BROOKHAVEN NATIONAL LABORATORY

2009

Site Environmental Report

GROUNDWATER STATUS REPORT

VOLUME II

2009
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	United States 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
ER	Emissions Rate
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	milliCuries
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDL	Minimum Detection Limit
mg/kg	milligrams per kilogram
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	picoCuries 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

2009 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 *2009 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 450.1A, 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 2009, 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 2009. **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 2009:

- The desired flow conditions continued to be maintained in the central portion of the site during 2009, with 75 percent of the supply well 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 2009.
- Total annual precipitation in 2009 was 54.2 inches, which is above the yearly average of 48 inches. Nine of the past 12 years have featured above-normal average precipitation at BNL.

GROUNDWATER RESTORATION (CERCLA)

Table E-1 summarizes the status and progress of groundwater cleanup at BNL under the provisions of CERCLA. During 2009, 11 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 2009, 229 pounds of VOCs were removed from the aquifers by the treatment systems. To date, 6,363 pounds of VOCs have been removed from the aquifer. The Operable Unit (OU) III Chemical/Animal Holes Sr-90 System removed 0.46 milli Curies (mCi) of Sr-90 from the Upper Glacial aquifer in 2009, for a total of 3.79 mCi since operations began in 2003. The OU III Brookhaven Graphite Research Reactor (BGRR) Sr-90 System removed 1.4 mCi of Sr-90 during the year, for a total of 17.5 mCi since operations began in 2005.

While groundwater remediation is expected to be a long-term process, there are noticeable improvements in groundwater quality for 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 is being decommissioned in 2010. A number of individual extraction wells have been placed on standby because of remediation progress. A petition for shutdown of Industrial Park East System was approved in 2009. The submittal of a petition to shutdown the North Street East System is anticipated for 2010. The OU V/STP VOC plume attenuated to below Drinking Water Standards (DWS) in 2009. 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

2009, are summarized on **Figures E-1** and **E-2**, respectively. Significant items of interest during 2009 were the following:

- A total of 698 monitoring wells were sampled as part of the CERCLA Groundwater Monitoring Program, comprising a total of 1,617 groundwater samples. In 2009, 70 temporary wells were also installed under the CERCLA program. BNL continued to make significant progress in characterizing and restoring groundwater quality at the site.
- 1.7 billion gallons of groundwater were treated, and 229 pounds of VOCs and 1.9 mCi of Sr-90 were removed from the aquifer. (**Table E-1**).

Table E-1.
BNL Groundwater Remediation System Treatment Summary for 1997 – 2009.

	1997 – 2008		2009	
VOCs Remediation (start date)	Water Treated (gallons)	VOCs Removed (pounds)(c)	Water Treated (gallons)	VOCs Removed (pounds)(c)
OU III South Boundary (June 1997)	3,319,952,850	2,630	201,000,000	85
OU III Industrial Park (Sept. 1999)	1,492,478,330	1,033	148,000,000	12
OU III W. South Boundary (Sept. 2002)	667,647,000	54	115,300,000	12
OU III Carbon Tetrachloride (Oct. 1999)	153,538,075	349	0	0
OU I South Boundary (Dec. 1996)	3,442,314,000	347	172,000,000	6.4
OU III HFBR Tritium Plume (May 1997) (a)	334,987,000	180	103,000,000	0
OU IV AS/SVE (Nov. 1997) (b)	0	35	0	0
OU III Building 96 (Feb. 2001)	172,297,416	98	50,000,000	9
OU III Middle Road (Oct. 2001)	1,417,411,550	799	177,500,000	63
OU III Industrial Park East (May 2004)	320,172,000	35	37,000,000	3
OU III North Street (June 2004)	869,122,000	290	135,000,000	10
OU III North Street East (June 2004)	492,976,000	24	74,000,000	6
OU III LIPA/Airport (June 2004)	1,072,887,000	260	266,000,000	23
OU VI EDB (August 2004)	624,711,000	NA(d)	164,000,000	NA (d)
Totals	14,380,485,221	6,134	1,642,800,000	229

	2003 – 2008		2009	
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)	18,404,826	3.33	6,200,000	0.46
OU III BGRR (June 2005)	30,951,000	16.1	8,500,000	1.4
Totals	49,355,826	19.4	14,700,000	1.86

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 BGRR/Waste Concentration Facility (WCF) Sr-90 Treatment System will be modified in 2010 to incorporate four additional extraction wells to address the downgradient high concentration area. Groundwater monitoring and characterization over the five years that this system has been in operation indicates that source area Sr-90 concentrations in the vicinity of both the WCF and the Building 701 areas have not shown marked decreases. There may be a continuing source of Sr-90 in these areas. Sr-90 from both of these source areas is presently being captured and treated by source area extraction wells, thereby preventing any plume growth.
- The Operable Unit III Explanation of Significance for the Building 96 Groundwater Treatment System was signed by the regulators in September 2009 and calls for the removal of the PCE contaminated source area soils. This work is planned for 2010.
- There have been significant improvements to the OU I South Boundary VOC plume over the previous 14 years. However, based on the slower than expected migration rate of a small area of elevated VOCs, located in a low permeability unit approximately 500 feet north of the south boundary, it does not appear that the ROD cleanup goals would be met if the extraction wells are shutdown in 2011 as originally planned. BNL will evaluate extending the operational duration of the existing extraction wells to ensure that the cleanup goal is attained. Based on the peak Sr-90 concentrations characterized to date, groundwater modeling shows this area of Sr-90 reaching the site boundary at concentrations below the DWS in approximately 12 years.
- The High Flux Beam Reactor (HFBR) Tritium Pump and Recharge system was operational during 2009 with extraction well EW-16 capturing the downgradient high concentration tritium slug. The system is expected to remain operational for several years until this small area has been completely captured, and tritium concentrations in the area decrease below the 20,000 pCi/L DWS. Tritium concentrations immediately downgradient of the HFBR remained below the DWS during 2009, providing evidence that the inventory of tritium remaining in the unsaturated zone beneath the building continues to diminish.
- Temporary well characterization of the Building 650 and Sump Outfall Sr-90 plume in 2009 showed the area of highest concentrations approximately 500 feet north of Brookhaven Avenue. The new data will be used to update the groundwater model and determine when the plume is expected to attenuate to below DWS.
- Elevated concentrations of Dichlorodifluoromethane (Freon-12) were detected in a permanent well in the OU III Western South Boundary area during 2009 sampling events. This well had been installed following a detection of Freon-12 during groundwater characterization in 2008. The *2008 BNL Groundwater Status Report* recommended evaluating this contamination following a year of well monitoring. Additional characterization is recommended for 2010 to determine the extent of this contamination.

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 2009, 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
- Conduct five-year reviews (next scheduled for 2010), as required by CERCLA, until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program
- Implement controls on the installation of new supply wells and recharge basins on BNL property
- Provide public water service in plume areas south and east of BNL
- Place prohibitions on the installation of new potable water-supply wells where public water service exists (Suffolk County Sanitary Code Article 4)
- Implement 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

During 2009, the Facility Monitoring Program monitored groundwater quality at 10 research and support facilities. Groundwater samples were collected from 108 wells, for a total of approximately 183 individual samples. BNL also installed nine temporary wells to track the downgradient segment of the g-2 Tritium Plume. Although no new impacts to groundwater quality were discovered during 2009, 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 On-Site Service Station.

Highlights for the Facility Monitoring Program are as follow:

- Tritium continues to be detected in the g-2 Tritium Source Area monitoring wells at concentrations above the 20,000 pCi/L DWS. A short-term spike in tritium levels was observed in October 2009, with a tritium concentration of 138,000 pCi/L. Tritium concentrations in the source area wells dropped to less than 63,000 pCi/L by January 2010. 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 deep vadose zone following significant natural periodic fluctuations in the local water table.
- 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 92,200 pCi/L. This concentration was observed in a temporary well installed approximately 400 feet south of the HFBR facility, along Temple Place road. The southern extent of the plume was tracked to the north side of the National Synchrotron Light Source (NSLS), where a maximum tritium concentration of 78,600 pCi/L was detected. As a result of natural radioactive decay and dispersion in the aquifer, the tritium plume is 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 DWS since April 2006. The maximum tritium concentration during 2009 was 4,240 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.

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 a permanent well approximately 75 feet north of EW-1 and EW-2. Based on data from the new monitoring well, evaluate the alternatives of either increasing the operational duration of EW-1 and EW-2 or adding a third extraction well in order to achieve the cleanup goals. Install two new sentinel wells approximately 200 feet south of the Princeton Avenue firebreak road to monitor for the leading edge of the Sr-90 plume.
- **Building 96 System** – Install temporary wells upgradient of recirculation wells RTW-2, RTW-3, and RTW-4. If VOCs in these wells and the recirculation wells are below 50 µg/L, then wells RTW-2, RTW-3, and RTW-4 will be placed in standby mode. Maintain a monthly sampling frequency of the influent and effluent for each well. Based on the results of the data from the three temporary wells installed along Weaver Drive, a permanent well will be installed.
- **Middle Road System** – Install one temporary well approximately 300 feet west of monitoring well 104-36 and based upon the results of this temporary well install a monitoring well to monitor the progression of higher upgradient concentrations of TVOCs to the treatment system. Install a monitoring well centered on the high concentrations identified in the recent temporary well near well RW-1.
- **OU III South Boundary System -** Install a temporary well near well EW-4 to evaluate the depth of the high concentrations of VOCs are near this extraction well. This well should be installed at the Upper Glacial - Magothy Brown Clay interface (approximately -160 feet below MSL). This will help evaluate whether the VOCs detected in well 121-43 are caught in the stagnation zone or may be passing under well EW-4.
- **OU III Western South Boundary System** – Due to indications of increased TVOC concentrations in plume core monitoring wells in close proximity to extraction well WSB-1, installation of a permanent monitoring well should be implemented during 2010. The well should be located approximately 700 feet north of WSB-1. Install two temporary wells in the vicinity of Princeton Avenue to better define the northerly portion of the core area of the plume where higher concentrations of Freon-12 have been observed.
- **Industrial Park System -** It is recommended that well UVB-2 be placed in standby as TVOC concentrations have dropped to below 5 µg/L and all of the monitoring wells in the vicinity are below 50 µg/L. A temporary well should be installed and sampled between wells UVB-3 and UVB-4 to evaluate the VOC concentrations in this area. If concentrations in well 000-262 drop below the 50 µg/L TVOC capture goal a petition to shutdown this system may be submitted to the regulators.
- **Industrial Park East System** – Install one additional downgradient monitoring well in the vicinity of well 000-107 on Stratler Drive to monitor Magothy contamination identified in well 000-494.
- **North Street System –** It is recommended to begin pulse-pumping extraction well NS-1, one month on and one month off during 2010 due to TVOC concentrations below the 50 µg/L capture goal in upgradient monitoring wells. If there is any rebounding of higher TVOC concentrations the extraction well will be placed back in full-time operation.

- **North Street East System –** Extraction well NSE-1 will remain in full-time operation. Extraction well NSE-2 will be shut off, and placed in a stand-by mode. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, NSE-2 will be put back into full-time operation. Install a temporary well northwest (upgradient) of monitoring well 000-477 to determine the vertical extent of TVOC concentrations.
- **LIPA/Airport System** - Place LIPA Well EW-2 in standby as this well was below New York State Ambient Water Quality Standard (NYS AWQS) throughout 2009.
- **BGRR/WCF Sr-90 System –** Install four additional extraction wells during 2010 to address the Sr-90 hot spots identified in the WCF plume. Install several temporary wells to characterize Sr-90 concentrations in the WCF source area. Install sentinel wells on the south side of Brookhaven Avenue to monitor the leading edge of the BGRR Sr-90 plume. Characterize the width of the plume at the well 075-664 location and install a new permanent monitoring well for the BGRR Sr-90 plume adjacent to monitoring well 075-664 screened at a shallower depth. Install temporary wells at Brookhaven Avenue to characterize the leading edge of the Pile-Fan Sump plume.
- **Chemical/Animal Holes Sr-90 System –** Complete temporary well investigations in the vicinity of monitoring well 106-48 to determine the current plume perimeter.
- **HFBR Tritium System** - Increase the sampling frequency for monitoring wells 075-42, 075-43, 075-44, and 075-45 to monthly as a result of the historical high water-table elevations during 2010 to monitor for any corresponding source area tritium releases. Continue monitoring for six months and then re-evaluate based on water-table conditions and observed tritium data. 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.
- **Building 650 Sump Outfall Sr-90 and g-2 Plumes** – Update the groundwater model with the 2009/2010 characterization data and run a new simulation to predict the expected time frame for achieving drinking water standards by natural attenuation of the plume. Install two monitoring wells in the downgradient plume core area and a sentinel well near the leading edge of the plume.
- **CERCLA Groundwater Monitoring Program** – Adjust the sampling frequencies for a total of 64 monitoring wells as described in the individual program recommendations.

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	2011-15	Higher VOC concentration area of plume migrating slower than expected.
Current Landfill	VOCs tritium	Long Term Monitoring & Maintenance	Landfill capping	NA	Groundwater continues slow improvement. 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	Sr-90 data from 2009 characterization indicates concentrations will bebelow DWS before reaching site boundary.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-1 pulse pumping)	P&T with ion exchange (IE)	2014	System performing as expected. Began characterization of Sr-90 in western perimeter well.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Standby	P&T with carbon	2009 (Complete)	Petition for closure signed in 2009. System to be decommissioned in 2010.
Building 96 source control	VOCs	Operational	Recirculation wells with AS for 3 of 4 wells. RTW-1 is P&T with AS.	2016	System pumping and treating high concentrations of VOCs. Source area soil remediation scheduled for 2010.
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 one well 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

Project	Target	Mode	Treatment Type	Expected System Shutdown	Groundwater Quality Highlights
OU III (cont.)					
Western South Boundary	VOCs	Operational (Pulse)	P&T with AS	2019	Freon-12 detected during 2008 persisting in monitoring well. Additional characterization planned.
Industrial Park	VOCs	Operational (UVB-1 on standby)	In-well stripping	2012	VOC concentrations continued to decline. Place UVB-2 on standby.
Industrial Park East	VOCs	Standby	P&T with carbon	2009 (Complete)	Monitoring remaining low VOC concentrations.
North Street	VOCs	Operational	P&T with carbon	2012	Plume concentrations continue to decrease. Begin pulse pumping NS-1.
North Street East	VOCs	Operational (Pulse)	P&T with carbon	2010	Concentrations in plume core wells at very low levels in 2009. Prepare petition for shutdown.
Long Island Power Authority (LIPA) Right of Way/ Airport	VOCs	Operational	P&T and recirculation wells with carbon	2014 (LIPA) 2019 (Airport)	Airport wells continued pulse pumping in 2009. Place LIPA well EW-2 in standby.
HFBR Tritium	Tritium	Operational	Pump and recharge	2012	Leading edge of high concentration slug being captured by EW-16. Concentrations in source area wells remained below DWS throughout 2009.
BGRR/WCF	Sr-90	Operational	P&T with IE	2026	Continuing source areas observed at both the WCF and Building 701. System modification design in progress.
OU IV					
OU IV AS/SVE system	VOCs	Decommis-sioned	Air sparging/ soil vapor extraction	2003 (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)	NA	Plume characterized in 2009. Higher concentration area of plume ~500' north of Brookhaven Avenue.
OU V					
STP	VOCs, tritium	Long Term Response Action	MNA	NA	VOC plume has largely attenuated to below DWS.
OU VI					
Ethylene Dibromide (EDB)	EDB	Operational	P&T with carbon	2015	The EDB plume continues to migrate as predicted. The extraction wells are capturing the plume.

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 2009 Groundwater Status Report* is a comprehensive summary of groundwater data collected in calendar year 2009 that provides an interpretation of information on the performance of the Groundwater Protection Program. This is the 13 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 2009, 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 2009. 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. **Appendix H** contains the RW-2 Middle Road Pump Test Report, dated September 2009.

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, and 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 2009 Environmental Monitoring Plan* (BNL 2009a). 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 2009 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 2009 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
Plum	e Perimeter	2	4x
Senti	nel/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
Plum	e Perimeter	2	4x
Senti	nel/Bypass	2	4x
Standby Monitoring	Key Plume Core	5	2x
Plum	e Perimeter	5	1x
Senti	nel/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 2009, 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 2009, 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. However, one homeowner had iron detected in their well above standards. The groundwater in this section of Long Island often has naturally occurring iron at concentrations above standards.
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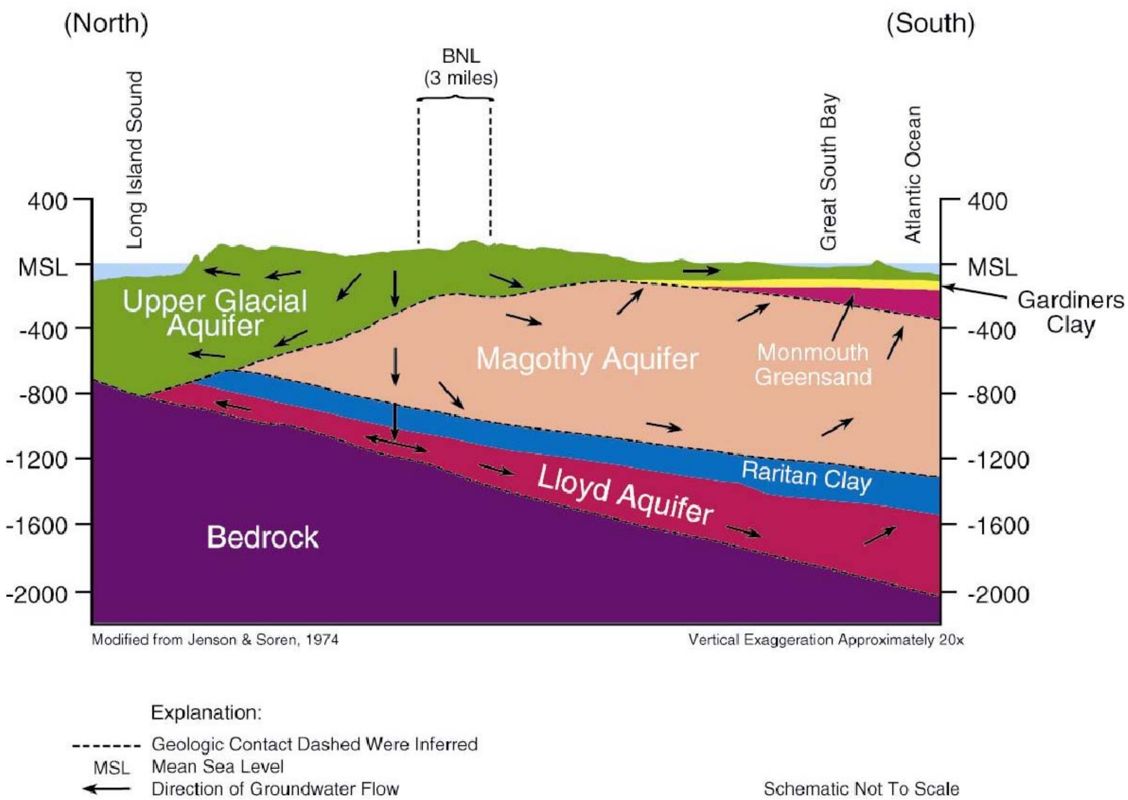
2.0 HYDROGEOLOGY

This section briefly describes the hydrogeologic environment at BNL and the surrounding area. It also summarizes the dynamics of the groundwater flow system in 2009, 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 the 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 2009 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 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.

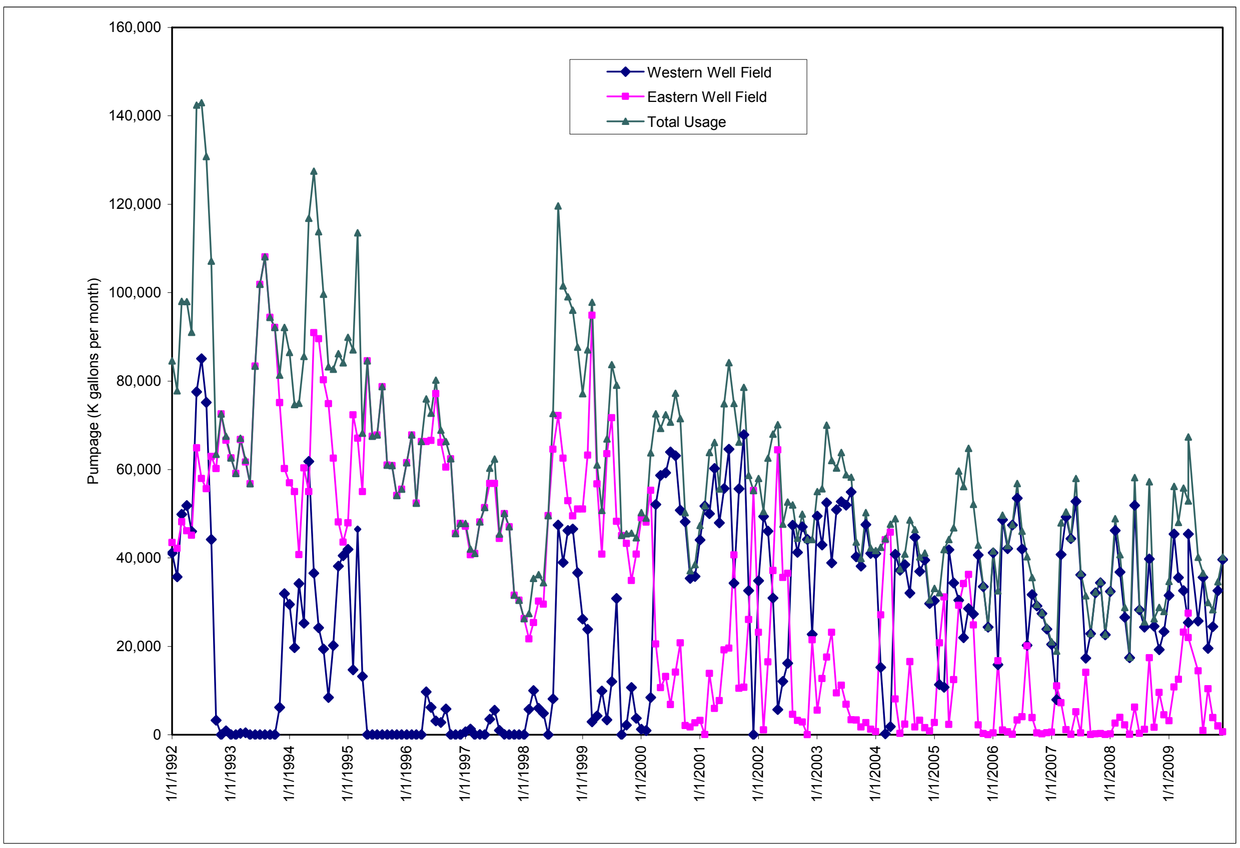
The synoptic water-level measurement events comprising the complete network of on-site and off-site wells were conducted in June 2009 with data collected from approximately 775 wells. Smaller scale synoptic measurement using wells located only in the central part of the BNL site were conducted in March and September 2009, with data collected from approximately 100 shallow Upper Glacial aquifer 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 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 2009, 19 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 2009 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 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. Supply well 12 has been out of service since October 2008, when a propane gas explosion destroyed the pump house and associated pump controls. 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.

