 or the nearby former Pile Fan Sump (**Section 3.2.15**). Because tritium was not detected in shallower well 065-325, it is unclear whether the low levels of tritium detected in well 065-37 are indicative of water released during the 2001 basement flooding event.

4.11.4 Building 801 Recommendations

The following is recommended for the Building 801 groundwater monitoring program:

- For 2009, the monitoring frequency for well 065-325 will continue to be semiannual, and one sample round will be conducted as close as possible to the planned annual sampling of wells 065-37, 065-169, and 065-170 under the CERCLA program.

Figure 4-28.
Building 801
Sr-90 Concentration Trends in Downgradient Wells 065-37 and 065-325.



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5.0 SUMMARY OF RECOMMENDATIONS

This section is provided as a quick reference to all of the recommendations included in **Sections 3** and **4**. The recommendations are sequenced as they appear in **Sections 3** and **4**. **Table 5-1** summarizes the changes to the monitoring well sampling programs.

5.1 OU I South Boundary Pump and Treat System

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

- Based on an elevated TVOC concentration in upgradient plume core well 107-40, the leading edge of the high concentration segment of the VOC plume is approaching the south boundary. As a result, full-time operation of extraction wells EW-1 and EW-2 will continue until further notice.
- Install up to nine shallow temporary wells using the Geoprobe® to characterize the current extent of the elevated area of Sr-90 contamination. These temporary wells will be installed in east-west transects beginning just south of monitoring well 107-35 and continuing to the north. Following review of the temporary well data, one or two monitoring wells may be installed.
- Add analysis of Sr-90 to system effluent sampling.
- Reduce and/or eliminate sample analyses for monitoring wells 098-33, 098-58, 098-59, 098-61, 107-10, 107-23, 107-24, 107-25, 107-26, 108-08, 108-12, 108-13, 108-14, 108-17, 108-18, 115-03, 115-30, 115-36 as described on **Table 5-1**. The frequencies have been reduced in these wells based on the lack of detections for given parameters over the past several years.
- The routine operation and maintenance monitoring frequency implemented in the fourth quarter of 2004 should be continued unless otherwise noted. Plume core and perimeter wells are monitored on a semiannual frequency. Sentinel and bypass wells are sampled at a quarterly frequency. Maintain a quarterly sampling frequency for well 107-40 to monitor the hot spot.

5.2 Carbon Tetrachloride Pump and Treat System

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

- Submit the Petition for Closure to the Regulators.
- Maintain the system in standby mode until the Petition for Closure is reviewed and approved.

5.3 Building 96 Air Stripping System

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

- Maintain operation of treatment well RTW-1 and downgradient recirculation wells RTW-2, RTW-3, and RTW-4. Continue operation until TVOC concentrations <50 µg/L are seen in the influent and adjacent monitoring wells. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Maintain integrity of the plastic liner covering the PCE-contaminated soils. Following regulator approval of the OU III ESD, excavate the PCE-contaminated soils from the vadose zone source area. This also involves the removal of monitoring well 085-353 located in the center of the proposed excavation area. Following excavation, three additional monitoring wells will be installed to monitor the effectiveness of the excavation, including a replacement for well 085-353.

- Once hexavalent chromium concentrations drop below allowable discharge levels and all monitoring wells in the vicinity of the pumping well are below these levels, treatment for chromium will be eliminated.
- Due to low historical TVOC detections, the sampling frequency for the following monitoring wells will be reduced as follows:
    - Wells 085-97, 095-171, and 095-296 will change from quarterly to annual.
    - Wells 095-294, 095-295, 095-307, and 095-308 will change from quarterly to semiannual.
    - The remaining monitoring wells will remain at the quarterly sampling frequency.
- Continue to analyze for total chromium and hexavalent chromium in the monitoring wells.