Figure 2-4.
Summary of BNL Supply Well Pumpage 1992 through 2009.



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 2009, a total of 525 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 75 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 (specifically on the g-2 tritium plume and the Waste Concentration Facility Sr-90 plume). However, with the loss of well 12 in October 2008, in early 2009 BNL started to use well 10 for short periods of time. **Table 2-2** summarizes the 2009 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 Parkway 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 2009 is provided as **Figure 2-5.** In 2009, the William Floyd Parkway (Parr Village) and Country Club Drive Well Fields produced 456 and 318 million gallons for the year, respectively. The Lambert Avenue Well Field, located south of BNL, produced 297 million gallons for the year.

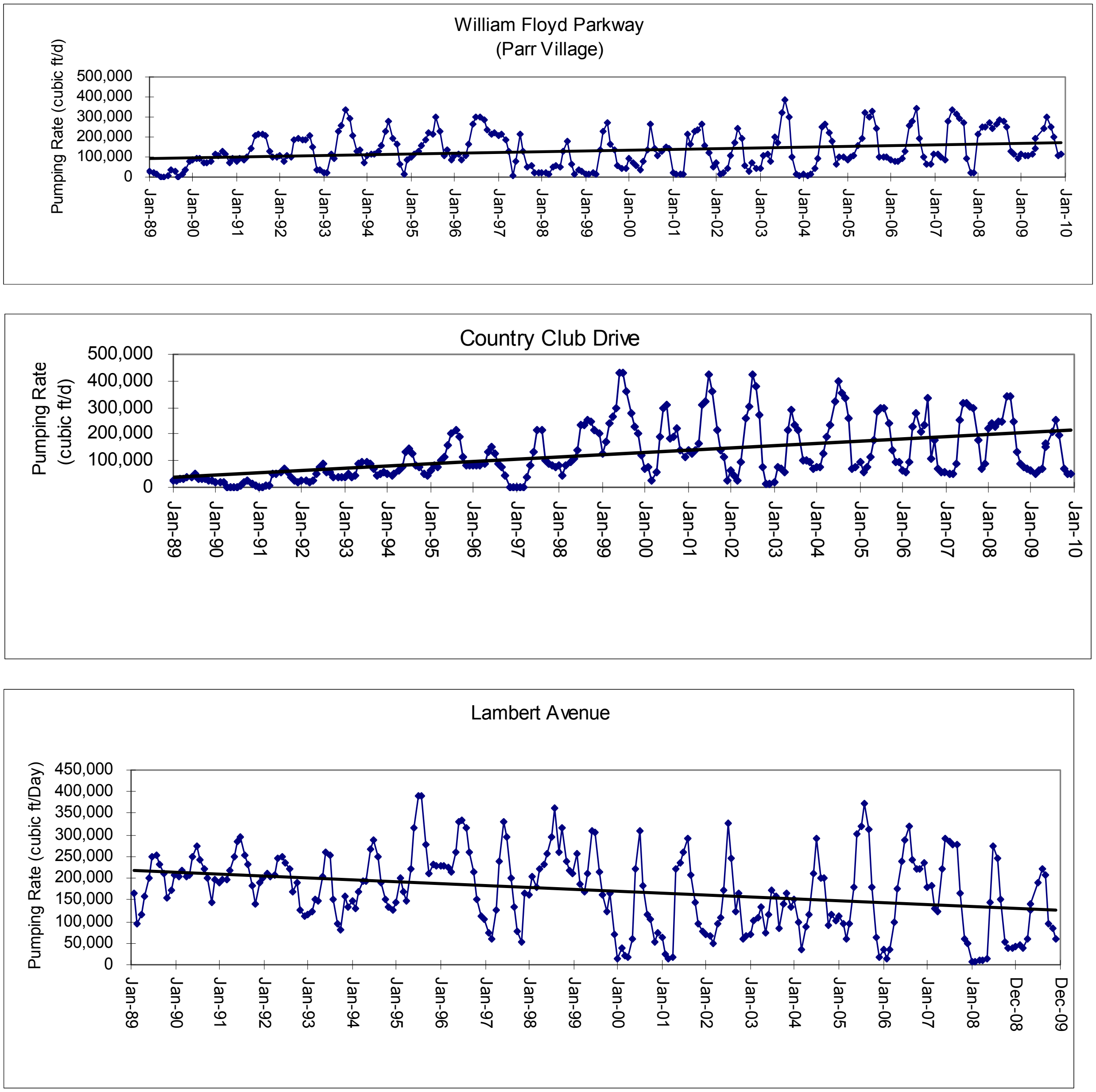
2.1.4 Summary of On-Site Recharge and Precipitation Data

This section summarizes artificial (i.e., on-site recharge basins) and natural recharge from precipitation. **Table 2-3** summarizes the monthly and total flow of water through 10 on-site recharge basins during 2009. 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 2-3** gives estimates of flow to these basins. The discharge to these basins for 2009 (16 and 30 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 2-3**, include a stormwater retention basin referred to as HW (on Weaver Drive), and the sand filter beds at the STP. The sand filter beds causes localized mounding of the water table. Of the approximately 300,000 gallons of wastewater treated at the STP each day, about 20 percent of the treated effluent seeps directly to the underlying water table beneath the filter beds tile-drain collection system, and the remaining treated effluent 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 precipitation 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 2009, it is estimated that the recharge at BNL was approximately 27 inches. **Table 2-4** summarizes monthly and annual precipitation results from 1949 to 2009 collected on site by BNL Meteorology Services. Variations in the water table generally can be correlated with seasonal precipitation patterns. As depicted on **Table 2-4**, total annual precipitation in 2009 was 54.17 inches, which was above the long-term yearly average of 48.85 inches. Nine of the past 12 years have featured above-normal annual average precipitation at BNL.

2.2 Groundwater Flow

BNL routinely monitors horizontal and vertical groundwater flow directions and rates 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 June 2009. 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 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 2009 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 June 2009. 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 2009 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 1950–2009) and short-term (1997–2009) 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 2009. 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.

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 at the BNL site during 2009, most of the geologic information obtained during their installation was consistent with previous investigations.

2.4 Monitoring Well Maintenance Program

BNL has a program to maintain its groundwater monitoring wells which includes maintaining the protective casings, concrete pads and sample pumps. During 2009, BNL conducted an extensive maintenance campaign aimed at repainting all of the protective casings for all on-site wells. BNL was able to repaint most of the casings, except for those located within the RHIC facility, where Collider operations prohibited work crews from entering the area.

3.0 CERCLA GROUNDWATER MONITORING AND REMEDIATION

Chapter 3 gives an overview of groundwater monitoring and remediation efforts at BNL during 2009. 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

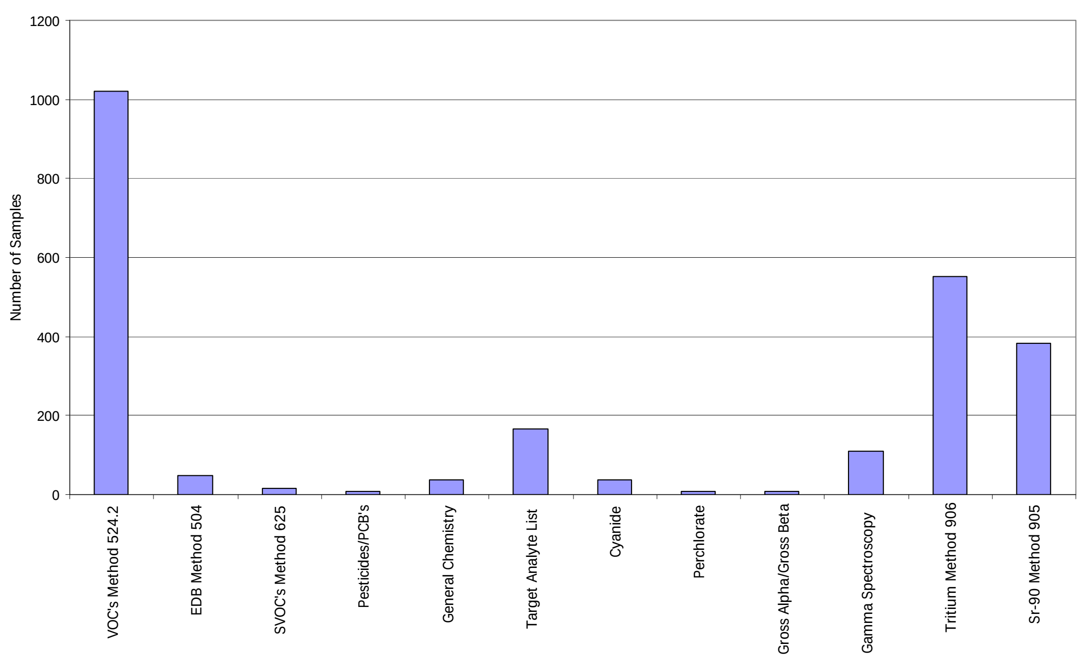
Additionally, BNL's ability to accurately depict these plumes has been enhanced over the years by the:

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

During 2009, the contaminant plumes were tracked by collecting 1,617 groundwater samples obtained from 698 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 2009 data from permanent monitoring wells. In several cases, data from temporary wells installed during the first three months of 2010 were utilized. Contaminant plumes associated with OU I South Boundary, HFBR Tritium, Brookhaven Graphite Research Reactor/Waste Concentration Facility (BGRR/WCF) Sr-90, Building 96, OU IV AOC 6 and g-2 Tritium Plume projects were further defined in 2009 or the first three months of 2010 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 Well Program in 2009.



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 2009, 1,272 treatment system samples were obtained from 104 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. 2009 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 2009/Cumulative
Operable Unit I						
South Boundary	P&T, AS	VOC	2	12	Basin	6/353
Operable Unit III						
South Boundary	P&T, (AS)	VOC	7	12	Basin	85/2,715
HFBR Pump and Recharge	Pump and Recirculate	Tritium 4		Operate: 5.5 Standby: 7.5	Basin	0/180
Industrial Park	Recirculation/ In-Well (AS/Carbon)	VOC 7		10	Recirculation Well	12/1,045
*Carbon Tet	P&T (Carbon)	VOC	3	Operate: 5 Standby: 5	Basin	NA/349
****Building 96	Recirculation Well (AS/Carbon)	VOC 4		Operate: 6 Standby: 3	Recirculation Well	9/107
Middle Road	P&T (AS)	VOC	6	8	Basin	63/862
Western South Boundary	P&T (AS)	VOC	2	7	Basin	12/66
Chemical Holes	P&T (IE)	Sr-90	3 7 Dry		Well	0.46**/3.79
North Street	P&T (Carbon)	VOC	2	5	Wells	10/300
North Street East	P&T (Carbon)	VOC	2	5	Wells	6/30
LIPA/Airport	P&T and Recirc. Wells (Carbon)	VOC	10	5	Wells and Recirculation Well	23/283
Industrial Park East	P&T (Carbon)	VOC	2	5	Wells	3/38
BGRR/WCF	P&T (IE)	Sr-90	5	4	Dry Wells	1.4**/17.5
Operable Unit VI						
EDB P&T	(Carbon)	EDB	2	5	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 2009 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 a 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 2009. Sr-90 was detected in several on-site permanent and temporary wells exceeding the 8 pCi/L DWS in 2009, 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 2009 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, 2009 through September 30, 2009. 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 *2009 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL, 2010a).

Sampling Frequency and Analysis

The wells are monitored as per the schedule provided on **Table 1-5**. A groundwater characterization was conducted in 2009 of the Sr-90 contamination which included the installation and sampling of 15 temporary wells.

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 2009. The primary VOCs detected in the on-site segment of this plume include chloroethane and 1,1-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 30 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 750 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 to the site boundary (a distance of approximately 1,800 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 area of the plume displaying the highest TVOC concentrations (greater than 50 µg/L) was in the vicinity of monitoring well 107-40. 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 2009 analytical results for the 44 wells. Significant findings for 2009 include:

- The trailing edge of the OU I South Boundary plume appears to have migrated to the vicinity of plume core well 107-41 based on a reduction in TVOC concentrations in this well over the past 2 years from 37 µg/L in 2008 to 15 µg/L in August 2009. The first quarter 2010 TVOC results for this well showed 3 µg/L. This well is screened in the Upton Unit immediately above the Gardiners Clay.
- The highest remaining VOC concentrations are currently located from south of well 107-41 to EW-1 and EW-2 located at the site boundary. 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-1 and EW-2 appears to be significantly reduced. This is due to the lower hydraulic conductivity of these materials in comparison to the Upper Glacial aquifer sands. It is difficult to determine whether this higher concentration segment has reached the extraction wells based on VOC concentrations in the influent due to the high rate of pumping and resulting dilution of VOC concentrations from samples collected in these wells. There has been no discernable increase in VOCs in monitoring well 115-14 which is located immediately adjacent and downgradient to EW-1. This well is not optimally positioned to detect VOCs prior to their capture at EW-1.
- 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 below NYS AWQS in 2009. VOCs greater than NYS AWQS continue to be hydraulically contained at the site boundary.

3.1.5 Radionuclide Monitoring Results

A subset of the OU I Monitoring Program wells is 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 highest tritium concentration during 2009 was in well 115-14 (adjacent to EW-1) at 1,690 pCi/L. 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)**. These wells were supplemented in 2009 with 17 temporary wells based on a recommendation in the 2008 Report (see **Figure 3.1-5** and **Figure 3.1-6** for locations and **Table 3.1-1** for data). The purpose of the Sr-90 characterization was to get an update on the area of Sr-90 contamination originally characterized in 2001. At that time, this area was approximately 100 to 150 feet in width by 200 to 300 feet in length. The highest concentration detected was 65 pCi/L at a location approximately 300 feet southwest of monitoring well 099-04 at a depth of 56 feet bls. Sentinel monitoring wells 107-34, 107-35, 108-43, and 108-44 were installed several hundred feet south of the leading edge of the Sr-90 in 2001. 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 17 pCi/L in February 2009. This sentinel well is approximately 1,000 feet from the site boundary. The source of this area of Sr-90 contamination is the former HWMF, and based on a 40 foot per year migration rate in the aquifer this area of contamination probably dates back approximately 50 years. The location of permanent and temporary wells and the extent of Sr-90 concentrations is shown on **Figure 3.1-5**. Sr-90 concentration trends for key monitoring wells are provided on **Figure 3.1-7**.

Although the current characterization effort is not completed the results to date indicate that the leading edge of the Sr-90 contamination is approximately 250 feet south of well 107-35. The highest concentration detected was 29 pCi/L in GP-18. This is approximately 250 feet south of the maximum detection of 65 pCi/L detected during the 2001 characterization.

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 3.1-2** provides the effluent limitations for meeting the requirements of the SPDES equivalency permit. The system continued full-time operation in 2009 following a period of pulse pumping that was implemented from September 2005 through July 2007.

Table 3.1-2.
OU I South Boundary Pump and Treat System
2009 SPDES Equivalency Permit Levels

Parameters	Permit Level	Max. Measured Value
pH	6.0 – 9.0 SU	6.4 – 8.0 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.

The following is a summary of the OU I operations for 2009:

January–September 2009
The system operated normally during the first quarter with only minor electrical and communication problems. During the second quarter the system was impacted by a number of electrical problems which resulted in the system being off for three weeks while repairs were being made. During the third quarter EW-2 was off for electrical repairs and modifications.

October–December 2009
The system operated normally during the last quarter of 2009.

3.1.7 System Operational Data

Extraction Wells
During 2009, 172 million gallons of groundwater were pumped and treated by the OU I system, with an average flow rate of 330 gallons per minute (gpm) for the year. **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**. TVOC levels in both wells continued to show a slight decreasing trend with time (**Figure 3.1-8**). Year-end tritium levels were below detection limits in both wells.

System Influent and Effluent
VOC concentrations in 2009 for the air-stripper influent and effluent are summarized on **Tables F-2** and **F-3**. The influent concentrations of TCA and DCA generally have displayed an overall decrease over the 13 years of OU I South Boundary System operation.

The air-stripper system effectively removed all contaminants from the influent groundwater. All 2009 effluent data for this system were below the analytical method detection limit and below the regulatory limit specified in the equivalency permit conditions.

Table 3.1-4
OU I South Boundary
2009 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual** ERP* (lb/hr)
Carbon tetrachloride	0.016	0.0000
Chloroform 0.00	86	0.0002
1,1-Dichloroethane 10**		0.00025
1,2-Dichloroethane 0.01	1	0.0000
1,1-Dichloroethylene 0.19	4	0.0000
Chloroethane 10**		0.0002
1,1,1-Trichloroethane 10**		0.0000
Trichloroethylene 0.11	9	0.0000

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.

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 3.1-9**). During 2009, 6.4 pounds of VOCs were removed. Cumulatively, 353 pounds have been removed since 1997. Cumulative mass removal data for this system are summarized on **Table F-4**.

Air Discharge
Table 3.1-4 presents the VOC air emissions data for the year 2009 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 2009 the highest detection of tritium was 753 pCi/L in well 076-173. 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.

The OU I South Boundary Pump and Treat system performance can be evaluated based on the five major decisions identified by applying the Data Quality Objectives (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 2009.

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 2009; 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 migrated approximately 200 to 250 feet south of well 107-35 which is about 800 feet north of the extraction wells at the site boundary.

The groundwater model was updated based on the fourth quarter 2009 monitoring well and 2009/2010 temporary well Sr-90 data. The model predicts that based on the current peak concentration of 29 pCi/L, Sr-90 will not migrate off-site at concentrations above the DWS of 8 pCi/L. The model assumed that EW-1 and EW-2 will run until 2015 and the simulation predicted that Sr-90 decays to below the DWS by 2022.

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

Recent groundwater modeling indicates that based on current plume concentrations the cleanup goal will not be met if the system is shutdown at the end of 2011 as currently planned due to the slower than anticipated migration of the higher concentration segment of VOCs through the Upton Unit in the southern portion of the site. The cleanup goals can be achieved by extending the operation of the extraction wells until 2015. These options are currently being evaluated.

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 3.1.10**. Changes in the distribution of the plume are shown on **Figure 3.1-11**, which compares the TVOC plume from 1997 to 2009.

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 3.1-10**).

4c. How many individual plume core wells are above 50 µg/L?
Monitoring well 107-40, 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. There is no benefit in pulse pumping until the remainder of the high concentration segment of the plume has been captured and treated.

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. Updated groundwater modeling predicts that MCLs will not be achieved under the currently planned operation schedule.

3.1.9 Recommendations

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

- Install a permanent well approximately 75 feet north of EW-1 and EW-2. Data from this well will be used to determine when the higher concentration segment of the plume has been completely captured.
- Based on data from the new monitoring well (above recommendation), evaluate increasing the operational duration of EW-1 and EW-2 to ensure meeting the cleanup goal for this project.
- Install two new sentinel wells approximately 200 feet south of the Princeton Avenue firebreak road to monitor for the leading edge of the Sr-90 plume.

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 2009. 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 12-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 and the LIPA system is evidenced by the break in the plumes in these areas.
- 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.

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 Former 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 in October 1999, and was formally shut down and placed in standby mode in August 2004 after receiving regulatory approval of the petition for shutdown. Groundwater monitoring has continued and a Petition for Closure of the system was submitted to the regulators in August 2009. Comments were received and the document was revised to incorporate these comments. Final regulatory approval for decommissioning was received in October 2009. Plans are currently under way for system removal and abandonment of the extraction wells and 15 monitoring wells.

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.

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 originally extended from the former UST southeast to the vicinity of Weaver Drive, a distance of approximately 1,300 feet (**Figure 3.2.1-1**). However, the plume as defined by the 5 µg/L carbon tetrachloride isocontour now starts just to the southeast of the Chilled Water Building 600 and all concentrations are close to the standard of 5 µg/L. The source area near the former carbon tetrachloride tank no longer has groundwater concentrations of carbon tetrachloride above the NYS AWQS of 5 µg/L. The complete 2009 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 2009 follows.

Figure 3.2.1-2 shows a plot of key monitoring wells associated with this project. As of October 2009 all wells are at or near the NYS AWQS for carbon tetrachloride. The plume will continue to be monitored until NYS AWQS are achieved in all monitoring wells associated with this project. Fifteen of the monitoring wells are being abandoned in 2010 as per recommendations in the petition for closure. These are wells: 085-07, 086-16, 085-160, 085-161, 085-238, 095-183, 095-185, 095-186, 095-296, 095-301095-43, 095-45, 095-47, 095-88, 095-89, and the three extraction wells for this system will also be abandoned (085-158, 085-159 and 095-278). This data is also shown in the Table below (**Table 3.2.1-1**) and on **Figure 3.2.1-3**

Table 3.2.1-1 Summary of Well Data OU III Carbon Tetrachoride

Well ID	Well Type	Depth	CCL4 Conc (ppb)*	Well Status	Rationale
085-07	Plume Core	140-145	<0.5	Abandon	Historically (Since 1997) Been below NYS AWQS
085-13	Plume Core*	250-255	<0.5	Maintain	Magothy well for Water Levels
085-16	Plume Core	34-54	0.76	Abandon	Below NYS AWQS Other wells nearby
085-160	Plume Core	34-54	0.5	Abandon	Below NYS AWQS
085-161	Plume Core	33-53	1.3	Abandon	Below NYS AWQS
085-162	Plume Core	29-49	2.1	Maintain	Low levels CCL_4 present (in 2008)
085-163	Plume Core	29-49	1	Maintain	Low levels CCL_4 present (in 2008)
085-17	Plume Core	34-54	13	Maintain	Low levels CCL_4 present
085-236	Plume Core	35-50	1.6	Maintain	Low levels CCL_4 present (in 2008)
085-237	Plume Core	35-50	3.3	Maintain	Low levels CCL_4 present (in 2008)
085-238	Plume Perimeter	25-45	<0.5	Abandon	Below NYS AWQS
085-98	Plume Core	39-49	2.8	Maintain	Low levels CCL_4 present (in 2008)
095-183	Plume Core	29-49	<0.5	Abandon	Below NYS AWQS
095-185	Plume Core	32-62	0.92	Abandon	Below NYS AWQS
095-186	Plume Perimeter	30-60	2.8	Abandon	Below NYS AWQS
095-277	Plume Core	47-57	2.9	Maintain	Low levels CCL_4 present (in 2008)
095-279	Plume Core	70-80	2.9	Maintain	Low levels CCL_4 present (in 2008)
095-280	Sentinel	85-95	1.4	Maintain	Low Levels CCL_4 present
095-296	Plume Perimeter	60-70	<0.5	Abandon	Below NYS AWQS
095-300	Plume Perimeter	70-80	4.4	Maintain	Low levels CCL_4 present (in 2008)
095-301	Plume Core	70-80	<0.5	Abandon	Below NYS AWQS
095-42	Sentinel	100-105	<0.5	Maintain	Middle Road Monitoring
095-43	Plume Core	108-113	<0.5	Abandon	Below NYS AWQS
095-45	Plume Core	108-113	<0.5	Abandon	Below NYS AWQS
095-47	Plume Core	195-200	<0.5	Abandon	Below NYS AWQS
095-53	Sentinel*	87-92	1.6	Maintain	Low levels CCL_4 present
095-88	Plume Core	155-160	<0.5	Abandon	Below NYS AWQS
095-89	Plume Core	155-160	<0.5	Abandon	Below NYS AWQS
095-90	Sentinel*	98.5-108.5	12	Maintain	Low levels CCL_4 present
095-92	Sentinel	116-126	<0.5	Maintain	Middle Road Monitoring
104-11	Sentinel (Middle Rd. Tracking)	185-195	<0.5	Maintain	Well used in Middle Road Program
104-36	Sentinel (Middle Rd. Tracking)	126-146	11	Maintain	Well used in Middle Road Program
105-23	Sentinel*	175-185	11	Maintain	Well used in Middle Road Program
105-42	Sentinel (Middle Rd. Tracking)	145-150	<0.5	Maintain	Well used in Middle Road Program
085-158	OU III (Carbon tet) EW-13	32-52	<0.5	Abandon	Extraction well Less then NYS AWQS
085-159	OU III (Carbon tet) EW-14	32-52	1.2	Abandon	Extraction well Less then NYS AWQS
095-278	OU III (Carbon tet) EW-15	65-85	1.2	Abandon	Extraction well Less then NYS AWQS

*Concentration is the most recent sample available in June 2009 generally from the first quarter 2009.

3.2.1.4 System Operations

Operating Parameters

In 2009, the extraction wells were sampled quarterly. These samples are analyzed for VOCs. The extraction well data are located on **Table F-5**. The parameters for sampling pH and VOCs adhere to the requirements of the SPDES equivalency permit. However, the system was in standby in 2009 and in October approval for system decommissioning was received from the regulatory agencies. The system operations are summarized below.

January – December 2009

The system was in standby mode during this period. Sampling for the SPDES equivalency permit was not performed since the system was shutdown.

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 2009 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, 2008 and 2009.

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 2009 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 was approved in October 2009.

3. Has the plume been controlled?

Yes. The plume has been controlled, and the system will be decommissioned in 2010.

4. Is the system operating as planned?

Not applicable

3.2.1.7 Recommendations

The following is the recommendation for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Continue monitoring the remaining groundwater monitoring wells until NYS AWQS are achieved.

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3.2.2 Building 96 Air Stripping System

This section summarizes the 2009 operational data from the OU III Building 96 Treatment System, which consists of three recirculation wells and one pumping well 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. All treatment wells, RTW-1 through RTW-4 operated full time during 2009. For a history of the operation of these wells over the last nine years, refer to previous Groundwater Status Reports.

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. In May 2008, well RTW-1 was modified from a recirculation well to a pumping well with hexavalent chromium ion exchange treatment, and discharge to the nearby surface drainage culvert. This well also continues to use air stripping for the treatment of VOC's.

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 *Operations and Maintenance Manual Building 96 Groundwater Treatment System* (BNL June 2009- Rev.1).

3.2.2.2 Source Area Characterization and Selected Remedy

In 2008, detailed soil characterization and soil vapor testing identified high PCE concentrations in the unsaturated zone from just below land surface to a depth of approximately 15 feet bls. 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. A summary of the characterization is provided in the 2008 Groundwater Status Report. **Figure 3.2.2-1** shows the location of the PCE source area soil contamination in relation to the 2009 VOC groundwater plume.

In November 2008, as a temporary measure to minimize infiltration from precipitation, a plastic liner was installed over the soil contamination area. This liner was upgraded in July 2009.

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 three to six years of the soil excavation (by 2016). 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 was to document the change in an Explanation of Significant Differences (ESD) to the OU III ROD. Following review and approval by the regulators, the *Final Operable Unit III Explanation of Significant Differences for Building 96 Remediation* (BNL September 2009) was issued.

As shown on **Table 2-4**, since the second half of 2009 the water table throughout the site has risen dramatically due to above normal precipitation. As a result, the water table immediately below the contaminated source area has risen approximately four feet since January 2010. A cross-section of the soil contamination area in relation to the water table as of April 2010 is shown on **Figure 3.2.2-2.** An extended cross section of the Building 96 area is shown on **Figure 3.2.2-4.** Consequently, the water table is currently approaching the bottom of the planned soil excavation area.

Excavation of the source area is expected to be performed in the summer/fall of 2010. Based on seasonable water table fluctuations, the water table would be lower at this time of the year.

3.2.2.3 Groundwater Monitoring

A network of 34 wells is used to monitor the VOC plume and the effectiveness of the Building 96 groundwater remediation system (**Figure 1-2**). Well 095-312 (formerly B96-MW2009) was installed in March of 2009. The majority of the wells are sampled quarterly and analyzed for VOCs in accordance with **Table 1-5**. As noted in the recommendations in the 2008 Groundwater Status Report, the sampling frequency for several wells was reduced. In addition, since 2008, all wells are sampled quarterly for chromium (Cr) and hexavalent chromium (Cr [VI]).

3.2.2.4 Monitoring Well Results

Complete VOC results are provided in **Appendix C**. The fourth quarter 2009 plume is shown on **Figure 3.2.2-1**. A summary of key monitoring well data for 2009 follows.

- The highest TVOC concentration seen in 2009 was 7,344 µg/L in groundwater from core well 085-353 during the first quarter sampling round. The primary contaminant is PCE, with a value of 7,300 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 in trend **Figure 3.2.2-3**, this well has historically contained significant contamination, with TVOC levels never lower than 600 µg/L. However in October 2009, well 085-353 TVOC concentrations dropped significantly to 79 µg/L. These drastic fluctuations are related to the rise and fall of the water table in relation to the location of the well screen. As shown on trend **Figure 3.2.2-3**, plume core monitoring wells 085-347, 085-353, and 095-84 continue to show significant rebounding of contaminant levels over the last several years.
- TVOC concentrations in plume core well 085-352 (screened in the silt zone in the eastern portion of the plume) continued rebounding since 2007 (up to 1,409 µg/L in October 2009) after two years of lower concentrations from mid 2005 through 2006 (maximum of 110 µg/L in May 2006). Conversely, TVOC concentrations in plume core well 095-306, located in the western portion of the plume, have been gradually increasing since 2008, to a high of 2,283 µg/L in July 2009. 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 from 2006 through 2008 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 below 5.0 µg/L TVOCs in January 2009, indicating effective capture of the contaminants by RTW-1. TVOCs in 2009 in well 095-172 ranged between 121 µg/L in January to 25 µg/L in July. This well is approximately 80 feet downgradient of 095-162.
- Plume core well 095-159 also began increasing since 2006 to 319 µg/L TVOCs in July 2009, its highest level since 2001. This well is the same distance downstream of RTW-1 as 095-162, but further to the west. This contamination will be captured by the downgradient recirculation treatment wells.
- The bypass monitoring wells immediately downgradient of extraction wells RTW-2, RTW-3, and RTW-4 generally showed reduced TVOCs since 2007. The reduced concentrations are consistent with the downgradient extraction wells being placed back in service in late 2007 and early 2008. In 2009, TVOC concentrations in the bypass wells were below 5.0 µg/L.
- As a follow-up to a concern raised by SCDHS, in March and April of 2010, three temporary wells (Bldg96-GP-01, Bldg96-GP-02, and Bldg96-GP-23) were installed along Weaver Drive to determine if hexavalent chromium has migrated downgradient to this area and to characterize the

concentration of PCE at this location. The highest hexavalent chromium and TVOCs detected from these wells were 12 µg/L and 98 µg/L, respectively . The data are presented in **Tables 3.2.2-1 and 3.2.2-2.**

- One of the 34 monitoring wells, 095-172, detected hexavalent chromium above the SPDES discharge limit of 100 µg/L with a value of 196 µg/L in January 2009. In 2008, seven monitoring wells exceeded 100 µg/L. The hexavalent chromium monitoring well data for 2009 is posted on **Figure 3.2.2-5.**

3.2.2.5 System Operations

Operating Parameters

All treatment wells, RTW-1 through RTW-4 operated full time during 2009.

Table 3.2.2-3
OU III Building 96 RTW-1 Pump & Treat Well
2009 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	5.0–8.5 SU	6.2–7.5 SU
chromium (hexavalent)	100	24
tetrachloroethylene	5.0	16
1,1,1-trichloroethane 5.0		<0.5
Thallium Mon	itor	1.7

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

January – September 2009

During this period the system operated normally for the majority of the time. There were short periods during these months that the system or individual wells were off for a couple of days. The system was off part of the month in April due to electrical problems. In July, the well drilling contractor re-graded and put a new poly liner over the Building 96 proposed soil excavation area. From January through September, approximately 38 million gallons of water were pumped (Table F-8).

October – December 2009

The system was down for about a week in December due to electrical problems. All wells operated normally for the remainder of this period. The groundwater treatment system pumped and treated approximately 12 million gallons of water in the fourth quarter of 2009.

During 2009, the groundwater treatment system pumped and treated a total of approximately 50 million gallons of water (Table F-8).

3.2.2.6 System Operational Data

Recirculation/Treatment Well Influent and Effluent

Table F-6 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 112 µg/L in RTW-1 in the first quarter. The maximum TVOC in the influent of the downgradient wells was 11 µg/L in RTW-3 in January 2009. RTW-2 and RTW-4 influent showed a maximum of 3 µg/L and 0.5 µg/L TVOCs in 2009, respectively. **Figure 3.2.2-6** shows the TVOC concentrations in the treatment wells over time. **Table 3.2.2-3** shows the maximum measured effluent contaminant concentrations compared to the equivalency permit for well RTW-1. The system met all equivalency parameters for operation except for PCE at 16 µg/L on the June 8, 2009 effluent sample from RTW-1. There were five sampling events in June on the 3rd, 8th, 18th, 22nd and 30th and all of the events (with the exception of June 8th) showed concentrations below the detection limit of 0.5 µg/L. The influent concentrations were similar on all of the events and the removal efficiency has always been greater then 99% for this system. It is believed that there was some contamination introduced into the June 8th

sample based upon the sampling data before and after this event. A NYSDEC *Report of Noncompliance Event* form was submitted to the regulators.

The maximum hexavalent chromium detection in the influent to RTW-1 in 2009 was 32 µg/L, approximately one third of the SPDES discharge standard. The maximum discharge level detected in the effluent in this well for the year was 24 µg/L. Since the second quarter of 2009, RTW-1 influent and the adjacent monitoring wells were below 100 µg/L of hexavalent chromium. The regulators were briefed during an IAG teleconference on October 29, 2009 on the status of the monitoring for the hexavalent chromium and BNL's intent to remove the resin treatment. In January 2010, the resin treatment was bypassed and placed in standby mode.

Air Treatment System

In 2009, 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-7**, and the VOC emission rates are summarized on **Table 3.2.2-4.** 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.

Table 3.2.2-4
OU III Building 96 Area
2009 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** ER (lb/hr)
dichlorodifluoromethane 0.00	00187	0.00000236
acetone 0.00	0674	ND
methylene chloride	0.000749	0.00000103
2-butanone 0.00	0187	ND
benzene 0.00	0112	0.0000138
tetrachloroethylene 0.00	0165	ND
m,p-xylene 0.00	00116	ND
isopropylbenzene 0.00	0243	ND
n-propylbenzene 0.00	00599	ND
1,3,5-trimethylbenzene 0.00	0375	0.0000139
1,2,4-trimethylbenzene 0.00	0225	0.0000271
4-isopropyltoluene 0.00	000749	ND
naphthalene 0.00	00225	ND
carbon disulfide	0.0000487	ND
styrene 0.00	000637	ND
trans-1,3-dichloropropane 0.00	00157	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

Cumulative Mass Removal

Table 3.2.2-5 shows the monthly extraction well pumping rates. The pumping and mass removal data are summarized on **Table F-8**. In 2009, approximately 9 pounds of VOCs were removed. Since February 2001, the system has removed approximately 107 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.

<u>*1. Was the BNL Groundwater Contingency Plan triggered?*</u>
No. As a follow-up to the triggering of the Contingency Plan in 2008, the selected remedy for the PCE soil source area was excavation and off-site disposal, with continued groundwater treatment. This remedy was documented in the *Final Operable Unit III Explanation of Significant Differences for Building 96 Remediation, issued in 2009.*

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 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 (by 2016).

3. Has the plume been controlled?
Yes. Following the modification of extraction well RTW-1 as a pumping well, it has demonstrated effective capture of the plume source area (**Figure 3.2.2-7**). Based on the low concentrations of VOCs in recirculation wells RTW-2, RTW-3, and RTW-4 and the nearby monitoring wells it appears that RTW-1 is effectively capturing the VOCs migrating from the source area.

4. Is the system operating as planned? Specifically, is the aquifer being restored as planned?
No. Although extraction well RTW-1 is effectively capturing the plume and treating high PCE concentrations there remains a continuing source for high concentrations of PCE in shallow soil contaminating groundwater. Significant reduction of PCE in groundwater cannot be achieved without the elimination of the source area.

5. Can the groundwater treatment system be shut down?
No, the system has not met all shutdown requirements.

5a. Is the mean TVOC concentration in core wells less than 50 µg/L?
No. The mean TVOC concentration in the core wells was 580 µg/L during the fourth quarter 2009.

5b. How many individual plume core wells are above 50 µg/L TVOCs?
TVOC concentrations in 15 of 21 core wells were above 50 µg/L in 2009.

5c. Have the groundwater cleanup goals been met? Are MCLs expected to be achieved by 2030?
MCLs have not been achieved for individual VOCs in all plume core wells. However, following soil excavation and between three to six more years of treatment system operation (by 2016), 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 full time operation of treatment well RTW-1.
- Install temporary wells upgradient of recirculation wells RTW-2, RTW-3, and RTW-4. If TVOCs in these wells and the recirculation wells are below 50 µg/L, then wells RTW-2, RTW-3, and RTW-4 will be placed in standby mode. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Maintain integrity of the plastic liner covering the PCE-contaminated soils. Excavate the source area in the summer/fall of 2010. 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 contaminated soil removal, including a replacement for well 085-353.

- Continue to analyze for total chromium and hexavalent chromium in the monitoring wells quarterly, and in the effluent to RTW-1 two times per month.
- Continue to maintain the resin treatment in standby mode, and if concentrations of hexavalent chromium increase to over 50 ug/L in RTW-1, treatment would resume.
- Based on the results of the data from the three temporary wells installed along Weaver Drive, a permanent well will be installed.

3.2.3 Middle Road Pump and Treat System

The Middle Road Groundwater Pump and Treat System began operating in October 2001. This section summarizes the operational data from the Middle Road system for 2009, 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 500 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). A temporary well was installed in April 2009 just west of RW-1 (MRVP-09). The data is shown on **Figure 3.2.3-2**. This was installed to evaluate the western extent of the VOC plume in this area. Based upon the depth and high concentrations of PCE in this temporary well a larger pump was installed in extraction well RW-2 to increase the capture zone of this well. A pump test was performed in September 2009 to evaluate the capture zone. A discussion of the aquifer test results is included below in **Section 3.2.3.5**.

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 monitoring well data (**Figure 3.2.3-1**). TVOC concentrations in monitoring wells east of RW-3 are generally below 10 µg/L. TVOC concentrations have generally been stable in 2009. Results for key monitoring wells are as follow:

- The highest TVOC concentration detected (449µg/L) was in bypass detection well 113-11 in October 2009. 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 2009.
- 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 59 µg/L in the fourth quarter of 2009 (**Figure 3.2.3-3)**.
- TVOC concentrations in plume core wells to the east of well 105-23, along Princeton Avenue, were below 100 µg/L in 2009 except for well 104-37. Well 104-37 saw a significant increase from 116 to 432 µg/L. The primary contaminants observed in this well was carbon tetrachloride at 200 and PCE at 210 µg/L. TVOC concentrations decreased in well 105-44, from 423 µg/L in 2001 to 6 µg/L in the fourth quarter of 2009, (See **Figure 3.2.3-3)**.

- New monitoring well 113-29, located west of RW-1, showed TVOC concentrations of 23 µg/L in 2009. This well is a perimeter monitoring well for the Middle Road System. This is below the capture goal for the treatment system of 50 µg/L
- New monitoring well 105-66, installed upgradient of extraction wells RW-1 and RW-2, showed TVOC concentrations of 273 µg/L in 2009. This is a core well installed in 2008 to monitor levels of VOCs migrating to these extraction wells. Concentrations have been stable in this well. This well is 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. The data shows that the highest concentrations are in the vicinity of RW-1 but at the depth correlating with the screen interval of RW-2 located approximately 150 feet east of MRVP-09. Due to these findings a larger pump was installed in RW-2 capable of increasing the flow rate from 170 gpm to about 300 gpm. After this installation, a pumping test was performed on this well with a pumping rate of 300 gpm, from September 10, 2009 until September 17, 2009. The complete aquifer test report (JR Holzmacher P.E., LLC January, 2010) is included in Appendix H.

Table 3.2.3-1.
OU III Middle Road Air Stripping Tower
2009 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Observed Value
pH range (SU)	6.5–8.5	6.9 – 7.5
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.

In summary the report concluded that with the increases pumping rate in well RW-2 to 300 gpm the estimated capture zone includes the portions of the plume that are greater then 50 µg/L. Figure 5 in the report shows the projected capture zone with well 2 operating at 300 gpm.

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.

Approximately 177 million gallons of water were pumped and treated in 2009 by the OU III Middle Road System. The following summarize the Middle Road System operations for 2009.

January – September 2009

The system was off from January to the end of March due to communication problems with the pump house and the blower building. The problem was a buried splice that had failed and could not be excavated until March due to the frozen ground. Approximately 141 million gallons of water were treated.

October – December 2009

The system operated normally in October and November, and pumped and treated approximately 36.5 million gallons of water during this quarter. The system was down sporadically during December to troubleshoot and repair the control system primarily due to electrical problems.

3.2.3.5 System Operational Data

System Influent and Effluent

Figure 3.2.3-5 plots the TVOC concentrations in the extraction wells versus time. Results of the extraction wells samples are found on **Table F-9.** The influent VOC concentrations remained constant over the reporting period. The average TVOC concentration in the influent during 2009 was 41 µg/L. The results of the influent and effluent sampling are summarized on **Tables F-10** and **F-11**, 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 337 gpm during 2009 (**Table 2-3**, and **Table F-12)**, and approximately 63 pounds of VOCs were removed. Approximately 862 pounds of VOCs have been removed since the system began operations in October 2001. The cumulative total of VOCs removed vs. time is plotted on **Figure 3.2.3-4**.

Table 3.2.3-2.
OU III Middle Road Air Stripper
2009 Average VOC Emission Rates

Parameter	Allowable ERP* (lb/hr)	Actual** (lb/hr)
carbon tetrachloride	0.022	0.0003
chloroform 0.00	31	0.0001
1,1-dichloroethane 10***		0.000047
1,2-dichloroethane 0.00	8	0.000001
1,1-dichloroethylene 0.03	4	0.0002
cis-1,2-dichloroethylene 10***		0.0002
trans-1,2-dichloroethylene 10***		0
tetrachloroethylene 0.38	7	0.0763
1,1,1-trichloroethane 10***		0.0006
trichloroethylene 0.14	3	0.0003

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 2009, 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**). The concentration of each constituent was averaged for 2009, 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 generally remained constant over the reporting period for the extraction wells, with the exception of well RW-5. RW-5 had two detections of TVOC concentrations of 72 µg/L in July and 11 µg/L in August. Then in October concentrations again were 72 µg/L. **Table 3.2.3-3** shows the monthly extraction well pumping rates.

3.2.3.6 System Evaluation

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 2009.

2. Has the plume been controlled?
Yes. TVOC concentrations in plume perimeter wells remained stable at low concentrations during 2009, 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. However these wells have shown a declining trend and some of them are in an area called the stagnation zone where there is little groundwater movement. 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 encompasses the 50 µg/L contour, 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 2009 (**Figure 3.2.3-3**).

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. However, 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 48.3 µg/L (**Figure 3.2.3-6**).

4c. How many individual plume core wells are above 50 µg/L?
Six 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 is currently in effect.

- Maintain extraction wells RW-4, and RW-6 in standby mode during 2010. Restart well RW-5 and operate until TVOC concentrations drop below 50 µg/L for two consecutive quarterly extraction well sampling events. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal. Maintain a minimum pumping rate of 250 gpm on well RW-2.
- Install one temporary well approximately 300 feet east of monitoring well 104-36 and based upon the results install a monitoring well to monitor the progression of higher upgradient concentrations of TVOCs to the treatment system.
- Install a monitoring well centered on the high concentrations identified in the recent temporary well near well RW-1.

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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 2009, 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. Perimeter well 121-08 had a TVOC concentration of 18 µg/L in October. Individual VOC concentrations in the remaining plume perimeter wells were less than 5 µg/L in October 2009 (**Figure 3.2.4-1**). This is well below the capture goal of the system of 50 µg/L for TVOC concentrations. 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 2009.

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. 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 3.2.3-3.** Results for key monitoring wells are as follow:

- 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 11µg/L in April 2009. However in the next sampling event in October concentrations had dropped to 2.3 µg/L.
- Plume core well 122-19 is directly downgradient of EW-8. Plume core well 122-04 is located between EW-7 and EW-8. Plume core well 114-07 is immediately upgradient of EW-12. VOCs have not been detected above standards during 2009 in these wells.
- Plume core well 121-23 is immediately downgradient of EW-5. During 2009, the TVOC concentrations ranged between 15 µg/L and 7 µg/L (In April and October). This is a decrease from concentrations observed last year in this well when concentrations were 30 µg/L to 40 µg/L.
- 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 2009 results showed TVOC concentrations as high as 374 µg/L during January but had declined to 215 µg/L by October **(Figure 3.2.4-1)**.

- Plume core well 121-11 is upgradient of EW-3. TVOC concentrations ranged from 26 µg/L in November 2009 to 3 µg/L in April 2009.
- Plume core well 122-05 is a Magothy monitoring well west of EW-8. TVOC concentrations have been showing a stable trend with a concentration of 32 µg/L in November 2009 **(Figure 3.2.4-1)**.
- Bypass Detection Well 121-43 located several hundred feet south of extraction well 4 has consistently shown elevated levels of VOCs. The TVOC concentration in this well was 160 µg/L in November 2009. This may be contamination that is trapped in the stagnation zone downgradient of EW-4.

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 equivalency permit 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 equivalency permit requirements.

System Operations

In 2009, approximately 201 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.