5.4 Middle Road Pump and Treat System

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

- Maintain the routine operation and maintenance monitoring frequency that began in 2003. However, the following wells will be changed to an annual sampling frequency due to consistent low VOC concentrations 105-52, 105-54, 113-06, 113-07, 113-16, 113-18, 113-20, and 113-21.
- Maintain extraction wells RW-4, RW-5, and RW-6 in standby mode during 2009. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal.
- Install a temporary well approximately 100 feet west of well RW-1 to identify the vertical distribution of contaminants in this area. Based on the results of this temporary well evaluate the pumping rates and pump locations in extraction wells RW-1, RW-2 and RW-3.

5.5 OU III South Boundary Pump and Treat System

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

- Maintain wells EW-6, EW-7, EW-8, and EW-12 in standby mode. The system’s extraction wells will continue to be sampled on a quarterly basis. The wells will be restarted if extraction or monitoring well data indicate TVOC concentrations exceed the 50 µg/L capture goal.
- Maintain the routine operations and maintenance monitoring frequency that began in 2003 except for the changes noted below.
- Stop sampling the following wells that have historically been below MCL’s: 121-07, 121-19, 122-02, 122-15, and 122-16. The following wells are to be reduced to an annual sampling schedule due to low VOC concentrations: 122-04, 122-19, 122-18, 122-20, 122-31, 122-32, 122-33, 122-34, and 122-35.

5.6 Western South Boundary Pump and Treat System

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

- Continue full-time operation of extraction well WSB-1, and pulse pumping of WSB-2 at the schedule of one month on and two months off. This process will continue and any changes to the VOC concentrations in the influent and the monitoring wells will be evaluated.
- If any of the three by pass detection w ells st arts showing increasing trends, the need to ta ke further action will be evaluated.

- Due to the elevated dichlorodifluoromethane detected at the deepest interval in WSB VP-7 between Middle Road and Princeton Avenue, a monitoring well will be installed in 2009. The data will be evaluated for approximately one year to determine if additional actions are necessary.
- Maintain the routine O&M monitoring frequency that began in 2005.
- Due to low historical detections of VOCs, the sampling frequency for monitoring wells 126-01 and 130-04 will be reduced from semiannual to annual.

5.7 Industrial Park In-Well Air Stripping System

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

- The current routine operations and maintenance monitoring frequency will be maintained during 2009.
- The system will continue operations at 60 gpm per well except for well UVB-1, which is to remain in a standby mode. It is recommended that well UVB-7 be placed in standby as TVOC concentrations have dropped to below 5 µg/L in this well. Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, well UVB-1 or UVB-7 will be restarted.
- Wells 000-272 and 000-280 plume perimeter wells should be changed to an annual sampling schedule, as these wells have historically shown low VOC concentrations.

5.8 Industrial Park East Pump and Treat System

The following is the recommendation for the Industrial Park East Pump and Treat System and groundwater monitoring program:

- Submit Petition for Shutdown to the Regulators in July 2009. The system has met all shutdown requirements.

5.9 North Street Pump and Treat System

The following is recommended for the North Street Pump and Treat System and groundwater monitoring program:

- Maintain the operations and maintenance sampling frequency for monitoring wells.
- Due to historically low VOC concentrations, the sampling frequency for monitoring wells 000-108, 000-154, and 000-212 will be reduced from semiannual to annual.
- Due to the location of well 086-43 north of the Former Landfill and since groundwater samples have not exceeded DWS since it was installed, it is recommended that this well be dropped from the North Street monitoring program.
- VOCs have remained below DWS for wells 115-33, 115-34, and 115-35 since they were installed in 1996, and there have been no detections above DWS for well 115-32 since 2004. Additionally, tritium concentrations have been less than 400 pCi/L in each of these four wells since they were installed. As a result, it is recommended that these four wells be dropped from the North Street monitoring program.