Table 3.2.4-1.
OU III South Boundary Air Stripping Tower
2009 SPDES Equivalency Permit Levels

Parameters	Permit Limit*	Max. Observed Value
pH range (SU)	6.5 – 8.5	6.7–7.8
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.

January – September 2009

Approximately 154 million gallons of water were pumped and treated. There were communications and electrical problems during the first quarter, which resulted in the system being off for the first three months of the year. Well EW-8 was put back in service in April 2009 due to a slight increase in TVOC concentrations noted in this well. Concentrations increased to 45 µg/L in April and then subsequently steadily declined back to 7 µg/L in October. The operation of EW-8 was stopped in November 2009 due to the decrease in concentrations. The system operated normally for the second and third quarter.

October – December 2009

The OU III South Boundary System pumped and treated approximately 47.5 million gallons of water. The system was off for part of December due to communications problems with the wells and the treatment system.

3.2.4.5 System Operational Data

System Influent and Effluent

Figure 3.2.4-3 plots the concentrations of TVOC concentrations in the extraction wells versus time. The overall influent water quality and the individual extraction wells show a general declining trend in concentrations. The system was also sampled monthly for tritium, which was not detected above the reporting limit in any sample during 2009. System influent and effluent sampling results are summarized on **Tables F-14** and **F-15**, respectively.

Cumulative Mass Removal

Average flow rates for each monthly monitoring period were used, in combination with the TVOC concentration in the air-stripper influent, to calculate the mass removed (**Table F-16**). The cumulative total of VOCs removed by the treatment system versus time is plotted on **Figure 3.2.4-4**. The 2009 total was approximately 85 pounds. Cumulatively, the system has removed approximately 2,715 pounds since it was started in June 1997.

Air Discharge

Table 3.2.4-2 shows the air emissions data from the OU III South Boundary system for 2009, 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-14**). 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.

Table 3.2.4-2.
OU III South Boundary Air Stripper
2009 Average VOC Emission Rates

Parameter	Allowable ERP*	Actual** ER
carbon tetrachloride	0.022	0.0009
chloroform	0.0031	0.0002
1,1-dichloroethane	10***	<0.000025
1,2-dichloroethane	0.008	<0.0001
1,1-dichloroethylene	0.034	0.0001
cis-1,2-dichloroethylene	10***	<0.0000
trans-1,2-dichloroethylene	10***	0
tetrachloroethylene	0.387	0.0080
1,1,1-trichloroethane	10***	0.0003
trichloroethylene	0.143	0.0002

Notes:
ERP = Emissions Rate Potential, stated in lb/hr.
* ERP is based on NYSDEC Air Guide 1 Regulations.
** Actual emission 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.

Extraction Wells

In general, the extraction wells continued to show slowly decreasing VOC concentrations during 2009 (**Figure 3.2.4-3**). **Table F-13** 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 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 2009.

2. Has the plume been controlled?

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

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 2009 it had operated for approximately 12.5 years. The system is removing contamination at the expected rate and hydraulic control of the plume is 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 TVOC concentrations from over 1,300 µg/L to 162 µg/L in October. Monitoring well 121-45 was installed in 2008 and had a concentration of 215 µg/L in October 2009. It was installed to monitor concentrations of TVOCs immediately upgradient of extraction well EW-4, which has historically had the highest TVOC concentrations. Monitoring well 121-43 located downgradient of EW-4 was installe din 2003. It has shown persistently elevated concentrations of VOCs. It is screened slightly deeper then well EW-4. This may be due to this well being located near the stagnation zone downgradient of EW-4 which has slowed down the migration of the VOCs that were present in this area prior to system startup. Or it may be that some VOC contamination is migrating under well EW-4. A vertical profile is planned near well EW-4 to evaluate if this is occurring.

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?
The average TVOC concentrations of the OU III South Boundary wells showed a slight decrease in 2009 (**Figure 3.2.4-5**).

4b. Is the mean TVOC concentration in core wells less than 50 µg/L?
Yes, the average TVOC concentration in 2009 was 23 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 implemented last year.
- It is recommended that a vertical profile be installed near well EW-4 to evaluate how deep the high concentrations of VOCs are near the extraction well. This well should be installed to a depth of approximately -160 feet below MSL, until the Magothy Brown Clay is encountered. This will help evaluate whether the VOCs detected in well 121-43 are caught in the stagnation zone or may be passing under well EW-4.

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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 starting in November 2008 and has continued full-time through 2009. 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 16 wells is used to monitor this plume. As noted below, well 103-15 was installed in 2009. Their locations are shown on **Figure 3.2.5-1**. 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 plume are dichlorodifluoromethane (Freon-12), 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 2009 monitoring well concentrations. A summary of key monitoring well data for 2009 follows:

- Monitoring well 119-06 was installed at the location of WSB VP-1 in 2008 along Middle Road. This core well had TVOC concentrations up to 170 μg/L in December 2008, with TCA (100 μg/L) as the primary compound. During 2009, this well showed a steady decrease in TVOC concentrations from 114 μg/L in February to 87 μg/L in April and a leveling off for the third and fourth quarters averaging 35 μg/L, (primarily TCA and DCE). This leveling off is an indication of upgradient high concentrations passing through the vicinity of the Middle Road monitoring well.
- As a follow up to the 2008 report recommendations, due to the elevated dichlorodifluoromethane detected at the deepest interval, 192 feet, in WSB VP-7 between Middle Road and Princeton Avenue, monitoring well 103-15 was installed in the first quarter of 2009. This well was sampled in May, July and November of 2009 and analysis indicates VOCs exceeding DWS were dichlorodifluoromethane and trichloroethylene. TVOC values for this well indicate a steady increase over the three quarters of 26, 62 and 69 μg/L respectively. The highest concentration of dichlorodifluoromethane was in November 2009 at 55 μg/L.
- TVOC concentrations in plume core wells 121-42 and 127-06, located upgradient of extraction well WSB-2, and well 127-04 located at well WSB-2 have remained around 20 μg/L or less 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 remained below 20 μg/L TVOCs. In 2009, the TVOC levels did not exceed 9 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

68 µg/L in November 2009 (see trends on **Figure 3.2.5-2**). Plume core well 126-13 located just north of extraction well WSB-1 had the highest TVOC concentration detected in the seven downgradient plume core wells in 2009 with a value of 100 µg/L TVOC in November. The concentrations in this well increased significantly from 2008 of less than 10 µg/L TVOC in the fourth quarter. The sampling analysis indicates primarily TCA and DCE. Extraction well WSB-1 influent concentration data was not yet reflecting the increased TVOC values in December 2009.

- In bypass detection well 130-08, located south of extraction well WSB-1, the maximum TVOC concentration during 2009 was 32 µg/L in the second quarter. The highest individual VOC detected was dichlorodifluoromethane at 12 µg/L.
- In bypass well 126-16, located south and between the two extraction wells, TVOC concentrations were approximately 30 µg/L. Bypass well 127-07, located downgradient of WSB-2, has shown steadily declining VOCs since 2005. In 2009, TVOC concentrations were less than 10 µg/L and no individual compound exceeded DWS.

Table 3.2.5-1
OU III Western South Boundary Pump & Treat System
2009 SPDES Equivalency Permit Levels

Parameter	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH range	6.5–8.5 SU	6.9–8.1 SU
carbon tetrachloride	5	<0.5
chloroform 7		<0.5
dichlorodifluoromethane 5		<0.5
1,1-dichloroethane 5		<0.5
1,1-dichloroethylene 5		<0.5
methyl chloride	5	<0.5
tetrachloroethylene 5		<0.5
toluene 5		<0.5
1,1,1-trichloroethane 5		<0.5
1,1,2-trichloroethane 5		<0.5
trichloroethylene 10		<0.5

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 33 µg/L in November 2009. 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.

3.2.5.4 System Operations

During 2009, the extraction wells were sampled quarterly and the influent and effluent of the air-stripper tower were sampled twice per month. Extraction well WSB-1 continued full-time operation through 2009 due to increasing TVOC concentrations greater than the capture goal of 20 µg/L in upgradient core wells. System samples were analyzed for VOCs. In addition, the effluent sample was analyzed for pH and tritium twice a month. A tritium value of 590 pCi/L was detected in February 2009. **Table 3.2.5-1** 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 2009

The treatment system operated normally from January to September. The WSB-1 extraction well operated for the entire year. The WSB-2 extraction well schedule was one month on and two months off. During this time, approximately 87 million gallons of groundwater were pumped and treated.

October – December 2009

The system operated normally with being down a few days due to an electrical outage. During this quarter, approximately 29 million gallons of groundwater were pumped and treated.

3.2.5.5 System Operational Data

Extraction Wells

During 2009, approximately 115 million gallons of groundwater were pumped and treated by the OU III Western South Boundary System, with an average flow rate of approximately 206 gpm while in operation. **Table 2-3** gives monthly pumping data for the two extraction wells. **Table 3.2.5-2** shows the monthly extraction well pumping rates. VOC and tritium concentrations for extraction wells WSB-1 and WSB-2 are provided on **Table F-17**. VOC levels in both wells had been showing a slight decreasing trend since system start-up in 2002, through 2005. In 2006 WSB-2 showed increasing TVOCs, but had been decreasing in 2007 and 2008. In the fourth quarter of 2009, WSB-2 is indicating a slight increasing trend and WSB-1 is expected to increase based on higher concentrations of upgradient VOCs showing up in adjacent monitoring wells. The maximum TVOC concentration in 2009 was 16 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 3.2.5-3** provides a graph of extraction well trends over time. Most of the individual VOC compounds were either below or slightly above the NYS AWQS.

Table 3.2.5-3
OU III Western South Boundary
2009 Air Stripper VOC Emissions Data

Parameter	Allowable ERP* (lb/hr)	Actual ERP (lb/hr)
carbon tetrachloride	0.016	<0.0001
chloroform 0.00	86	0.0001
1,1-dichloroethane 10**		<0.000038
1,2-dichloroethane 0.01	1	<0.0000
1,1-dichloroethene 0.19	4	0.00004
chloroethane 10**		<0.0001
1,1,1-trichloroethane 10**		0.0006
trichloroethylene 0.11	9	0.0001

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.

System Influent and Effluent

Influent TVOC concentrations were less than 17 µg/L, and individual VOC concentrations were less than the NYS AWQS, except for TCA averaging above 6 µg/L for the second half of the year 2009. These levels are consistent with the historical influent concentrations. The influent consists primarily of dichlorodifluoromethane, TCA, TCE, and chloroform (**Tables F-18** and **F-19**).

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-20**). The cumulative mass of VOCs removed by the treatment system is provided on **Figure 3.2.5-4**. During 2009, 12 pounds of VOCs were removed. A total of 66 pounds have been removed since the start-up of the system in 2002.

Air Discharge

Table 3.2.5-3 presents the VOC air emission data for the year 2009 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 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.

<u>1. Was the BNL Groundwater Contingency Plan triggered?</u>
Yes. The contingency plan was implemented during 2009. Permanent monitoring well 103-15 has been installed during the first quarter of 2009 because of the high concentrations in the temporary well installed previously at this location.

<u>2. Has the plume been controlled?</u>
Yes. VOC concentrations in the plume perimeter wells (except 130-03) remained stable at or below the drinking water standard during 2009, indicating that the plume is being controlled as shown on **Figure 3.2.5-1**. Perimeter well 130-03 had been slowly decreasing since late 2004 with a slight increase of 33 µg/L in November 2009. 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**.

<u>3. Is the system operating as planned? Specifically, is the aquifer being restored as planned?</u>
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. In 2009, VOC concentrations in well 126-11 and 126-13 started to increase steadily as discussed previously. VOCs present in monitoring wells immediately upgradient of WSB-1 (i.e., 126-11, 126-13 and 126-14) will be captured by the system. Based on groundwater modeling performed in late 2008, it is projected that VOCs detected in wells installed along Middle Road during 2008, 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 to ensure complete capture of the upgradient portion of the plume.

<u>4. Can the groundwater treatment system be shut down?</u>
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 and 4b). Extraction well WSB-1 was placed back into full-time operation in late 2008 and continued through 2009 due to elevated VOCs in nearby monitoring wells.

<u>4a. Have asymptotic VOC concentrations been reached in core wells?</u>
No. Several core wells upgradient of WSB-1 have been indicating a steady increase in VOC concentrations.

<u>4b. Is the mean TVOC concentration in core wells less than 20 µg/L?</u>
No. The mean TVOC concentration in the core wells is 34 µg/L (**Figure 3.2.5-5**).

<u>4c. How many individual plume core wells are above 20 µg/L TVOC?</u>
TVOC concentrations in five of nine core wells were above 20 µg/L as discussed in Section 3.2.5.3.

<u>4d. During pulsed operation of the system, is there significant concentration rebound in core wells?</u>
No. As noted above, plume core well 126-11 has been steadily increasing since 2006, shortly after pulse pumping began. The highest TVOC concentration in 2009 was 68 µg/L. TVOC concentrations in the extraction wells increased slightly since 2006; however, they remained below 20 µg/L in 2009. Extraction well WSB-1 has been on full time during 2009.

<u>5. Have the groundwater cleanup goals been met? Are MCLs expected to be been achieved by 2030?</u>
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 show increasing VOC trends, the need to take further action will be evaluated.
- Due to indications of increased TVOC concentrations in plume core monitoring wells in close proximity to extraction well WSB-1, installation of a permanent monitoring well should be implemented during 2010. The well should be located approximately 700 feet north of WSB-1 to provide a data point between this well and the Middle Road.
- To better define the northerly portion of the core area of the plume where higher concentrations of dichlorodifluoromethane have been detected, two temporary wells should be installed in the vicinity of Princeton Avenue.
- Maintain the routine O&M monitoring frequency that began in 2005.

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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 2009 and presents conclusions and recommendations for its future operation. The system began operation in September 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 3.2.6-1** 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 VOCs in the vicinity of the industrial park south of the site, and 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 3.2.6-1.** Screen depths are set to capture water levels at multiple depths and to obtain water quality data as follows: 1) above the treatment well effluent depth, 2) at the effluent depth, and 3) at the treatment well influent depth.

Sampling Frequency and Analysis

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 2009. Based on these data, the plume is effectively bounded by the current well network. **Figure 3.2.6-1** shows the plume distribution based on fourth-quarter 2009 data. The vertical extent of contamination is shown on **Figure 3.2.6-2**. The location of this cross section (G–G') is illustrated on **Figures 3.2-1 and 3.2.6-1**. The 2009 results for key monitoring wells are:

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. However, in 2009 the sampling showed a significant drop to 21 and 36 µg/L. 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 5 µg/L in November 2009 (**Figure 3.2.6-3**).
- Well 000-262 (between UVB-4 and UVB-5) began showing decreasing TVOC concentrations in 2002 (**Figure 3.2.6-3**). 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 2009 showed TVOC concentrations of 209 µg/L in May and 225 µg/L in November.
- The TVOC concentration in well 000-268 (between UVB-6 and UVB-7) was 6 µg/L in November 2009 (**Figure 3.2.6-3**). 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 2009. 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 11 µg/L during 2009. TVOC concentrations in 000-431 were below NYS AWQS during 2009. The low VOC 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 11 µg/L (February 2009) in well 000-276.
- 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 that were hung up in the "stagnation zone." The data from November 2009 shows concentrations decreasing to47 µg/L.
- TVOC concentrations in well 000-273 varied from 49 µg/L in February 2009 to 11 µg/L in July. Well 000-274 varied from 105 µg/L in February 2009 to 31 µg/L in November 2009. These wells are located immediately downgradient of well UVB-1, which was shut down in October 2005. These VOC 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 as seen in 2009. 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 2009, approximately 150 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 2009.

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

January – September 2009

The system was off from March 19 to 25 due to maintenance work on the blower unit. Various wells were off for short periods of times due to issues ranging from electrical problems to routine well maintenance. They system pumped and treated a total of approximately 118 million gallons of water

October – December 2009

In October 2009, well UVB-7 was placed in standby mode as TVOC concentrations have remained below 10 µg/L in this well. Wells UVB-3 and UVB-4 were off for November due to electrical problems and were re-started in December. The rest of the system operated normally for the remainder of the period. Well UVB-1 remained in standby mode for this period. Approximately 30 million gallons were treated during this period.

3.2.6.5 System Operational Data

Recirculation Well Influent and Effluent

During 2009, influent TVOC concentrations in the treatment system wells showed a steady or declining trend. (**Figure 3.2.6-4**). The corresponding effluent well concentrations (**Figure 3.2.6-5**) showed decreasing or stable TVOC concentrations for the year. UVB-1 remained in standby mode for 2009. There was significant downtime for individual wells in 2009 due to electrical problems, flow meter issues and routine maintenance and cleaning of the wells.

For 2009, the overall average removal efficiency was 70 percent (**Table F-21**). This is lower than historical removal rates of 90 to 95 percent but is due to so many of the compounds being near the method detection limit and below AWQS. 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-22** summarizes these data. During 2009, flow averaged approximately 49 gpm per well for the five operating wells. **Figure 3.2.6-6** plots the total pounds of VOCs removed by the treatment system vs. time. During 2009, 12 pounds were removed from the aquifer, with a total of 1,045 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 529 cfm during 2009 (**Table F-23**).

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 2009.

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 2009, higher concentrations in wells 000-273 and 000-274, 000-277 and 000-278 during 2008 have declined significantly in 2009. This was 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 for the system to operate 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 2009. The cutoff of the high-concentration areas of the plume near the south boundary is evident. This is consistent with the dramatically reduced concentrations of VOCs being observed in the industrial park monitoring and extraction wells.

The overall trend in the mean TVOC concentrations in the core groundwater monitoring wells is declining (**Figure 3.2.6-7**). The system is removing contamination at the expected rate and hydraulic control of the plume is demonstrated; hence, it is operating as planned.

4. Can the groundwater treatment system be shut down?

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

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

No. Concentrations show an overall 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 31.6 µg/L in November 2009.

4c. How many individual plume core wells are above 50 µg/L TVOC?
One (000-262) of the nine plume core wells had TVOC concentrations exceeding 50 µg/L in 2009.

4d. During pulsed operation of the system, is there significant concentration rebound in the core wells?
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 and monitoring results, MCLs are expected to be achieved by 2030, as required by the OU III ROD.

3.2.6.7 Recommendations

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

- The current routine operations and maintenance monitoring frequency will be maintained during 2010. The system will continue operations at 60 gpm per well except for well UVB-1 and UVB-7 which are to remain in a standby mode. It is recommended that well UVB-2 be placed in standby as TVOC concentrations have dropped to below 5 µg/L in this well and all of the monitoring wells in the vicinity are below 50 µg/L TVOC. Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, wells UVB-1, UVB-2 or UVB-7 will be restarted.
- Currently all the monitoring wells except 000-262 are below the capture goal of 50 µg/L. All of the extraction wells now have influent concentrations below the capture goal of 50 µg/L. If concentrations in well 000-262 drop below the TVOC 50 µg/L capture goal a petition to shutdown this system may be submitted to the regulators.
- A temporary well should be installed and sampled between wells UVB-3 and UVB-4 to evaluate the VOC concentrations in this area since no monitoring wells are present in this area.

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3.2.7 Industrial Park East Pump and Treat System

This section summarizes the 2009 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. The Petition to Shutdown the OU III Industrial Park East Groundwater Treatment System was submitted to the regulators for review in early October 2009. In November 2009, the regulators concurred with the Petition. The system was placed in standby in December 2009.

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 (**Figure 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.

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 **Figure 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 2009 was 31 µg/L in downgradient well 000-494 during the fourth quarter, with TCA (17 µg/L) as the highest individual VOC detection (**Figure 3.2.7-2**). 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. Groundwater modeling projects that this contamination will attenuate to concentrations below NYS AWQS and achieve the OU III ROD Cleanup Goal.
- In plume core well 000-514, approximately 100 feet west of the extraction wells, VOC concentrations were less than NYS AWQS during 2009.
- VOCs in plume bypass well 000-493 have remained below the NYS AWQS since it was installed in June 2004.
- Upgradient wells 122-24 and 122-25, which had shown TVOC concentrations as high as 570 µg/L in 2002, were below NYS AWQS in 2008 and 2009.

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
2009 SPDES Equivalency Permit Levels

Parameters	Permit Limit (µg/L)	Max. Measured Value (µg/L)
pH (range)	5.5–8.5 SU	5.6–62 SU
bromoform 50		<0.50
carbon tetrachloride	5	<0.50
chloroform 5		0.73
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 2009.

January – September 2009

The system operated normally for the majority of this period with the system pulse pumping one month on and one month off Twenty-nine million gallons were pumped and treated during the first three quarters of 2009.

October – December 2009

The system operated normally for this period still in a pulse pumping mode. The system pumped and treated 7.4 million gallons of groundwater this quarter. The Petition to Shutdown the OU III Industrial Park East Groundwater Treatment System was submitted to the regulators for review in early October 2009. In November 2009, the regulators concurred with the Petition. The system was placed in standby mode in December 2009.

Extraction Wells Operational Data

During 2009, approximately 37 million gallons were pumped and treated by the IPE system. The system was pulse pumped, one month on and one month off, so the average rate for the months it was in operation was 140 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-24.** In 2009, TVOC concentrations in EWI-1 ranged from 2.5 to 3.1 µg/L and 6.5 to 8.2 µg/L in EWI-2. All individual VOC compounds were below AWQS in both extraction wells.

3.2.7.5 System Operational Data

System Influent and Effluent

The overall VOC influent concentrations to the carbon vessels were consistently below AWQS in 2009 (**Figure 3.2.7-3**). **Tables F-26** and **F-27** 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-25 lists total pounds of VOCs removed by the treatment system in 2009. **Figure 3.2.7-4** plots mass removal versus time. Approximately 2.6 pounds of VOCs were removed from the aquifer during 2009 and 37.7 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 AWQS in the Upper Glacial aquifer by 2030. According to the *OU III Explanation of Significant Differences* (BNL 2005a), AWQS within the Magothy aquifer must be met by 2065. The system will address the highest VOC concentration portion of the plume (above 50 µg/L TVOC).

The Industrial Park East Pump and Treat System performance during 2009 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 2009.

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, as planned, the system is in a shutdown monitoring period.

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?

All 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 was observed prior to shutdown in December 2009.

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)?

Yes for the Upper Glacial aquifer currently MCLs have been achieved for individual VOCs in all IPE plume core wells. MCLs are expected to be achieved by 2065 for the Magothy aquifer 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.

- Continue the current groundwater monitoring post shutdown monitoring schedule.
- It is recommended that one additional downgradient monitoring well be installed in the vicinity of monitoring well 000-107 on Stratler Drive to monitor Magothy contamination identified in well 000-494.

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 3.2.8-1**).

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 26 wells monitors the North Street VOC plume (**Figure 1-2**). 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**. All 26 wells are also sampled and analyzed annually for tritium. Only one well, 000-211 was analyzed for Sr-90, gamma spectroscopy, and gross alpha/beta because of its use in the Industrial Park East program. This analysis for well 00-211 will discontinue during 2010 due to non-detect or below DWS concentrations being reported for several years.

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 2009 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 2009 follows:

- In 2009 the highest TVOC concentration in the plume was 114 µg/L in well 000-472 during fourth quarter sampling. TVOC concentrations have increased in this well since the April 2009 TVOC sampling value of 39 µg/L. The primary VOCs in this well are PCE with the highest concentrations averaging about half of the TVOCs with TCA and DCE accounting for the balance of VOCs above AWQS. This well is located west of North Street, approximately 90 feet west of extraction well NS-2. A portion of the leading edge of the higher concentration plume segment, has reached this location. This contamination will be captured partially by the North Street System and contamination beyond the capture zone of extraction well NS-2 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 10 µg/L in the fourth quarter of 2009. This correlates well with the low TVOC concentrations observed in NS-1. VOC concentrations in plume core well 000-463, located approximately 200 feet north of NS-1, began to show a steady decline during 2009, as shown on **Figure 3.2.8-3.** Plume core well 000-154 had historically shown high VOC concentrations (primarily carbon tetrachloride). TVOC concentrations, greater than 1,000 µg/L were observed in this well in 1997 and 1998, but have steadily declined since then to approximately 6 µg/L in 2009. The trailing edge of the higher concentration segment of this plume has migrated south of this location.
- The bypass detection well 800-63, located on Vita Drive approximately 1,600 feet south of extraction well NS-1 has slowly declined to an average of 50 µg/L from a high in January 2008 of 174 µg/L.
- 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 95 µg/L TVOCs in the first quarter 2009 and Magothy well 800-90 detected a maximum TVOC concentration of 102 µg/L in May 2009. 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 and within the vicinity of the North Street VOC plume. The highest Tritium value was detected in bypass detection well 000-469 at a value of 840 pCi/L. Tritium concentrations continue to be well below the AWQS of 20,000 pCi/L. Tritium monitoring of North Street wells will continue in 2010.
- The plume continues to be controlled as indicated by perimeter wells.

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
2009 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 2009

Routine operations continued from January through September, with approximately 83 million gallons pumped and treated during the first three quarters. The system was off periodically to allow for scheduled carbon filter change-outs and for a longer period during the month of February due to injection well maintenance. Various electrical problems were experienced during the first three quarters, all of which required system restarts and repair.

October – December 2009

Routine operations continued from October through December. The system was off periodically to allow for scheduled carbon change-outs. Approximately 51 million gallons were pumped and treated during this quarter.

3.2.8.5 System Operational Data

The system was operational from January to December 2009, with only minor shutdowns due to electrical outages, PLC issues, scheduled maintenance, and GAC change-outs.

Extraction Wells

Table F-28 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-29**. TVOC values in well NS-1 remained consistent with 2008 values ranging from 10 to 21 µg/L over the year, and well NS-2 remained unchanged, with TVOC values ranging from 11 to 14 µg/L. The NS-1 TVOC concentrations correlate 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 2009.

System Influent and Effluent

The 2009 VOC concentrations for the North Street carbon influent and effluent are summarized on **Tables F-30** and **F-31**. The combined influent TVOC concentration declined from 75 µg/L in December 2004 to 9 µg/L in December 2009. There was no detection of tritium (Table F-31 pCi/L) in the effluent in 2009. The influent is no longer sampled for tritium.

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. All 2009 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 2009, approximately 135 million gallons of groundwater were pumped and treated by the North Street system, and approximately 10 pounds of VOCs were removed. Since May 2004, the system has removed 300 pounds of VOCs. The mass removal data are summarized on **Table F-28**.

3.2.8.6 System Evaluation

Figure 3.2.8-6 compares the TVOC plume from 1997 to 2009. The following changes were observed in the plume over this period:

- 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. Monitoring wells 800-99 which is approximately 1,300 feet north of the Airport System and 800-101, just north of extraction well RTW-4A have low but steadily increasing values.

The OU III North Street Monitoring Program can be evaluated from the five decision rules identified in 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 or extraction wells associated with the North Street Pump and Treat System during 2009.

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

Yes. An analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2009; 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 Airport extraction wells are controlling the leading edge 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 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 five years of operation, the system influent VOC concentrations are steadily declining. The pre-design modeling predicted that the system will need to operate until 2012. Based on current data this prediction appears to remain valid.

<u>4. Are there off-site radionuclides that would trigger additional actions?</u>

No. As noted in **Section 3.2.8.3**, during 2009 there were only trace values of tritium detected in monitoring wells with concentrations below 850 pCi/L.

<u>5. Can the groundwater treatment system be shut down?</u>

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 one of 12 plume core wells of the North Street system are showing concentrations greater than 50 µg/L TVOC and three are slightly below 50 µg/L TVOC. There are TVOC concentrations above 50 µg/L downgradient of the North Street system in Airport system monitoring wells just south of Moriches Middle Island Road. These higher concentrations will be captured by the Airport system extraction wells.

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 well 000-476 will be reduced from semiannual to annual.
- Due to the location of well 086-43 north of the Former Landfill (with respect to the plume) and since groundwater samples have not exceeded AWQS since it was installed, it is recommended that this well be dropped from the North Street monitoring program.
- VOCs have remained below AWQS for wells 115-33, 115-34, and 115-35 since they were installed in 1996, and there have been no detections above AWQS 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.
- It is recommended to begin pulse-pumping extraction well NS-1, one month on and one month off during 2010, due to TVOC concentrations below 50 µg/L in upgradient monitoring wells. If there is any rebounding of higher TVOC concentrations, the extraction well will be placed back in to full-time operation.

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3.2.9 North Street East Pump and Treat System

This section summarizes the 2009 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. The extraction well pump for NSE-1 is designed to operate at a rate of approximately 200 gpm; extraction well pump for 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 (**Figure 1-2**). 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. During 2009, as recommended in the *2008 Groundwater Status Report* (BNL 2009b) the wells were sampled at shutdown monitoring frequency beginning in the second quarter (sampled quarterly). The wells are sampled at least annually for tritium. See **Table 1-5** for details.

3.2.9.3 Monitoring Well Results

Figure 3.2.9-1 shows the extent of the VOC plume. The plume originated from the Current Landfill and former HWMF (sources in OU I). The higher concentration segment of the plume (greater than 10 µg/L TVOCs) is just north of the LIPA right-of-way and extends to 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 2009 analytical results for the 15 NSE program wells. A summary of key monitoring well data for 2009 follows:

- All monitoring wells in the plume have remained below the treatment system capture goal of 50 µg/L TVOCs from 2005 through 2009, except for one detection in well 000-478 (58 µg/L) in March 2005.
- TVOC concentrations in plume perimeter well 000-137, and core well 000-138 remained very low during 2009, with concentrations below 5 µg/L. Plume core well 000-124 was also less than 5 µg/L TVOC through 2009.
- The maximum plume TVOC concentration observed in 2009 was 47 µg/L in plume core well 000-477. The primary compounds identified in the sample were TCA at 26 µg/L and DCE at 11 µg/L in November 2009. This well is located in the west side of the plume approximately 250 feet upgradient of NSE-1. **Figure 3.1-3** indicates the trend graph for this well.
- In core well 000-478 the maximum TVOC concentration during 2009 was 5 µg/L. TVOC concentrations in core well 000-479 steadily decreased to below 3 µg/L in 2009. Plume core well 000-480 in 2009 has shown a steady decline in TVOC from second quarter sampling of 42 µg/L to 34 µg/L in the third quarter and 26 µg/L in the fourth quarter. The primary compounds in this

well during 2009 were TCA and chloroform. In November the concentrations of these compounds were 3.8 µg/L TCA and 17 µg/L for chloroform.

- TVOC concentrations in plume core well 000-481, located between NSE-1 and NSE-2, have been less than 5 µg/L in 2007 through 2009. In addition, nearby core wells 000-482, 000-483, 000-484, and 000-485 have remained below 5 µg/L since 2005.
- Plume bypass well 000-486 has not detected TVOC concentrations above 2 µg/L since it was installed in 2004.
- In 2009, the highest tritium concentration in the plume (780 pCi/L) was detected in well 000-215 in November. 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 AWQS) in 1998.

3.2.9.4 System Operations

Influent, midpoint, and effluent samples from the GAC units have been sampled every other month since the system is in pulse-pumping mode. The extraction wells were sampled quarterly during 2009. All NSE system samples were analyzed for VOCs. In addition, the influent and effluent samples were analyzed monthly for pH. During 2009, 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
2009 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		2.9
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 2009 with only minor shutdowns due to electrical outages, PLC issues, and scheduled maintenance. During 2009, approximately 5.9 pounds of VOCs were removed. Since June 2009, extraction well NSE-2 has been pulse pumped with the well on one month and off the next, and NSE-1 running full-time. Based on the pumpage report for 2009, **Table 2-3** there have been some interruptions with the pulse pumping due to maintenance being performed.

January through September 2009

The system operated normally with only minor shut downs due to electrical problems and injection well maintenance. The system pumped and treated approximately 53 million gallons of water.

October through December 2009

Due to PLC component repairs and repairs on NSE-1 and associated electrical components, the system was off for most of October and part of November. In this quarter, the system pumped and treated approximately 11 million gallons of water.

Extraction Wells

During 2009, 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-32**. Steady TVOC concentration trends are noted for both wells during 2009, with concentrations averaging below 12 μg/L reported in NSE-1 and averaging below 4 μg/L in NSE-2 during the entire year.

System Influent and Effluent

VOC concentrations for 2009 for the carbon treatment influent and effluent are summarized on **Tables F-33** and **F-34**. Influent TVOC concentrations have been at or below 15 μg/L since 2005. In December 2009 influent TVOC concentrations reached 15 μg/L with the primary compounds being TCA, DCE and chloroform. The carbon treatment system effectively removed VOCs from the influent groundwater resulting in all 2009 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-35**). The cumulative mass of VOCs removed by the treatment system versus time is shown on **Figure 3.2.9-3**. During 2009, 5.9 pounds of VOCs were removed, with a cumulative total of 30 pounds of VOCs removed since system start-up in April 2004.

3.2.9.6 System Evaluation

The system began full 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 five years, and an analysis of the plume perimeter and bypass wells shows that there have been no significant increases in VOC concentrations in 2009, 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. If concentrations remain below the capture goal of 50 µg/L TVOCs, in the first two quarters of 2010 and monitoring well 000-477 indicates declining trends, a Petition for Shutdown of the NSE system will be prepared during 2010.

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 are below 50 µg/L TVOCs.

4c. During pulsed operation of the system, is there significant concentration rebound in core wells?
No. Since the system was first shut down for pulse pumping starting October 2006, all core wells have remained low and no 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 North Street East Pump and Treat System and groundwater monitoring program:

- Extraction well NSE-1 will remain in full time operation. Shut off extraction well NSE-2, placing it in a Stand-by mode. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, NSE-2 will be put back into full-time operation.
- Install a temporary well northwest (upgradient) of monitoring well 000-477 to determine the extent of VOC concentrations in this area.
- Drop monitoring well 800-54, located south of Moriches Middle Island Road, from the North Street East sampling program.
- Sample for Tritium only once per year in all wells.
- Following the review of additional monitoring well data, specifically evaluating 000-477, a Petition for Shutdown of the system will be prepared during 2010.
- Continue the shutdown monitoring frequency (sampled quarterly) for the NSE monitoring wells through 2010.

3.2.10 LIPA/Airport Pump and Treat System

This section summarizes the 2009 operational and monitoring well data for the OU III LIPA/Airport Groundwater Pump and Treat System, and presents conclusions and recommendations for its future operation. The LIPA system was designed to provide capture and control of the downgradient portion of the plume of VOCs in the Upper Glacial aquifer that had migrated past the Industrial Park System before that system became operational in 1999. The Airport Treatment System was designed to capture the leading edge of the OU III and OU I/IV VOC plumes and to prevent further migration of the plumes, which have migrated past the LIPA extraction wells and the North Street extraction wells.

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** and **3.2.10-1** identify 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 Well Results

The primary VOCs associated with these portions of the plume are carbon tetrachloride, TCA, TCE, and 1,1-dichloroethylene. Groundwater monitoring for these systems was initiated in 2004. Fourth-quarter 2009 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 2009 TVOC concentrations for the Magothy extraction well EW-4L on Stratler Drive ranged from 38 µg/L in January to 26 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 (30 µg/L) in May 2009. **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 shut down in October 2007. Well EW-2L had a high TVOC concentration of 10 µg/L in January and a low of 8 µg/L in October 2009. Well EW-3L continued to show VOC concentrations below AWQS. EW-1L showed TVOC concentrations ranging from 9 µg/L in January to 6 µg/L in October 2009. 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 AWQS, 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. The concentrations were 13 µg/L and 32 µg/L in November 2009.
- Five of the six airport extraction wells had VOC concentrations below AWQS throughout 2009. Newly installed extraction well RW-6A showed TVOC concentrations of 10 µg/L in January to 14 µg/L in July.
- 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 up to 113 µg/L in February 2009 and to 47 µg/L in November 2009. None of the monitoring wells installed downgradient of this area have shown carbon tetrachloride above AWQS.
- 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 (800-133) that is screened from 215 to 235 ft bls (**Figure 3.2.10-1**). This well has low concentrations of VOCs below the AWQS.

3.2.10.4 System Operations

In 2009, 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 2009.

January – September 2009

The LIPA System was down in January for a carbon change out and communication problems between the LIPA vault and the Airport system. In September the system was down due to a communication problem. The Airport wells continued normal operations, with wells RTW-1A and RW-6A operating on a full-time basis. RTW-3A which had temporarily operated on a full-time basis due to a sample round showing concentrations above 10 µg/L stopped full-time operations in October 2009.

October – December 2009

The system operated normally for the last quarter of 2009 with minimal down time due to scheduled maintenance and carbon change-outs.

Extraction Wells Operational Data

During 2009, approximately 266 million gallons were pumped and treated by the OU III Airport/LIPA System, with an average flow rate of 514 gpm (**Table 3.2.10-2). Table F-37** summarizes the system's mass removal. VOC concentrations for the airport and LIPA extractions wells are provided on **Table F-38.**

3.2.10.5 System Operational Data

System Influent and Effluent

VOC concentrations for the carbon influent and effluent in 2009 are summarized on **Tables F-39** and **F-40.**

The carbon vessels for the system effectively removed the contaminants from the influent groundwater. 2009 System effluent data were below the analytical below the regulatory limit specified in the SPDES equivalency permit. **(Table 3.2.10-1).**

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 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 2009, with a total of 283 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 AWQS 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

Table 3.2.10-1
OU III LIPA/Airport Pump & Treat System
2009 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–7.5 SU	5.8-7.45 SU
carbon tetrachloride	5	ND
chloroform 7		ND
1,1-dichloroethane	5	ND
1,1-dichloroethylene 5		ND
methylene chloride	5	0.62
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

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 of the LIPA/Airport Treatment System during 2008.

2. Has the plume been controlled?
Yes, based on the historical analytical data collected from the monitoring wells and the 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;

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, 800-101, and 800-106) had TVOC concentrations greater than 10 µg/L in 2009.

4d. During pulsed operation of the system, is there significant concentration rebound in core wells?
The intent of the current pulse pumping at the Airport is not to evaluate for rebound but to monitor for the high-concentration segment currently located north of the Airport 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 2065, 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. 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.

- Place LIPA Well EW-2 in standby, as this well was below AWQS throughout 2009.

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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 and Industrial Park East. 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 2009).

Location	Max. TVOC (in µg/L) 2009	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	113	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	102	102	TCE	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	11	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	31	570	TCA, CCl_4	TVOC concentrations currently are 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	31	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 [currently in standby], Airport, Industrial Park East [currently in standby], and LIPA).

2. Continued evaluation of monitoring well 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 until cleanup goals are met.
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 (this well is currently in standby as cleanup goals have been met). 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 VOCs identified on Carleton Drive and prevent migration of high concentrations of VOCs 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 TVOC concentrations ranged from 15 µg/L to 31 µg/L in 2009. 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 44 µg/L in August to 11µg/L in November 2009. Well 000-250 had VOC concentrations below AWQS in 2009. 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 zone 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 5 µg/L to 10 µg/L during 2009. 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 0.3 to 10 µg/L in 2009.

Well 122-05: This well, located at the eastern edge of the OU III South Boundary System, showed TVOC concentrations at approximately 30 µg/L in 2009.

Well 000-343: Located south and between the OU I and OU III South Boundary systems, this well had TVOC concentrations around 10 µg/L in 2009.

Well 115-50: Located south and between the OU I and OU III South Boundary systems, this well had VOC concentrations below AWQS in 2009.

Wells 000-427 and 000-429: These wells are located just south of the Industrial Park East System on Carleton Drive. In 2009, well 000-427 had TVOC concentrations ranging from 3 µg/L to 12 µg/L and well 000-429 had concentrations ranging from 3 µg/L to 7 µg/L in 2009.

Well 800-90: This well is located near Moriches-Middle Island Road upgradient of Airport extraction wells RTW-3 and RTW-4. It is screened at approximately 255 feet below grade. TVOC concentrations ranged from 62 µg/L to 102 µg/L in 2009. 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 RTW-3 and RTW-4.

Well 113-09: This well is located at the Middle Road west of extraction well RW-1. It is screened near the Upper Glacial/Magothy interface at 220 feet. It has shown TVOC concentrations of 94 µg/L in October 2009. Concentrations have been stable for the past few years in this well.

3.2.11.2 Recommendations

No changes to the Magothy groundwater monitoring program are warranted at this time. Continue the current monitoring schedule for the Magothy monitoring program. The IPE and South Boundary Magothy extraction wells are currently in standby as they have reached the cleanup goals (TVOC <50 µg/L) identified for shutdown of these wells.

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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 13 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**).

3.2.12.2 Monitoring Well Results

Only two VOCs were detected in the OU III Central wells above NYS AWQS. Well 065-02 had a TCA concentration of 9.3 µg/L and Well 076-317 had a PCE concentration of 12 µg/L, which are both above the NYS AWQS of 5 µg/L for each compound. In many of the wells in the north-central developed portion of the site, the primary constituent is TCA. 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 2009. Radionuclides were not detected in any of the samples collected from wells 109-03 and 109-04 during 2009.

Due to access issues caused by the construction at the National Synchronous Light Source II site, well 096-07 could not be sampled.

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.

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unusual or unexpected VOC or radionuclide concentrations in the monitoring wells associated with this program during 2009.

2. Are there potential impacts to the SCWA William Floyd Well Field from on-site contamination?
No. There were no detections of contaminants in the sentinel monitoring wells during 2009, with the exception of low-level (below 0.5 ug/L) chlorinated organic compounds (below NYS AWQS). These compounds were chloroform, methyl chloride, and methylene chloride.

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 2009 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

No changes to the OU III Central groundwater monitoring program are warranted at this time.

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 they 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** and **3.2.13-1**). 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 2009.

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 2009, they continued to have VOC concentrations below the NYS AWQS. Chloroform was detected at up to 2.1 µg/L in well 000-98 during November 2009. 1,1,1-Trichloroethane was detected at 1.7 µg/L and Trichloroethylene was detected at 1.4 µg/L in well 800-52 during November 2009.

3.2.13.3 Groundwater Monitoring Program Evaluation

There were no unexpected results during 2009 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 OU III Off-Site Groundwater 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 56 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 2009.

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.

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

No. There were no unexpected results during 2009 to trigger the BNL Groundwater Contingency Plan.

3.2.14.4 Recommendations

The following are the recommendations for the South Boundary Radionuclide groundwater monitoring program:

- Since there are wells directly upgradient of monitoring wells 121-43, 122-24, 122-25, 122-34, and 122-35 and there have been no radionuclide detections reported, sampling of these wells for radionuclides should be discontinued.

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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 for tritium for the g-2 plume (**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 dry 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 extending south from the WCF area, one extending south of the BGRR Below Ground Ducts (BGD) and former 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 Waste Management Facility). 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 located approximately 850 feet west of Building 855. A 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 84 monitoring wells is used to monitor the Sr-90 plumes associated with the BGRR, WCF, and PFS areas. This network is currently being supplemented with temporary wells in the vicinity of the HFBR to monitor the high concentration Sr-90 and tritium (g-2) plume identified in this area in 2007 through 2009. Most recently, temporary wells were installed in this area during the fourth quarter of 2009 and the first quarter of 2010.

Sampling Frequency and Analysis

In 2009, the sampling frequency for all three of the Sr-90 plume segments, (BGRR, PFS and WCF) is in the O&M phase (annual) for most wells. 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 Results

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 2009 and first-quarter 2010 sampling of the permanent 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 monitoring data for the three Sr-90 plumes.

WCF Plume

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

- In 2009, the highest Sr-90 concentration in the source area for this plume was 371 pCi/L 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 fluctuating Sr-90 concentrations with no significant trend in this well over the past nine years. This contamination is captured by extraction well SR-2.

- As recommended in the *2008 BNL Groundwater Status Report* (BNL 2008b), select samples were analyzed for Sr-90 during the installation of temporary wells to characterize the g-2 tritium plume just south of the HFBR. The cross section on **Figure 3.2.15-4** shows both plumes and illustrates the relationship between the two plumes. The data from this effort is being 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 be achieved. From February through March 2010, two sets of east-west temporary well transects were installed and sampled for both tritium and Sr-90. The six 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 Sr-90 data did not show any appreciable change in the downgradient portion of the WCF plume during 2009. The latest data does show that the g-2 tritium plume high concentration slug has continued to migrate south. Based on this data there are no longer tritium concentrations exceeding the DWS in the area adjacent to the HFBR currently being targeted for additional Sr-90 extraction wells.

BGRR Plume

Refer to **Figure 3.2.15-2** for a cross-sectional view of the BGRR plume. The monitoring well data for this plume was supplemented with nine temporary wells in 2009 as per the recommendation from the *2008 BNL Groundwater Status Report*.

- Temporary well GP-36 was installed immediately adjacent to monitoring well 075-664. The purpose of this well was to determine if the screen zone in the permanent well was too far below the water table to intercept high concentrations of Sr-90 still migrating from the BGD and Building 701 area. The results from GP-36 (peak Sr-90 concentration of 592 pCi/L at the water table) as compared to the results from well 075-664 (14 pCi/L) confirmed that in fact the permanent well is screened too deep. The results also confirm a continuing source of Sr-90 contamination from the BGD/Building 701. The high Sr-90 concentrations in this area are captured by extraction well SR-3.
- Temporary well GP-37 results indicate that the plume center-line at Cornell Avenue is to the east of well cluster 075-190, 075-191, and 075-192. Extensive underground utilities preclude monitoring the plume center-line in this area.
- A higher than expected Sr-90 detection at well 075-671 (located on Brookhaven Avenue) of 82 pCi/L in October of 2009 prompted the installation of seven additional temporary wells from just south of Cornell Avenue to south of Brookhaven Avenue. This concentration was in the upper range of concentrations that could be expected in this area based on the system design groundwater modeling. Three temporary wells adjacent to this monitoring well showed a maximum concentration of 54 pCi/L. In addition, in a subsequent sampling during the first quarter of 2010 the concentration in 075-671 decreased to 29 pCi/L. Two additional temporary wells were installed approximately 150 feet south of Brookhaven Avenue and showed a maximum Sr-90 concentration of 12 pCi/L(GP-44).
- Following the Sr-90 detection at well 075-671 additional temporary wells (GP-39 and GP-38) were installed at locations between Cornell and Brookhaven Avenue where there are no current monitoring points. The data from these temporary wells showed levels of Sr-90 that were within the expected range of concentrations for this segment of the plume.