5.10 North Street East Pump and Treat System

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

- Continue pulse pumping of both extraction wells. The pulse pumping consists of having the system on for one month, then off in standby mode for the next month. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, the extraction well(s) will be put back into full-time operation.
- Following the review of additional monitoring well data, a Petition for Shutdown of the system will be prepared.
- Change the monitoring frequency for the monitoring wells from routine operations and maintenance to shutdown monitoring in the second quarter 2009. This calls for all NSE monitoring wells to be sampled quarterly.
- It is recommended that monitoring well 000-394 be added to the North Street East well network.

5.11 LIPA/Airport Pump and Treat System

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

- Continue the airport extraction wells pulse-pumping schedule of pumping one week per month except for wells RTW-1A and RW-6A, which will continue with full-time operations. Discontinue full-time pumping of well RTW-3A since VOC concentrations in this well are now well below MCLs and have been for over six months. This well will revert back to the one week per month pumping schedule. If concentrations above the capture goal of 10 µg/L TVOCs are observed in any of the extraction wells or the monitoring wells adjacent to them, the well(s) will be put back into full-time operation.
- Maintain LIPA wells EW-1L and EW-3L in standby mode. These extraction wells will be restarted if TVOC concentrations rebound above the 50 µg/L capture goal in either the plume core monitoring wells or the extraction wells.

5.12 Magothy Monitoring

The following is recommended for the Magothy groundwater monitoring program:

- Continue the current monitoring schedule for the Magothy monitoring program, except for wells 000-428 and 115-50. Well 000-428 will be changed from quarterly to semiannual and well 115-50 from quarterly to annual.

5.13 Central Monitoring

The following is recommended for the OU III Central groundwater monitoring program:

- Based on the lack of VOC detections above standards, wells 064-03, 066-08, 066-09, 075-01, 075-02, 105-05, and 105-06 should be dropped from the sampling program.

5.14 Off-Site Monitoring

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

5.15 South Boundary Radionuclide Monitoring Program

The following are recommendations for the OU III South Boundary Radionuclide groundwater monitoring program:

- Due to the wells' locations and the lack of detections of radionuclides, it is recommended that the following wells be dropped from the sampling program: 119-03, 124-02, 125-01, and 099-10.

- Due to the lack of detections of radionuclides, it is recommended that gamma and tritium analyses be dropped from the well 107-10 sampling.

5.16 BGRR/WCF Strontium-90 Treatment System

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

- Perform pre-design groundwater modeling for modifying the system to address the high concentration Sr-90 area in the vicinity of the HFBR. Utilize the fourth quarter 2008 permanent and temporary well data and the first-quarter 2009 temporary well data for model initialization. Determine the number and placement of extraction wells necessary to remediate this area and reduce Sr-90 concentrations to levels that will allow for achievement of OU III ROD cleanup goals.
- Install additional extraction wells to address the Sr-90 hot spot identified in the WCF plume. The modification to the existing Sr-90 treatment system will consist of several new extraction wells. The location and exact number of wells will depend on the distribution of the hot spot following the departure/attenuation of the g-2 tritium slug from this area. It is currently estimated that the modification will be implemented in 2010.
- For the BGRR Sr-90 plume, install temporary wells near 075-670 and 075-671 to determine the width of the downgradient portion of the plume.
- Install a temporary well adjacent to monitoring well 075-664 to determine if a permanent well screened at a shallower depth is necessary at this location.
- Eliminate sampling at monitoring wells 065-11 and 065-177. These wells are significantly outside of the current plume position and have not detected more than trace levels of Sr-90 over a number of years.
- Install a temporary well approximately 75 feet north of monitoring well 075-86 at the corner of Cornell Avenue to characterize the centerline of the PFS plume.