Pile Fan Sump Plume

Refer to **Figure 3.2.15-3** for a cross-sectional view of the Pile-Fan Sump plume

- As recommended in the *2008 Groundwater Status Report* (BNL 2008b), a temporary well (GP-43) was installed just north of well 075-86. The purpose of this well was to determine whether the screen zones of the well cluster 075-46, 075-85, 075-86, and 075-672 were spaced appropriately to intercept and characterize the plume center-line. The high concentration for GP-43 was 57 pCi/L at 82 feet bls which is located in a gap within the screen zones at this well cluster (**Table 3.2.15-1**). This data correlates with monitoring well 075-683 (located approximately 50 feet east) which is screened from 79 to 84 feet bls and also had a concentration of 58 pCi/L of Sr-90 (**Figure 3.2.15-3)**.
- Plume core well 065-37, located just downgradient of the PFS, detected 52 pCi/L Sr-90 in October 2009. As noted on **Figure 3.2.15-5**, this is a slight decrease from the 2007 data but steady from prior year data.

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, throughout 2009 while the system was operating, samples from the influent, effluent, and midpoint locations of the treatment system were collected twice a month 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 2009 are summarized on **Table F-40**. System influent and effluent concentrations are summarized on **Tables F-41** and **F-42**. **Table F-43** contains the monthly Sr-90 removal totals for the system.

Operating details are given in the O&M manual for this system (BNL 2005d). Below is a summary of the system operations for 2009.

January – September 2009

The system was off from February 23 to March 23 for a resin vessel change out. In July the system was off for ten days for a piping re-configuration. In addition in July and part of August, wells SR-1 and SR-2 were shutdown for a week while the A/B waste line excavation work took place. Well SR-3 was off for most of the month of August with electrical problems. The system was also off for most of September while maintenance was being performed. The system pumped a total of 6.5 million gallons for this period.

October – December 2009

SR-3 and SR-5 were off for part of the month of October with electrical problems. Well SR-5 was also off for part of November due to this problem. The system operated normally the remainder of the time and pumped a total 2 million gallons for this period.

Extraction Well Operational Data

During 2009, approximately 8.5 million gallons were pumped and recharged by the OU III BGRR/WCF SR-90 Treatment System, with an average flow rate, including maintenance down time, of 17 gpm. **Table 3.2.15-3** shows the monthly extraction well pumping rates while **Table F-40** shows Sr-90 concentrations.

3.2.15.5 System Operational Data

During 2009, influent concentrations of Sr-90 ranged from 21 to 54 pCi/L, with the highest concentration observed in March. The highest influent tritium concentration during 2009 was 353 pCi/L in November (**Table F-41**). During 2009, Sr-90 was detected three times in the effluent samples in January, February and December, at concentrations of 1.7, 1.6 and 0.78 pCi/L respectively (**Table F-42**). These detections were 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 2009 influent or effluent samples.

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 2009, the flow averaged 17 gpm. Approximately 1.4 mCi

Table 3.2.15-2
BGRR Sr-90 Treatment System
2009 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	1.72
Chloroform	7.0 µg/L	<0.5
1,1-Dichloroethane	5.0 µg/L	<0.5
Ethylbenzene	5.0 µg/L	<0.5
Methyl Chloride	5.0 µg/L	<0.5
Methylene Chloride	5.0 µg/L	<0.5
Toluene	5.0 µg/L	<0.5
1,2,3-Trichlorobenzene	5.0 µg/L	<0.5
1,1,1-Trichloroethane	5.0 µg/L	<0.6
1,2,4-Trimethylbenzene	5.0 µg/L	<0.5
Xylene, total	10.0 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.

of Sr-90 was removed during 2009, for a total of 17.5 mCi removed since system start-up in 2005 (**Table F-43**). Cumulative mass removal of Sr-90 is shown on **Figure 3.2.15-6**.

Extraction Wells

Maximum Sr-90 concentrations in each of the extraction wells during 2009 were as follows:

- SR-1 60 pCi/L in July
- SR-2 98 pCi/L in April
- SR-3 89 pCi/L in November
- SR-4 15 pCi/L in July
- SR-5 52 pCi/L in July

During 2009, no VOCs were detected above the drinking water standard in the extraction wells. **Figures 3.2.15-7** and **3.2.15-8** 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 Groundwater Treatment 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 2009.

BGRR Plume: Yes. Sr-90 was detected at a higher than expected concentration of 82 pCi/L at well 075-671 (located on Brookhaven Avenue) in October of 2009.

PFS Plume: No. There were no unusual or unexpected concentrations in the monitoring wells associated with this program during 2009.

2. Has the plume been controlled?

WCF Plume: The source area is controlled by extraction wells SR-1 and SR-2 although monitoring well data indicates that there may be a continuing source. It has been determined that the higher concentration downgradient segment of the plume in the vicinity of the HFBR will have to be addressed with active remediation in order to achieve the OU III ROD ESD cleanup goals of meeting DWS by 2070.

BGRR Plume: Yes. Based on the monitoring well data and recent temporary well data, the high concentration portion of the plume is being captured by extraction wells SR-3, SR-4, and SR-5. Based on the concentrations in temporary well GP-36 there appears to be a continuing source from the BGD/Building 701 area.

PFS Plume: Yes. Based on the monitoring well data and recent temporary well data, the high concentration portion of the plume is expected to attenuate to below DWS by 2070.

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 SR-1 and SR-2 in the source area 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 DWS. However, based on current model projections on the long-term restoration of the aquifer, the elevated Sr-90 concentrations identified in the vicinity of the HFBR indicate that the OU III ROD ESD cleanup goal of meeting DWS by 2070 will not be met without active remediation of this area. Additional extraction wells will be installed during 2010 to reduce the high concentration slug (identified as part of the recent effort) to levels that will attenuate in accordance with the cleanup goal.

<u>BGRR Plume</u>: 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. Data from GP-36 indicates that there is a continuing source at the BGD/Building 701. Recent data from this plume will be used for an updated groundwater modeling simulation to confirm that downgradient concentrations are within the range that will allow for the plume to naturally attenuate to DWS as per the OU III ROD cleanup goal.

<u>PFS Plume</u>: Based on the Sr-90 concentrations detected in 2009, the plume is attenuating as projected.

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

<u>WCF Plume</u>: 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. Installation of additional pump and treat wells in the vicinity of the HFBR in 2010 will allow for the OU III ROD ESD cleanup goal to be achieved.

<u>BGRR Plume</u>: 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.

<u>PFS Plume</u>: 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:

- Implement the installation of four additional extraction wells during 2010 to address the Sr-90 hot spots identified in the WCF plume.
- Install several temporary wells to characterize Sr-90 concentrations in the WCF source area.
- For the BGRR Sr-90 plume, install sentinel wells on the south side of Brookhaven Avenue to monitor the leading edge of the plume.
- Characterize the width of the plume at the well 075-664 location and install a new permanent monitoring well for the BGRR Sr-90 plume adjacent to monitoring well 075-664 screened at a shallower depth.
- Install temporary wells at Brookhaven Avenue to characterize the leading edge of the Pile-Fan Sump plume.

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 2009, 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. In 2009 the Sr-90 plume (as defined by the 8 pCi/L isocontour) was approximately 680 feet long and 75 feet wide, with a maximum thickness of 15 feet. It is approximately 22 to 45 feet below ground surface.

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.
2. Operation of the system to minimize plume growth and meet DWS by 2040.
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).

3.2.16.2 Groundwater Monitoring

Well Network

The Chemical/Animal Holes monitoring network consists of 35 wells. **Figure 1-2** and **3.2.16-1** 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. Eleven of the 35 monitoring wells were sampled semiannually for Sr-90; the remaining wells were sampled annually. The eleven semiannually sampled wells are considered key plume core, perimeter or bypass detection wells to provide indications of plume changes.

3.2.16.3 Monitoring Well Results

Figure 3.2.16-1 shows the Sr-90 plume distribution. The plume depiction is derived from third quarter monitoring well data.

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.

A summary of key monitoring well data for 2009 follows:

- The highest Sr-90 concentration observed in 2009 was 562 pCi/L in plume core well 106-16 during the first quarter sampling. 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 four 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 3.2 pCi/L in 2009. This is the second year that a break in the plume downgradient of EW-1 was observed.
- 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 42.1 pCi/L in January and 104 pCi/L in July 2009. The data for this well are the lowest since 1999. This indicates that EW-1 is controlling the northerly high concentration area of the plume and the trailing edge of the southerly segment of the plume continues to slowly move through this 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 38 pCi/L in July 2009. Plume core well 106-119, located upgradient of the southern-most extraction well EW-3 averaged approximately 20 pCi/L of Sr-90 during 2009.
- Plume perimeter well 106-48 has been showing average values of Sr-90 for the last two years of approximately 30 pCi/L **(Figure 3.2.16-2)**. The data continues to reflect slight shifting of the western portion of the plume south of Princeton Avenue. As part of the 2008 recommendations temporary well installations in this area are ongoing in early 2010.
- Plume perimeter well 106-50 continues to bound the plume to the east since it has been below the DWS since 2006.
- 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 was 1.6 pCi/L in July 2009 in well 106-122.

The complete monitoring results for all wells in this program 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, and in October 2009 the sampling frequency was changed to twice per month. These samples were analyzed for Sr-90 and the influent and effluent samples were analyzed for pH on a monthly basis (**Table 3.2.16-1**). The SPDES Equivalency Permit was renewed in February 2008 and the Sr-90 sampling frequency was changed from weekly to monthly and remained so for 2009. All extraction wells are sampled monthly **Table F-44**. Extraction well EW-1 remained in a pulse-pumping mode for 2009. Sr-90 concentrations for the system influent and effluent in 2009 are summarized on **Tables F-45** and **F-46**. **Table F-47** contains a summary of the monthly Sr-90 mass removal for the system.

Summarized below are the system operations data for 2009. Details for this system are given in the O&M manual.

Table 3.2.16-1.
OU III Chemical/Animal Holes Sr-90 Treatment System
2009 SPDES Equivalency Permit Levels

Parameter	Permit Level	Max. Measured Value
pH range (SU)	5.0–8.5	5.2–7.2
Sr-90 (pCi/L)	8.0	1.8

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 2009
For this period the system operated the majority of the time. The system was off several days in January due to planned power outages for construction projects at BNL. The system was also off from February 1st to the 4th due to electrical problems. From January through September, the treatment system pumped a total of 4.8 million gallons of water.

October – December 2009
The system operated normally for this quarter, with the exception of being off for several weeks in November and December due to a resin vessel change-out. The system pumped and treated a total of 1.4 million gallons of water this period.

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 and the concentration had steadily dropped to an average of 15 pCi/L for most of 2009. However, in December EW-2 had a concentration of 64 pCi/L. When EW-3 became operational, concentrations were already low at 13 pCi/L and averaged approximately 6 pCi/L for 2009 with a high of 8 pCi/L for the year. Concentrations of Sr-90 spiked up and down several times in EW-1, but averaged approximately 60 pCi/L for the year. Concentrations ranged from a low of 30 pCi/L to a high of 100 pCi/L in 2009. The spikes may be attributable to pulse pumping. **Figure 3.2.16-3** presents the extraction well influent data over time. The 2009 analytical data show that influent Sr-90 concentrations ranged from 8.5 to 50 pCi/L. Effluent samples were well below the SPDES equivalency permit level of 8 pCi/L for Sr-90. Approximately 6.3 million gallons of groundwater were processed through the system during 2009.

Cumulative Mass Removal
Average flow rates for each monitoring period were used, in combination with the Sr-90 concentration, to calculate the mCi removed. Flow averaged 12 gpm during 2009. **Table 3.2.16-2** shows the monthly extraction well pumping rates. The cumulative total mass of Sr-90 removed was approximately 0.46 mCi during 2009, with a total of approximately 3.79 mCi removed since 2003 (**Figure 3.2.16-4**).

3.2.16.6 System Evaluation
The Chemical/Animal Holes Sr-90 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 2009.

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 temporary

wells installed in 2008 in the upgradient portion of the plume and data for upgradient monitoring wells, 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 as planned 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 two additional extraction wells are also expected to operate approximately through 2017.

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 DWS by 2040 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:

- Continue to operate extraction wells EW-1, EW-2 and EW-3 in full-time mode.
- Maintain the operations and maintenance phase monitoring well sampling frequency begun in 2009.
- Drop wells 106-24, 106-25 and 114-01 from the monitoring program since there have been no historical detections of Sr-90 in this well.
- Complete temporary well investigations in the vicinity of monitoring well 106-48 to determine the current plume perimeter.

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 migrate 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 extraction wells.

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 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**).

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 includes 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-start-up 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 3,620 pCi/L.

For a complete description of the HFBR Tritium Pump and Recharge System, see the *Operations and Maintenance Manual 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 103 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 supplemented with temporary wells. A total of 17 temporary wells were installed and sampled from October 2009 to April 2010. (**Figure 3.2.17-1** and **Table 3.2.17-1)**. There was only one round of temporary well sampling in 2009 due to the construction of the National Synchrotron Light Source II facility impacting access to a number of locations. 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 Results

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 2009, supplemented with data obtained from 17 temporary wells installed from October 2009 through April 2010 **(Table 3.2.17-1)**. The temporary wells were installed to fill in data gaps along key segments of the plume. Specifically, the temporary wells were installed between Temple Place and Brookhaven Avenue, and then in several locations between EW-16 and the area south of Rowland Street 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. 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 2009 was consistently to the south. Supply well 10 and 11 provided less than 25% of the lab's water supply in 2009 and did not have a significant impact on sitewide groundwater flow directions. 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 2009 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 was a steady decline in water-table elevations from the middle of 2007 through 2008, which 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. There was a steady increase in water-table elevation through 2009 with no resulting spike in source area monitoring well tritium concentrations to date. It is important to note that there was a sharp rise in water-table elevation at the site during the first quarter of 2010 due to well above average precipitation during the winter months. The water table was nearing historical high elevations as of May 2010. It would be expected that any remaining inventory of tritium in the unsaturated zone beneath the HFBR spent fuel pool may be mobilized by this water table increase. The HFBR source area wells will continue to be monitored in 2010 for this possibility. Based on the long-term 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 2009 tritium concentration in this area was 17,900 pCi/L in well 075-44 (located on the HFBR south lawn) in March 2009 (**Figure 3.2.17-4**). The tritium concentrations in this well declined to 2,110 pCi/L by October of 2009. It appears based on some increases in concentrations in several of the westernmost monitoring wells in this area that the plume may have shifted slightly to the west during 2009. There were no concentrations above the DWS of 20,000 pCi/L in any of the wells in this area during 2009. The monitoring well network was supplemented with four temporary wells in 2009 to better characterize the eastern edge of the plume from Temple Place to Brookhaven Avenue. The HFBR tritium plume as depicted on **Figure 3.2.17-1** now consists of several discontinuous segments. In the fourth quarter of 2009 there were no tritium concentrations above the DWS from the HFBR to Brookhaven Avenue although a small area of inferred concentrations above 20,000 pCi/L is shown approximately 200 feet south of Temple Place based on 2008 data and tritium transport rates.

Brookhaven Avenue to Princeton Avenue Firebreak Road

The monitoring well network in this area was supplemented with 13 temporary wells during 2009/2010. The plume in this area has become discontinuous as defined by the 20,000 pCi/L contour.

The discontinuous nature of the plume is the result of the intermittent nature of tritium flushing in the vadose zone beneath the HFBR over the past several years resulting in pulses or slugs of tritium.

The high concentration downgradient slug is now located between the Weaver Drive area and pump and recharge well EW-16. Temporary wells installed along the Chilled Water Facility transect in 2008 and 2009 have shown peak tritium concentrations below 20,000 pCi/L following a detection of 113,000 pCi/L in this area in 2007. The highest tritium concentration observed in the plume was 56,600 pCi/L in GP-340, located about 100 feet north of EW-16.

EW-16 is sampled on a weekly basis. The peak concentration in this well was 3,620 pCi/L during June of 2009. Tritium concentrations slowly dropped off thereafter, and have remained below 2,400 pCi/L since August of 2009. 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** presents the VOC and tritium detections in the extraction wells for 2009.

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 2009. 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. 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 2009 SPDES equivalency permit levels.
The following is a summary of the OU III HFBR AOC 29 Tritium System operations for 2009:

January – September 2009

The system was off for the month of January due to the electrical construction work conducted at the NSLS II project. Otherwise, normal down time was experienced due to scheduled maintenance and alarm testing. During the first three quarters of 2009 approximately 75 million gallons of groundwater were pumped and recharged.

October – December 2009

The system operated normally during the last quarter of 2009. Approximately 29 million gallons of groundwater were pumped and recharged.

Extraction Well Operational Data

During 2009, approximately 103 million gallons of groundwater were pumped and recharged by the OU III HFBR AOC 29 Tritium System, with an average flow rate of 193 gpm. **Table 3.2.17-3** shows the monthly extraction well pumping rates whereas **Table F-48** 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.

Table 3.2.17-2
OU III HFBR AOC 29 Tritium System
2009 SPDES Equivalency Permit Levels

Parameters	Permit Level (µg/L)	Max. Measured Value (µg/L)
pH	5.5–8.5 SU	5.7-7.7 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

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 2009. 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 during continued operation.

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 between Weaver Drive and EW-16, which is positioned to capture the plume. The area immediately downgradient of the HFBR was below DWS during 2009. There has been a notable reduction over the past several years in both the frequency and concentrations of new tritium slugs. See **Figure 3.2.17-5** for the plume distribution comparison between 1997 and 2009.

3. Are observed conditions consistent with the attenuation model?
Yes. Groundwater modeling conducted in 2007 to address the downgradient high concentration plume segment approaching Weaver Drive predicted that the pump and recharge system would operate for a duration of approximately 2-4 years. This prediction is reasonable based on the tritium concentrations observed in this area in 2009.

4. Is the tritium plume migrating toward the zone of influence of water supply wells 10 and11?
No. Groundwater flow from this area was to the south during 2009 (**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 AOC 29 Tritium Pump and Recharge System and monitoring program:

- Increase the sampling frequency for monitoring wells 075-42, 075-43, 075-44, and 075-45 to monthly as a result of the historical high water-table elevations during 2010 to monitor for any corresponding source area tritium releases. Continue monitoring for six months and then re-evaluate based on water-table conditions and observed tritium data.
- Continue to install and sample temporary wells as necessary 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 2010. 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 EW-16 has captured concentrations of tritium greater than 20,000 pCi/L in this area. 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

This section summarizes the data from the Former OU IV Air Sparging/Soil Vapor Extraction (AS/SVE) System and offers conclusions and recommendations for monitoring.

3.3.1 OU IV AS/SVE System Post Closure Monitoring Program

The OU IV 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.

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

Monitoring wells 076-04 and 076-06 were sampled and analyzed annually for VOCs and semivolatile organic compounds. Well 076-185 was sampled and analyzed for VOCs semi-annually.

3.3.1.2 Monitoring Well Results

Post-closure sampling of monitoring wells was conducted for 2009. The complete groundwater data are given in **Appendix C**. There were no detections of SVOCs above reporting limits in any of the samples collected. The only VOCs detected above the NYS AWQS were cis-1,2-dichloroethylene and PCE in well 076-185. The compounds cis-1,2-dichloroethylene and PCE were detected above the NYS AWQS in the April and November rounds at concentrations up to 19 µg/L and 23 µg/L, respectively. These results confirm those reported from the third quarter of 2008. 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.

1. Was the BNL Contingency Plan triggered?

No. There were no unexpected VOC concentrations in groundwater during 2009.

3.3.1.4 Recommendation

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

- Due to the increasing concentrations of cis-1,2-dichloroethylene and tetrachloroethylene, the sampling frequency of monitoring well 076-185 should increase to semi-annual.

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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 24 wells used to monitor the Sr-90 concentrations originating from the former Building 650 sump outfall area (**Figure 1-2 and 3.3.2-1**).

Sampling Frequency and Analysis

During 2009, 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/Temporary Well Results

The complete monitoring well radionuclide sampling results 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. Based on a recommendation from the 2008 Report the monitoring well network was supplemented with 14 temporary wells in order to characterize the leading edge of this plume and the location of the downgradient plume core. The locations of the permanent and temporary wells and the Sr-90 concentrations are shown on **Figure 3.3.2-1**. The temporary well data (obtained using a Geoprobe) is summarized in **Table 3.3.2-1.** The leading edge of the plume as defined by the 8 pCi/L DWS is presently located approximately 400 feet north of Brookhaven Avenue. Sr-90 concentrations in the source area continue to decrease as evidenced by the declining Sr-90 concentrations in wells 076-13 and 076-169 over the prior twelve years (**Figure 3.3.2-2**). During 2009/2010, the highest Sr-90 concentration (74 pCi/L) was detected in temporary well AOC 6-GP-05 in January 2010. Based on the temporary well characterization it appears that the center-line of the plume is located approximately 50 to 100 feet west of well 076-24. The highest concentrations within the plume appear to be between approximately 500 feet to the north of Brookhaven Avenue. The plume appears to be behaving as predicted and a recommendation will be made to update the groundwater model with the latest data and determine the predicted date range in which attenuation of the plume to below drinking water standard can be expected.

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.

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

No. There were no unexpected Sr-90 concentrations detected in groundwater during 2009.

<u>2. Were performance objectives met?</u>

No. The performance objective for this project is to achieve Sr-90 concentrations below the DWS of 8 pCi/L. There were three permanent and two temporary wells exceeding this limit in 2009 (076-13, 076-169, 076-24, AOC6-GP-04, and AOC6-GP-05). 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:

- Drop monitoring wells 066-17, 076-167, 076-20, 076-26, and 076-183 from the monitoring program. The sampling frequency is currently annual in these wells. This recommendation is based on both the long history of very low Sr-90 detections in these wells along with the fact that they are clearly outside of the Sr-90 plume area based on the latest comprehensive plume characterization. The sampling of wells can be resumed and sampling frequencies increased if warranted by future changes in groundwater flow conditions.
- Re-instate an annual sampling frequency for well 076-182 in light of the latest plume characterization as it appears to be positioned as a sentinel well for the leading edge of the plume.
- Update the groundwater model with the 2009/2010 characterization data and run a new simulation to predict the expected time frame for achieving drinking water standards by natural attenuation of the plume.
- Install two monitoring wells in the downgradient plume core area and a sentinel well near the leading edge of the plume.

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 annually for perchlorate (**Table 1-5)**.

3.4.3 Monitoring Well Results

The OU V wells were sampled once during 2009. **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 (LIE) (**Figure 3.4-1**). During 2009, the highest TVOC concentration was 6 µg/L in off-site plume core well 000-122 located immediately north of the LIE. The highest individual VOC in this well was TCE at a concentration of 3 µg/L. The AWQS for TCE is 5 µg/L. 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 (based on the downgradient well data). 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 continued, gradual decline in concentrations (**Figure 3.4-2**). A comparison of the plume from 1997 to 2009 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. The sampling program has been gradually been reduced over the past five years in response to a decrease in perchlorate detections and concentrations. Perchlorate was detected in two of the 2009 samples (wells 050-01 and 061-05) at concentrations just above detectable limits. 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. Monitoring will continue for these eight wells in 2010.

Tritium has historically been detected at low concentrations in monitoring wells 049-06, 050-02, and 061-05. Tritium concentrations in each of these wells have steadily declined over the past 12 years. During 2009, the maximum tritium concentration detected was 940 pCi/L in well 061-05; this is approximately one-twentieth the NYS AWQS of 20,000 pCi/L. Tritium was not detected in the off-site monitoring wells.

3.4.4 Groundwater Monitoring Program Evaluation

The OU V Groundwater Monitoring Program can be evaluated in the context of three basic decisions established for this program using the groundwater DQO process:

1. Was the BNL Groundwater Contingency Plan triggered?
No. There were no unexpected contaminant concentrations in groundwater from the OU V Monitoring Program during 2009.

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. Individual VOCs were below NYS AWQS in the program monitoring wells in 2008 and 2009.

3. Is the extent of the plume still defined by the existing monitoring well network?
Yes. The leading edge of the TVOC 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 recommendations are 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 or 2009. It was recommended in the 2008 Groundwater Status Report that the monitoring well network be sampled on an annual basis for one more year. If individual VOC concentrations and tritium remained below NYS AWQS during 2009, BNL could recommend reducing the number of wells being monitored. It is recommended that monitoring for VOCs and tritium be discontinued based on the observation that there have been no detections of either constituent above NYS AWQS dating back to 1997 and 1998 (the timeframe in which these wells were installed) in the following wells: 037-02, 037-04, 041-01, 041-02, 041-03, 049-05, 050-02, 061-03, 061-04, 000-123, 000-147, 000-141, 000-142, 000-143, 000-144, 000-145, 000-146, 600-15, 600-16, and 600-18.
- There have been no detections of percholorate in wells 000-122, 000-123, and 049-06 since sampling began in 2004. Based on the absence of perchlorate in these wells over the previous six years analysis for perchlorate will be discontinued. Continue perchlorate sampling in the five remaining monitoring wells for one more year. If perchlorate concentrations are below standards for two consecutive years, sampling for perchlorate will be discontinued.
- If individual VOCs remain below NYS AWQS in monitoring wells during 2010 a petition will be prepared and submitted to the regulatory agencies to conclude the monitoring program.

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 biology fields located in the southeastern portion of the site (**Figure 3.5-1**). 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. During 2009, EDB was not detected on BNL 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 24 wells monitor the EDB plume from just north of the BNL south boundary to locations on private property south of North Street (**Figure 3.5-1**). As suggested by EPA during review of the 2008 Groundwater Status Report, an additional perimeter monitoring well in the northeast portion of the plume will be installed in 2010.

Sampling Frequency and Analysis

The OU VI EDB plume monitoring program is in the O&M phase (**Table 1-8**). The sampling frequency for most of the plume core and perimeter wells (**Table 1-5**) is semiannual. The exception to this was core well 000-178 and bypass detection wells 000-508 and 000-519, 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 using EPA Method 524.2. 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 on **Figure 3.5-1** for the fourth quarter of 2009. 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 2009 follows:

- During 2009, the highest EDB concentration observed in the plume was 1.4 µg/L in core well 000-178. In comparison, during 2008 the maximum concentration in the plume was 1.5 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. However, EDB in well 000-178 has been increasing since late 2006, indicating movement of the plume south. This well is upgradient of EW-2E. 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.

- 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 in 2009 was 0.43 µg/L. This portion of the plume is downgradient of well 000-178 and will be captured by EW-2E (**Figure 3.0-1**).
- Core well 000-507 has detected gradually increasing levels of EDB above the DWS since it was installed in 2005 through mid 2008. During 2009, EDB concentrations have remained steady, just above the DWS. This well is immediately upgradient of the extraction wells.
- Plume bypass wells 000-501 and 000-508 have not detected EDB in 2009. Since it was installed in March 2009, plume bypass well 000-519 has not detected EDB.

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 2009 (**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 1.4 µg/L in 2009 (in well 000-178).

EDB was the only VOC detected above the MCL in any OU VI well in 2009 (**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 equivalency permit. Following a request from DOE, in December 2009 the NYSDEC renewed the EDB groundwater treatment system SPDES equivalency permit for another five years and modified the effluent limits. The effluent criterion for EDB was reduced from 5.0 µg/L to 0.03 µg/L to reflect an updated practical quantitation limit based on EPA Method 504. In addition, effluent criteria were added for methyl chloride and methylene chloride.

Table 3.5-1
OU VI EDB Pump & Treat System
2009 SPDES Equivalency Permit Levels

Parameters	Permit Limit	Max. Measured Value
pH (range)	5.0 – 8.5 SU	5.8 – 7.6 SU
ethylene dibromide	0.03 µg/L	<0.02 µg/L
chloroform	7.0 µg/L	1.3 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
methyl chloride	5.0 µg/L	<0.50 µg/L
methylene chloride	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 2009

The system operated with EW-1E and EW-2E running at 180 and 160 gpm, respectively, for almost this entire period. EW-2E was down from mid- February to mid-March due to a broken flow meter. From January through September, approximately 130 million gallons of water were pumped and treated.

October – December 2009

The system was off for a few weeks in November for development of the injection wells. The system operated normally for the remainder of this period. Approximately 34 million gallons of water were pumped and treated this quarter.

Extraction Wells

During 2009, 164 million gallons were pumped and treated by the OU VI EDB System, with an average flow rate of approximately 320 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**. Low levels of EDB were detected monthly in extraction well EW-1E during 2009, with a maximum of 0.075µg/L in March. Ten of the detections of EDB in EW-1E were slightly above the federal DWS of 0.05 µg/L. There were five EDB detections in EW-2E in 2009, with a maximum concentration of 0.03 µg/L. No other VOCs were detected in the extraction wells above the MCLs.

System Influent and Effluent

During 2009, 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 in 10 of 12 monthly sampling events of the influent throughout 2009, with a maximum concentration of 0.076 µg/L. Only two of the 10 detections were above the standard.

Cumulative Mass Removal

No cumulative mass calculations were performed, based on the typically low detections of EDB historically below the federal DWS in the system influent. The two detections in 2009 were the only historical samples above the standard, except for one detection in early 2005. 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

The OU VI EDB System was designed to capture and remediate the EDB plume as it travels 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 until 2015. 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.

1. Was the BNL Groundwater Contingency Plan triggered?

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

2. If not, has the plume been controlled?

Yes. An analysis of data from the plume perimeter and bypass wells shows no detections of EDB above the DWS in 2009 except in perimeter well 000-500, located just upgradient and slightly east of extraction well EW-2E. This well had two detections of EDB in 2009, with a maximum of 0.43 µg/L. Extraction well EW-2E is expected to capture this portion of the plume. Based on the recommendation in the *2008 BNL Groundwater Status Report*, an additional well to the northeast of well 000-500 will be installed in 2010 to enhance the monitoring well network. This well will be located next to the treatment system building.

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

The hydraulic capture of the system is operating as designed. Since 2007, EDB was detected in the system influent monthly, except for the first two months of 2009. The majority of these detections were at concentrations just below the federal DWS. The plume is migrating towards the extraction wells as projected.

4. Can the groundwater treatment system be shut down?

No, the system has not met all shutdown requirements.

4a. Have asymptotic EDB concentrations been reached in plume core wells?
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 2009, all 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.
- Change the sampling frequency of the extraction wells from monthly to quarterly.

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 2009 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 2009 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 0.85 μg/L of methyl tertiary-butyl ether in well 018-04.

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 Groundwater Monitoring Program Evaluation

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

<u>1. Is groundwater quality at BNL being impacted by off-site, upgradient source(s) of contamination?</u>
No. There were no VOCs detected in site background wells above NYS AWQS during 2009. 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	300

Note:
<MDA = Less than minimum detectable activity

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3.7 CURRENT AND FORMER LANDFILL GROUNDWATER MONITORING

Groundwater monitoring data from both the Current and Former Landfills are discussed in detail in the *BNL 2009 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2010a). 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 2009, the landfill had been capped for 14 years. Groundwater quality has been slowly improving. The trend in the data suggests that the cap is effective in mitigating contamination. Groundwater monitoring wells for the Current Landfill are shown on **Figure 3.7-1**. The following is a summary of the results from the samples collected during 2009:

- VOCs such as benzene, and/or chloroethane continue to be detected in downgradient wells 087-11, 087-23, and 088-109 at concentrations above groundwater standards. The maximum chloroethane concentration was 26.9 µg/L in well 088-109. Benzene was detected at a maximum of 2 µg/L in well 088-11. During 2009, TVOC concentrations in these three wells ranged up to 28.7 µg/L 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 historical observations.
- 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

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

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 any remaining contamination from entering the groundwater. Based on VOC and Sr-90 concentration trends in downgradient wells, it appears that the landfill cap is performing as planned. Groundwater monitoring wells for the Former Landfill are shown on **Figure 3.7-2**. The following is a summary of the results from the samples collected during 2009:

- The Former Landfill Area is not a significant source of VOC contamination. No VOCs were detected above groundwater standards in 2009. VOC concentrations in the downgradient wells were at or near the minimum detectable 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 has been decreasing with time and is 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

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

4.0 FACILITY MONITORING PROGRAM SUMMARY

During 2009, the Facility Monitoring Program at BNL monitored the groundwater quality at 10 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 2009, 108 groundwater monitoring wells were sampled during approximately 200 sampling events. BNL also installed 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 2009 are provided 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, former g-2 experimental area, former 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 the standard 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 activated soil shielding 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 55 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**. The wells are routinely monitored for tritium because it is the best early indicator of a possible release (i.e., tritium is more leachable than sodium-22, and it migrates at the same rate as groundwater).

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 continues to be detected downgradient of the g-2 (VQ-12 magnet) soil activation area at concentrations that exceed 20,000 pCi/L (**Section 4.2**).

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). Although these beam lines stopped operations in 2002, the building could be used for new experiments in the future.

Beam loss and the production of secondary particles at the target areas resulted in the activation of the adjacent 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

Twenty-three shallow Upper Glacial aquifer wells are positioned upgradient and downgradient of Building 912 (**Figure 4-1**). The two upgradient wells (054-69 and 055-14) 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. Ten 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 2009, 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

As in past years, low-level tritium contamination that is traceable to the g-2 source area continues to be detected in the six downgradient monitoring wells. The g-2 tritium plume has been tracked from the source area, beneath a portion of Building 912, to an area south of the HFBR facility (**Figure 4-8**). Tritium from the g-2 plume was detected in six wells downgradient of Building 912 (065-321, 065-322, 065-323, 065-324, 065-122, and 065-123), with a maximum concentration of 50,100 pCi/L found in a sample from well 065-323 in March 2009. As described in **Section 4.2**, remedial actions for the g-2 source area and tritium plume are described in the Record of Decision (ROD) signed in May 2007 (BNL 2007b). The groundwater monitoring data for the remainder of the Building 912 area wells suggest that tritium is not being released in appreciable amounts from activated soil beneath the experimental floor. Although low levels of tritium were detected in two wells located downgradient of the former C Target area of Building 912 (a maximum of 2,840 pCi/L in well 065-124 and 620 pCi/L in well 065-125), with the close proximity of the defined centerline of the g-2 plume, this tritium could have originated from the g-2 source area.

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. If this tritium originates from Building 912, these results indicate that the building and associated stormwater management operations are effectively preventing significant rainwater infiltration into the 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 2010, 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.

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.

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 scheduled to be sampled one time during 2009, and the samples were to be analyzed for tritium (**Table 1-6**). However, due to restricted access to the Booster area during extended beam line operations and scheduling issues, these wells were not sampled during 2009.

4.1.2.2 AGS Booster Monitoring Well Results

As noted above, the Booster area wells were not monitored during 2009. Although low levels of tritium were detected in the Booster area wells during 2001 and 2002 (up to 1,340 pCi/L in well 064-52), tritium was not detected in the Booster area wells from 2003 through 2008 (**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 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 activated soil shielding.[1] Tritium has not been detected in the Booster area monitoring wells since 2002.

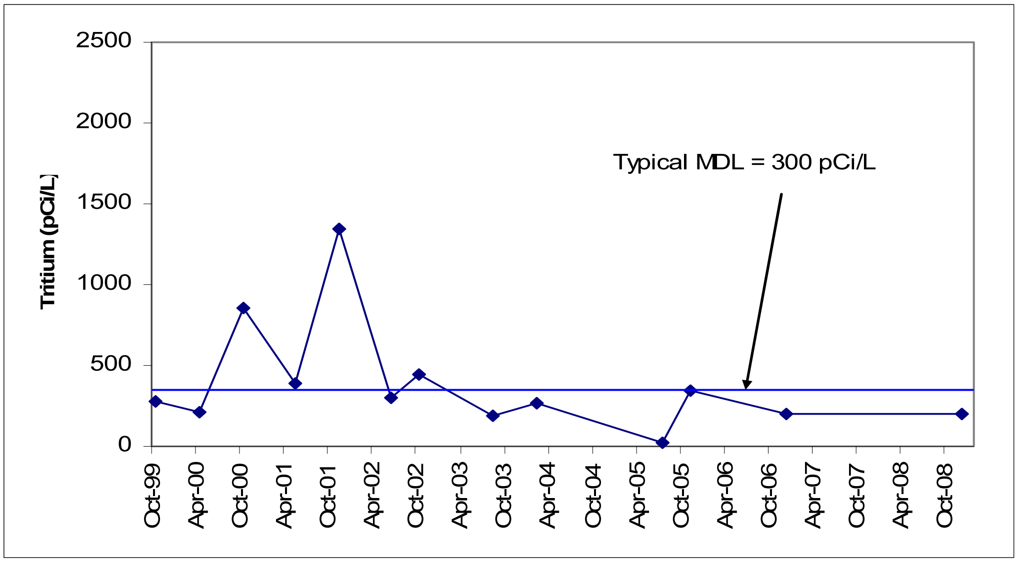
4.1.2.4 AGS Booster Recommendation

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

- For 2010, the monitoring frequency for the Booster area 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 former 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 (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 2009, 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 2010, the monitoring frequency for the NSRL wells will continue to be annually.

4.1.4 Former AGS E-20 Catcher

The E-20 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.

Like other beam loss areas in the AGS complex, the soil surrounding the former 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 Former AGS E-20 Catcher Groundwater Monitoring

Well Network

To verify the effectiveness of the impermeable cap over the former 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 2009, the former E-20 Catcher wells were monitored one time, and the samples were analyzed for tritium (**Table 1-6**). Since 2002, groundwater samples from this area have only been analyzed for tritium.

4.1.4.2 Former 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 DWSs (**Figure 4-3**). During 2009, the maximum observed tritium concentration was 890 pCi/L, detected in well 064-80.

4.1.4.3 Former AGS E-20 Catcher Groundwater Monitoring Program Evaluation

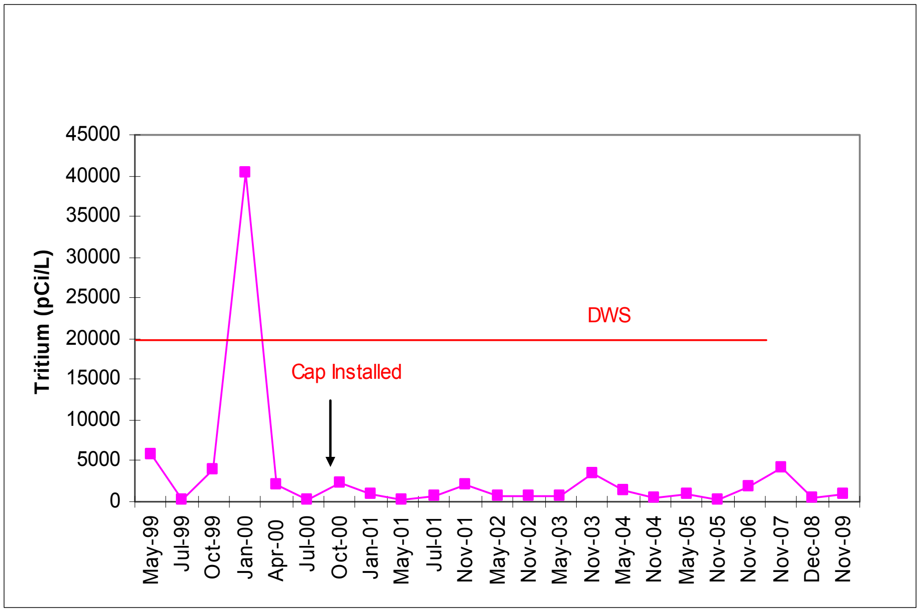
The reduction in tritium concentrations since the impermeable cap was constructed over the former E-20 Catcher area in 2000 indicates that the cap has been effective in preventing rainwater infiltration into the activated soil that surrounds this portion of the AGS tunnel.

4.1.4.4 Former AGS E-20 Catcher Recommendation

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

- For 2010, the monitoring frequency for the former E-20 Catcher wells will continue to be annually.

Figure 4-3.
Former 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 beam 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 2009, 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 (up to 1,000 pCi/L) were detected intermittently in groundwater downgradient of the Building 914 during 2000 through 2005 (**Figure 4-4**). Although tritium was not detected in any of the groundwater samples during 2006 and 2007, in 2008 and 2009 low-levels of tritium were detected in well 064-03 at concentrations of 620 pCi/L and 250 pCi/L, respectively.

4.1.5.3 AGS Building 914 Groundwater Monitoring Program Evaluation

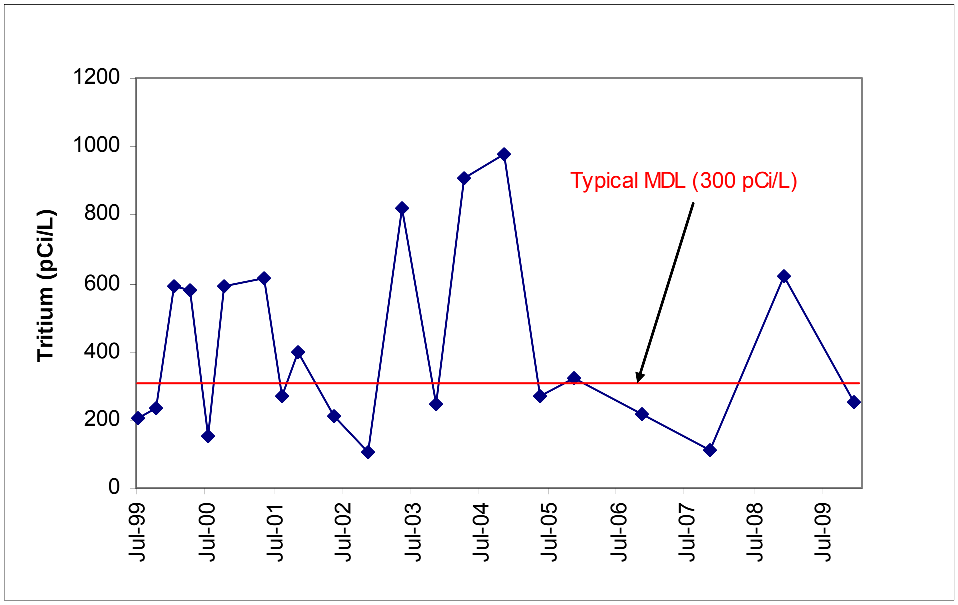
Groundwater monitoring downgradient of AGS Building 914 continues to indicate that the building structure and associated stormwater controls are effectively preventing significant rainwater infiltration into activated soil below the building. However, the periodic detection of trace levels of tritium 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 2010, 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 Former g-2 Beam Stop

The g-2 experiment operated from April 1997 until April 2001. The former g-2 Beam Stop is composed of iron and is covered by soil. Like other beam loss areas in the AGS complex, the former 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 former 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 previously installed 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 that 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 Former g-2 Beam Stop Groundwater Monitoring

Well Network

Groundwater quality downgradient of the former 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 cross gradient of the VQ-12 source area monitoring wells described in **Section 4.2**.

Sampling Frequency and Analysis

During 2009, the former g-2 Beam Stop wells were monitored annually, and the samples were analyzed for tritium (**Table 1-6**).

4.1.6.2 Former g-2 Beam Stop Monitoring Well Results

Although trace levels of tritium had been detected during 2008 in three of the four monitoring wells located downgradient of the former g-2 Beam Stop (up to 690 pCi/L in well 054-124), tritium was not detected in any of the wells in 2009.

4.1.6.3 Former g-2 Beam Stop Groundwater Monitoring Program Evaluation

Monitoring of wells downgradient of the former g-2 Beam Stop indicates that the cap is effectively preventing rainwater from infiltrating the activated soil shielding.

4.1.6.4 Former g-2 Beam Stop Recommendation

The following is recommended for the former g-2 Beam Stop groundwater monitoring program:

- During 2010, the former 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 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 2009, 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 (up to 1,000 pCi/L) have been routinely detected in groundwater downgradient of the J-10 beam stop (**Figure 4-5**). During 2009, trace levels of tritium were detected in both downgradient wells, with a maximum concentration of 490 pCi/L detected in well 054-63.