5.17 Chemical/Animal Holes Strontium-90 Treatment System

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

- Due to the low influent concentrations, continue pulse pumping of EW-1 (one month on, one month off). If concentrations in this extraction well increase significantly, then EW-1 will be put back into full-time operation. Continue to operate extraction wells EW-1, EW-2 and EW-3 between 5 and 7 gpm.
- Maintain the operations and maintenance phase monitoring well sampling frequency started in 2007.
- Drop well 114-01 from the monitoring program since there have been no historical detections of Sr-90 in this well.
- Install temporary wells adjacent to monitoring well 106-48 to determine the extent of the Sr-90 contamination detected in this well. Following review of the temporary well data, a monitoring well may be installed.

5.18 HFBR Tritium Pump and Recharge System

The following are recommendations for the HFBR Tritium Pump and Recharge System and monitoring program:

- Reduce the sampling frequency for 11 wells along Cornell Avenue (075-225, 075-228, 075-231, 075-234, 075-237, 075-240, 075-244, 075-42, 075-43, 075-44, and 075-45) from monthly to quarterly. The sampling frequency for these wells was increased during the fall of 2006 in response to a water leak in the HFBR building. There is no need to continue data collection at a monthly frequency as this leak has had no impact on groundwater.
- Reduce the sampling frequency for tritium for a number of wells as noted on **Table 5-1**. It is now well documented that these wells are outside the plume perimeter and, in most cases, there is another well located between these wells and the plume.
- Continue to install and sample temporary wells twice per year over the next several years to characterize the location of the high tritium concentration area approaching EW-16. Results will be communicated to the regulators via the IAG conference call and quarterly/annual reports.
- Continue operating EW-16 and EW-11 in 2009. Monitor tritium concentrations in EW-16 on a weekly basis.
- The pump and recharge well(s) will be operated until the tritium concentrations from Weaver Drive to EW-16 drop below 20,000 pCi/L. The estimated operational duration of 2 to 4 years (2011 to 2013) is based on the length of the high concentration area slug and the time it would take to be completely captured by EW-16. The decision to turn the wells back to standby will be based on:
  - concentrations of tritium decreasing to less than 20,000 pCi/L in the monitoring wells at Weaver Drive as well as the extraction wells, and
  - verification that the new extraction well has captured concentrations of tritium in this area greater than 20,000 pCi/L. A decision to turn the wells back to standby will be supported with data from additional permanent and temporary wells, as needed.

5.19 OU IV AS/SVE System Post Closure Monitoring

The following is the recommendation for the OU IV AS/SVE Post Closure Monitoring program:

- Collect a sample from well 076-185 for VOC analyses during the second-quarter 2009 to confirm the detections of cis-1,2-dichloroethylene and tetrachloroethylene.

5.20 Building 650 (Sump Outfall) Strontium-90 Monitoring

The following recommendations are made for the Building 650 Strontium-90 Groundwater Monitoring Program:

- Reduce the sampling frequency for monitoring wells 076-167, 076-183, 076-20, and 076-262 from semiannual to annual. These are all perimeter wells that have not been detecting Sr-90 over the past several years. Eliminate sampling of monitoring wells 076-10, 076-182, 076-264, 076-265, and 076-27. After approximately ten years of monitoring these wells, BNL has established that they are outside of the plume and are no longer providing useful data. The sampling of wells can be resumed and sampling frequencies increased if warranted by future changes in groundwater flow conditions.

- Install two to three temporary wells approximately 150 feet south of monitoring well 076-24 to a depth of 60 feet bls. The data will help in characterizing the leading edge of the plume and the width of the plume in this area. A permanent monitoring well may be installed pending the results.

5.21 Operable Unit V

The following recommendation is made for the OU V plume groundwater monitoring program:

- It appears that the OU V VOC plume has largely attenuated. No individual VOC exceeded the NYS AWQS in 2008. It is recommended that the monitoring well network be sampled on an annual basis for one more year. If individual VOC concentrations and tritium remain below NYS AWQS during 2009, BNL may recommend reducing the number of wells being monitored.

5.22 Operable Unit VI EDB Pump and Treat System

The following recommendations are made for the OU VI EDB Pump and Treat System and groundwater monitoring program:

- Maintain routine operations of the treatment system.
- Since there have been no historical detections of EDB above the DWS, except on one occasion for well 000-180 in 2001, sampling of monitoring wells 000-180, 000-285, 058-02, 089-13, 089-14, 099-06, 099-10, and 100-14 will be eliminated.
- For the remainder of the wells, maintain the routine operation and maintenance monitoring frequency.

5.23 Site Background Monitoring

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

5.24 Current Landfill Groundwater Monitoring

The following recommendations are made for the Current Landfill groundwater monitoring program:

- The sampling frequency for organic and inorganic compounds should be reduced from quarterly to semiannual, except for VOCs in wells 088-22 and 088-23. Based on the lack of VOC detections in these wells, the VOC analyses in wells 088-22 and 088-23 should be reduced from semiannual to annual. Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium and gamma spectroscopy will continue on an annual basis. .

5.25 Former Landfill Groundwater Monitoring

The following recommendations are made for the Former Landfill groundwater monitoring program:

- The monitoring frequency of all non-radiological parameters will be reduced from semiannual to annual.
- Based on the lack of detections of gross alpha and beta above 10% of the groundwater standard, it is recommended that these parameters be dropped from the sampling program. Individual radionuclide analyses for strontium-90, tritium, and/or gamma spectroscopy will continue.

5.26 Alternating Gradient Synchrotron (AGS) Complex

The following recommendations are made for the AGS Complex groundwater monitoring programs:

- For 2009, the Building 912 wells used to track the g-2 tritium plume will continue to be sampled semiannually, whereas the remainder of the AGS Complex monitoring wells will continue to be sampled annually.

5.27 g-2 Tritium Source Area and Groundwater Plume

In accordance with g-2/BLIP/UST ROD requirements, BNL will continue to monitor groundwater quality downgradient of the g-2 source area until the source is no longer a threat to groundwater quality. The following recommendations are made for the g-2 Tritium Source Area groundwater monitoring program:

- For 2009, BNL will continue to monitor the g-2 source area wells on a quarterly basis, and the g-2 wells located downgradient of Building 912 will continue to be monitored semiannually.
- During the summer/fall of 2009, additional temporary wells will be installed along Transect D and Transect E to track the leading edge of the g-2 plume.
- To fulfill the monitoring requirements defined in the ROD, BNL will continue to track the plume until the tritium concentrations drop below the 20,000 pCi/L DWS.

5.28 Brookhaven Linac Isotope Producer Facility

Because tritium levels in groundwater have been continuously below the 20,000 pCi/L DWS since January 2006, BNL proposes reducing the monitoring frequency for the downgradient monitoring wells 064-47, 064-48, and 064-67 from quarterly to semiannually starting in 2009. Sampling frequency for the two upgradient and two downgradient wells will be changed from semiannual to annual.

5.29 Relativistic Heavy Ion Collider Facility

For 2009, groundwater samples will continue to be collected on a semiannual basis.

5.30 Brookhaven Medical Research Reactor Facility

The monitoring frequency for the BGRR wells will continue to be once every two years, with the next set of samples being collected in 2010.

5.31 Sewage Treatment Plant

No changes to the STP groundwater monitoring program are proposed for 2009.

5.32 Motor Pool Maintenance Area

No changes to the Motor Pool groundwater monitoring program are proposed for 2009.

5.33 On-Site Service Station

No changes to the Service Station groundwater monitoring program are proposed for 2009.

5.34 Major Petroleum Facility Area

No changes to the MPF groundwater monitoring program are proposed for 2009.

5.35 Waste Management Facility

For 2009, monitoring will continue as required by the RCRA Part B Permit.

5.36 Building 801

For 2009, the monitoring frequency for well 065-325 will continue to be semiannual, and one sample round will be conducted as close as possible to the planned annual sampling of wells 065-37, 065-169, and 065-170 under the CERCLA program.

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