4.1.7.3 AGS J-10 Beam Stop Monitoring Program Evaluation

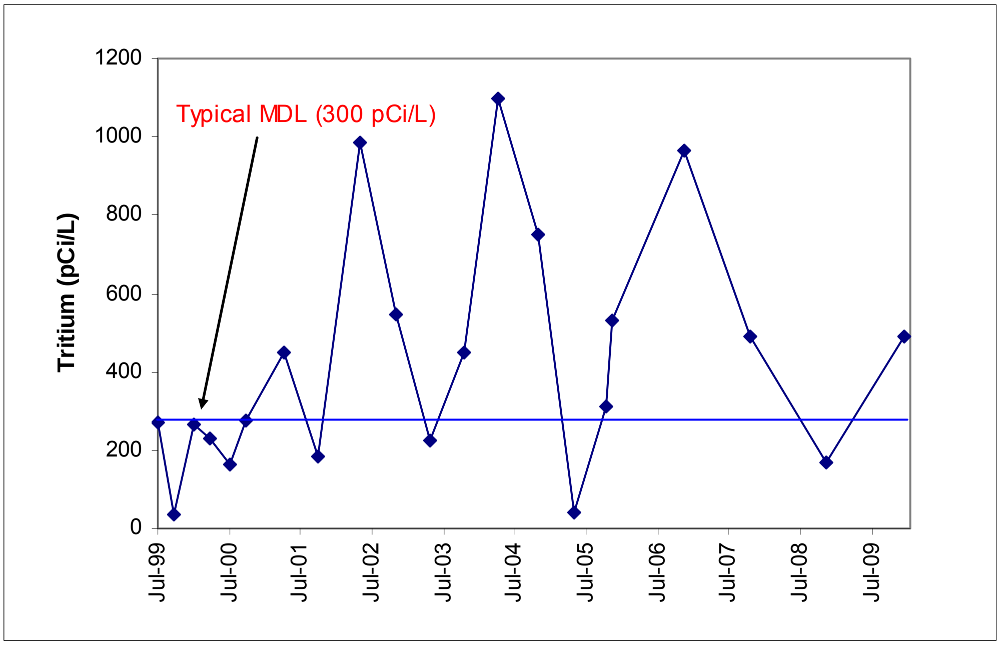
Groundwater monitoring results indicate that the engineered controls in place at J-10 are preventing significant rainwater infiltration into the activated soil shielding. The occasional detection of low levels of tritium (up to 1,000 pCi/L), indicates that the water infiltration is only minor. Continued groundwater monitoring is required to verify the long-term effectiveness of the controls.

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 2010, the J-10 Beam Stop area wells will continue to be sampled on an annual basis.

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 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 temporary wells downgradient of the former U-Line Beam Stop, which is approximately 200 feet north of the target area. Tritium was detected at a concentration of 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 former 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.

4.1.8.1 Former AGS U-Line Groundwater Monitoring

Well Network

The former U-Line area is monitored by one upgradient well (054-127), three downgradient wells that monitor the former U-Line Target area (054-66, 054-129, and 054-130), and three wells that monitor the former U-Line Beam Stop area (054-128, 054-168, and 054-169) (**Figure 4-1**).

Sampling Frequency and Analysis

During 2009, 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

Former U-Line Target Area

Although low levels of tritium had been routinely detected in wells downgradient of the former U-line Target from 2000 through 2007, only trace levels of tritium have been detected for the past two years, with a maximum concentration of 400 pCi/L in well 054-129 during 2009 (**Figure 4-6**).

Former 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 2009, tritium was not detected in the former U-Line Beam Stop area wells.

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 installed over the former U-Line Beam Stop has been effective in stopping rainwater infiltration into the residual activated soil. Monitoring downgradient of the former U-Line Target indicates that only low levels of tritium are being released.

4.1.8.4 Former AGS U-Line Recommendation

The following is recommended for the former AGS U-Line groundwater monitoring program:

- For 2010, the former U-Line area wells will continue to be monitored for tritium on an annual basis.

Figure 4-6.
Former AGS U-Line Beam Target
Maximum Tritium Concentrations in Downgradient Well 054-129

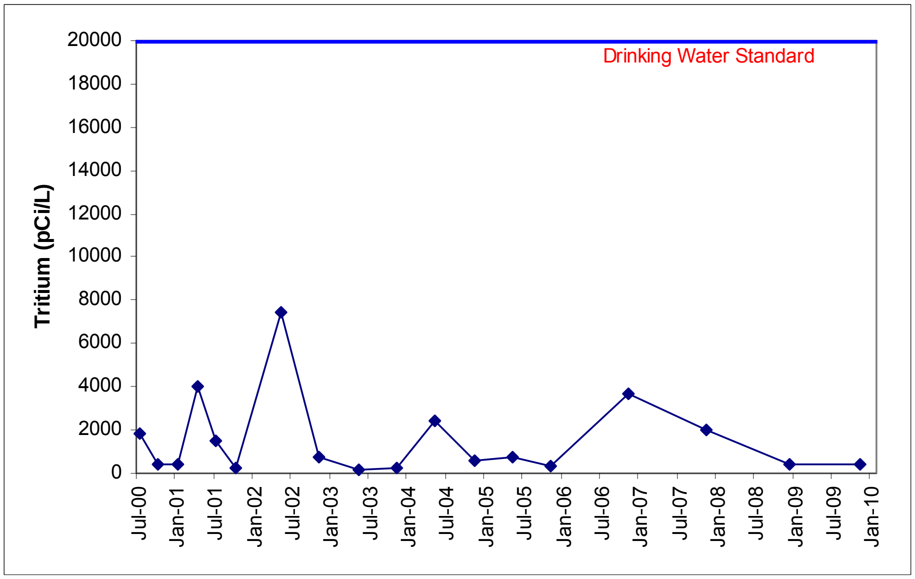
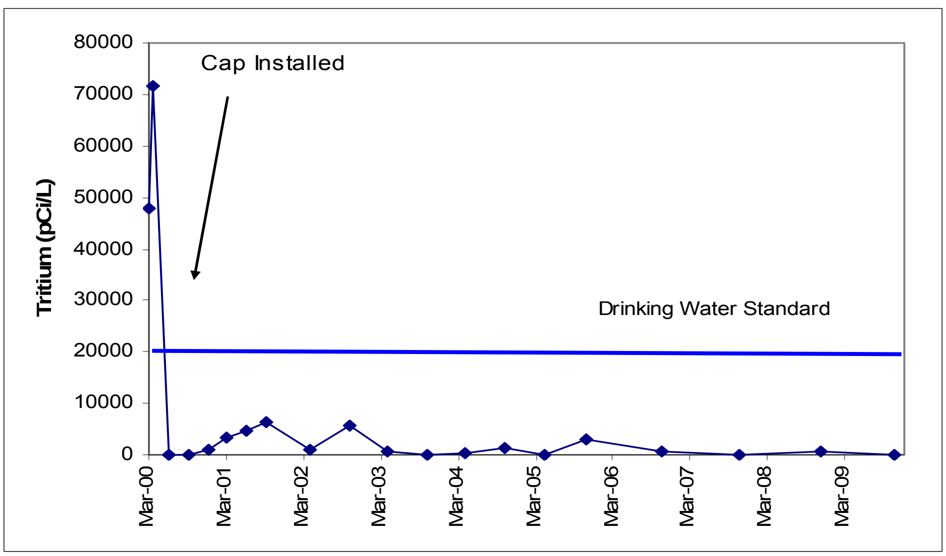


Figure 4-7.
Former AGS U-Line Beam Stop
Maximum Tritium Concentrations in Downgradient Temporary and Permanent Wells



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 five 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 and implemented 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 currently located south of the HFBR. Monitoring of the source area is accomplished using six wells immediately downgradient of the VQ-12 source (054-07, 054-124, 054-126, 054-184, 054-185, and 064-95) and 12 wells east of Building 912 (065-02, 065-121, 065-122, 065-123, 065-124, 065-173, 065-193, 065-194, 065-321, 065-322, 065-323, and 065-324). Monitoring of the downgradient sections of the tritium plume located south of the HFBR is accomplished using a combination of permanent and temporary wells (**Figures 4-8** and **4-9**).

Sampling Frequency and Analysis

During 2009, 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, temporary wells were installed along five east-west transects to track the leading edge of the g-2 tritium plume (reported in the 2008 Groundwater Status Report). At nine of these established locations, temporary wells were installed during February through April 2010 along three east-west transects, D, E, and F (**Figure 4-8**). Sample results for the temporary wells are summarized on **Tables 4.2-1** through **4.2-3**.

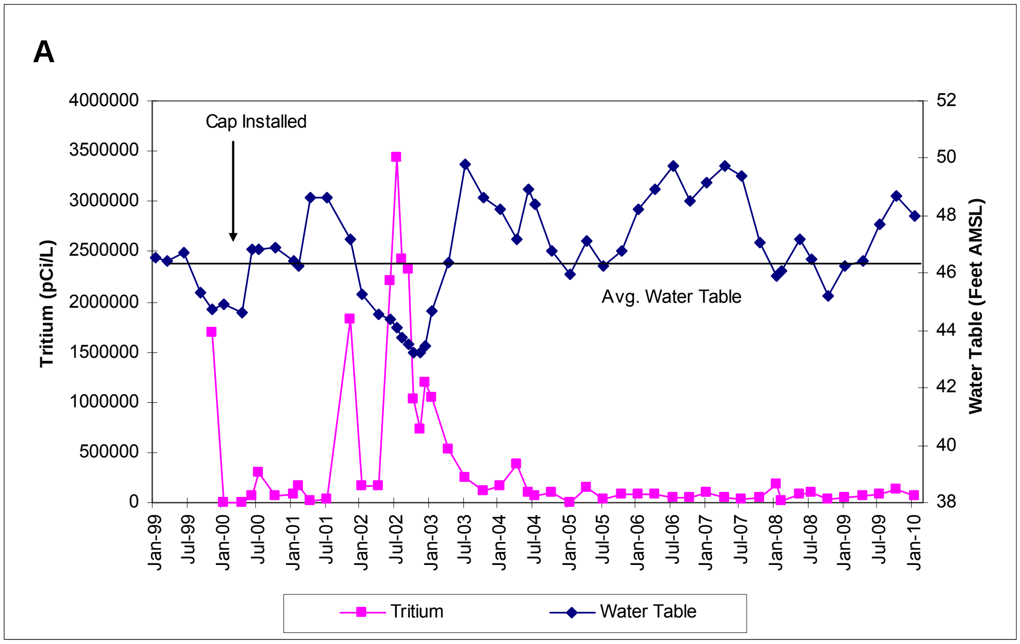
4.2.2 g-2 Tritium Source Area and Plume Monitoring Well Results

Source Area Monitoring Results

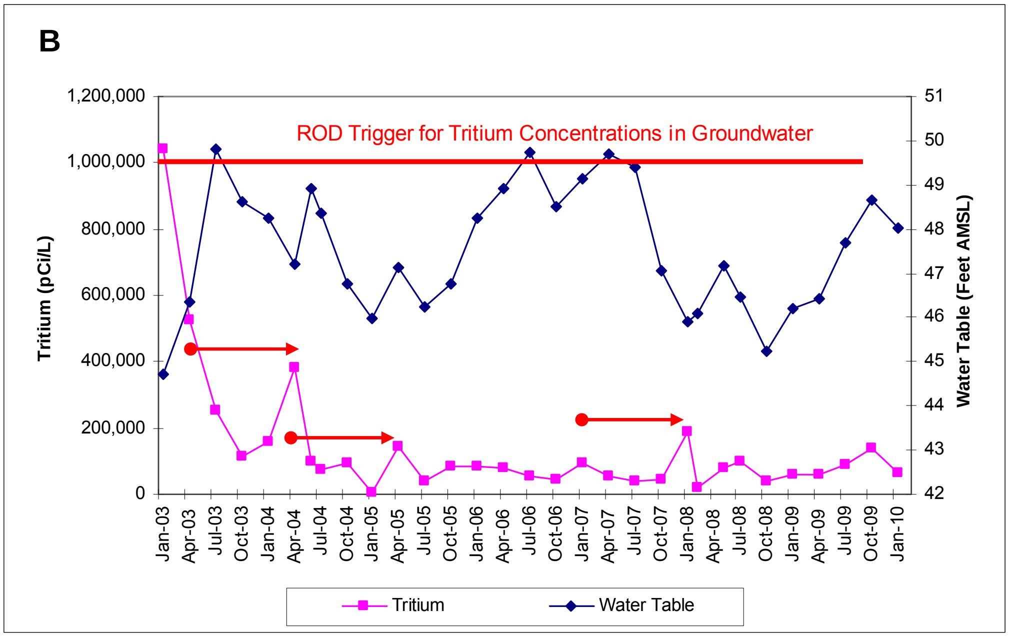
Monitoring data indicate that the high levels of tritium have entered the groundwater as a series of short-term releases (**Figure 4-10**). Following the initial releases of tritium that occurred prior to cap installation in December 1999, subsequent periodic releases, characterized by short-term spikes 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 three periods since 2003, tritium levels in all but five sets of quarterly samples from source area monitoring wells have been less than 100,000 pCi/L.

During this time period, tritium concentrations reached a maximum 186,000 pCi/L in January 2008 (**Figure 4-10**). During 2009, the maximum tritium concentration was 138,000 pCi/L in the quarterly monitoring samples collected in October. Tritium concentrations dropped to below 63,000 pCi/L by January 2010. 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. Select samples were also analyzed for sodium-22 during all four quarters of 2009. The maximum sodium-22 concentration was 43 pCi/L, detected in the sample from well 054-185. During the first quarter of 2010, the maximum sodium-22 concentration was 40 pCi/L, detected in the sample from well 054-184. 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 2010 in groundwater downgradient of the VQ-12 source area. The travel time from the source area to the first set of downgradient monitoring wells is approximately one year.



B: Comparison of January 2003–January 2010 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 in the 2008 Groundwater Status Report (BNL, 2009), and the extent of the plume during the first quarter of 2010 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. As described in **Section 4.1.1.2**, tritium contamination that is traceable to the g-2 source area continues to be detected in monitoring wells located downgradient of AGS Building 912. During 2009, the maximum concentration immediately downgradient of Building 912 was 50,100 pCi/L in a sample from well 065-323 collected in March.

Since June 2007, 41 temporary well locations have been established along six east–west transects (Transects A, B, C, D, E and F). Over this period, temporary wells have been installed at the same locations two to three times to evaluate changes in tritium concentrations over time; with the most recent wells installed between January and April 2010 (**Tables 4.2-1** through **4.2-3**). During the first quarter 2010 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 portion of the tritium plume (as defined by concentrations >20,000 pCi/L) is 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 southwest of the HFBR building (Transect D) to an area near the north side of the National Synchrotron Light Source (NSLS) (Transect F), a distance of approximately 600 feet. The highest tritium concentrations were observed along Transects E and F, where 92,200 pCi/L was detected in Transect E temporary well G2-GP-94 (**Table 4.2-2**) and 78,600 pCi/L was detected in Transect F temporary well G2-GP-103 (**Table 4.2-3**). 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 plume segments 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 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 has decrease by this flushing mechanism and by natural radioactive decay. The downgradient portion of the g-2 tritium plume extends from the HFBR area south to the NSLS, and is attenuating in the aquifer as predicted. 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, and the downgradient segment of the plume until it has attenuated to concentrations less than the 20,000 pCi/L drinking water standard.

4.2.4 g-2 Tritium Source Area and Plume Recommendations

As required by the ROD, BNL will continue to conduct routine inspections of the g-2 cap, monitor groundwater quality downgradient of the source area, and monitor the downgradient plume segments until tritium levels drop below the 20,000 pCi/L DWS. The following are recommended for the g-2 Tritium Source Area and Plume groundwater monitoring program:

- During 2010, the source area monitoring wells will continue to be sampled quarterly for tritium and annually for sodium-22, and the downgradient sections of the tritium plume will continue to be monitored using a combination of permanent and temporary wells.
- During the spring of 2010, additional temporary wells will be installed along Transect F to verify the western margin of the g-2 tritium plume. During the fall of 2010, additional temporary wells will be installed along Transects D, E, F and new Transect G to track the g-2 plume and evaluate its attenuation in the aquifer.
- Re-run the groundwater model for the downgradient portion of the plume using 2010 monitoring data.

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-foot underground tank. The targets rest inside a water-filled, 18-inch-diameter shaft that runs the length of the tank, and are cooled by a 300-gallon, closed-loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and 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 the 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 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 (054-61 and 064-46) and five downgradient wells (064-47 through 064-50, and 064-67). These wells provide a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality (**Figure 4-1**).

Sampling Frequency and Analysis

During 2009, one upgradient (064-46) and the five downgradient monitoring wells were monitored twice, and the groundwater samples were analyzed for tritium (**Table 1-6**).

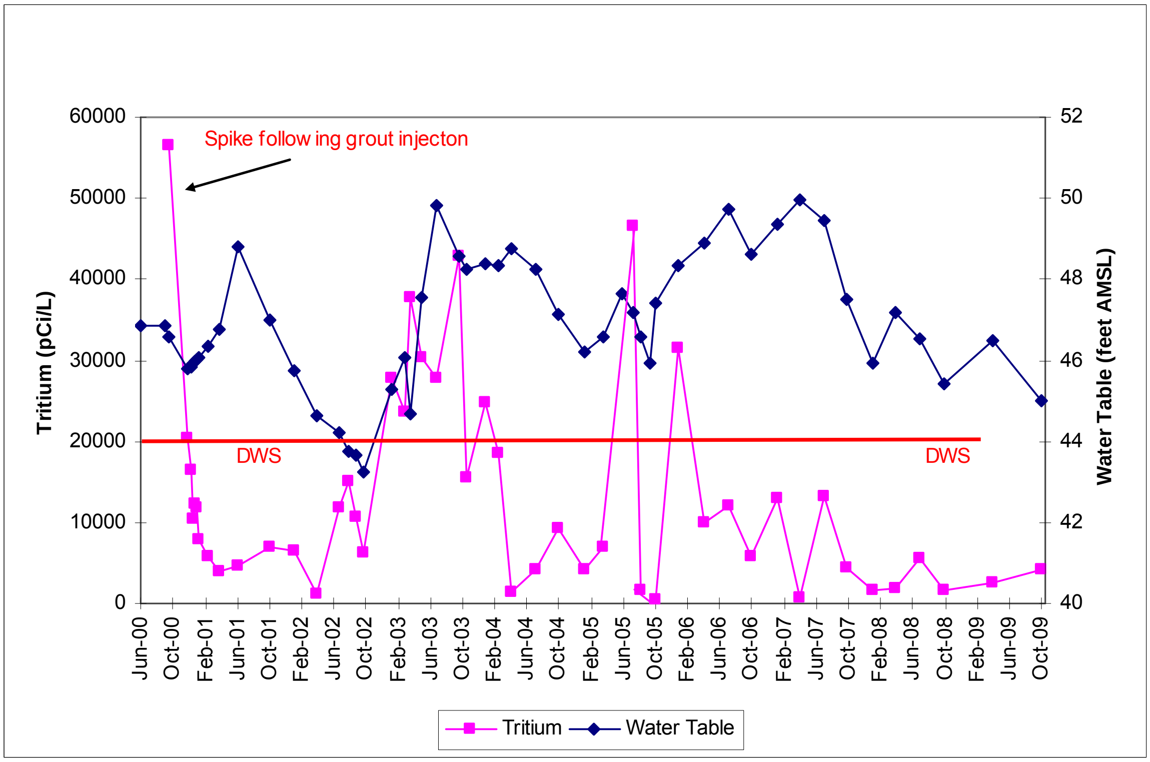
4.3.2 BLIP Monitoring Well Results

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 January 2006, there were

[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 five percent of the drinking water standard for tritium (i.e., 1,000 pCi/L) or sodium-22 (i.e., 20 pCi/L). In early 2010, a BNL management waiver was granted to increase the limit for sodium-22 in leachate to 25% of the drinking water standard (i.e., 100 pCi/L).

several short-duration periods when tritium concentrations once again exceeded 20,000 pCi/L. Since April 2006, tritium levels have remained below the 20,000 pCi/L DWS. During 2009, the maximum tritium concentration was 4,240 pCi/L.

Figure 4-11.
BLIP Facility
Tritium Concentrations vs. Water-Table Position, in Wells 40 Feet Downgradient,



Note: Approximate groundwater travel time from directly below the BLIP target to the first set of monitoring wells (e.g., well 064-67) 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. The short-term concentration increases observed in 2005 and 2006 correlated to increases in the elevation of the water table (**Figure 4-11**). 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. Although the water table has increased to nearly 50 feet AMSL several times since 2006, there has not been a corresponding increase in tritium concentrations. This suggests that the amount of tritium available to be flushed from the deep vadose zone by fluctuations in water-table position has decreased.

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, the monitoring frequency for the downgradient monitoring wells 064-47, 064-48, and 064-67 will continue to be semiannually.
- Sampling frequency for the two upgradient (054-61 and 064-46) and two downgradient wells (064-49 and 064-50) will be reduced 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 4-12**). 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 4-12**). As part of BNL's Environmental Surveillance program, surface water samples are also collected from the Peconic River, both upstream (location HY) and downstream (location HV) of the Beam Stop area. These monitoring results are used 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 2009, 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 were analyzed for tritium and gamma emitting radionuclides (such as 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 2010, groundwater samples will continue to be collected on a semiannual basis. Surface water samples will also continue to be collected quarterly 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 4-13**). 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. No samples were collected during 2009 (**Table 1-6**).

4.5.2 BMRR Monitoring Well Results

Although samples were not collected during 2009, monitoring results for the past years indicate that tritium concentrations are well below the 20,000 pCi/L DWS (**Figure 4-14**). 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

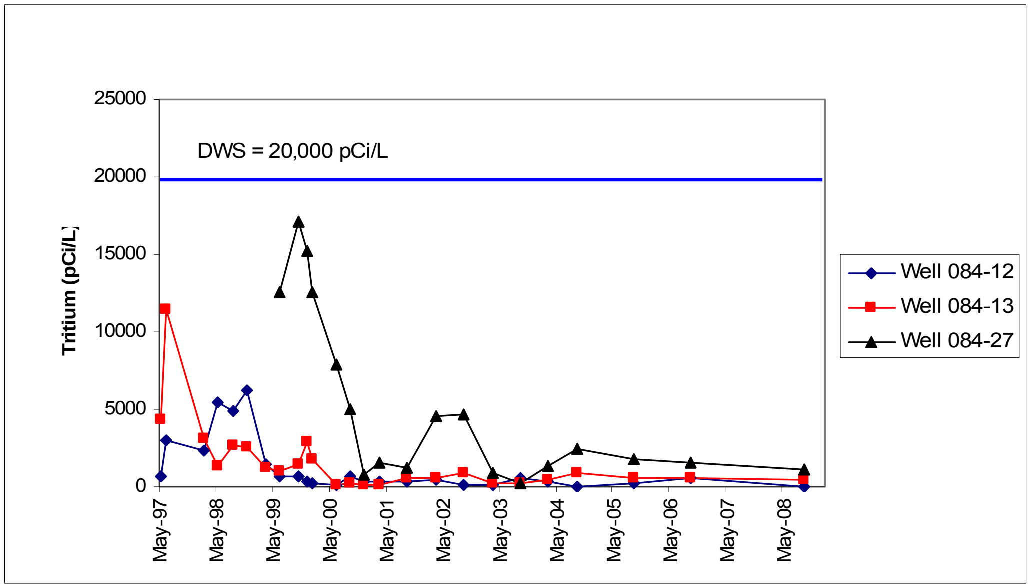
Tritium concentrations in groundwater from the BMRR well network have never exceeded the 20,000 pCi/L DWS, and have remained <5,000 pCi/L since September 2000. The BMRR structure is effectively preventing rainwater infiltration into the underlying soils, and therefore reducing the movement of any residual 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 4-14.
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, 0.5 million gallons per day (MGD) are processed during the summer and 0.3 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 (038-02, 038-03, 039-07, 039-08, 039-86, and 039-87) are used to monitor groundwater quality in the Filter Bed area, and three wells (039-88, 039-89, and 039-90) are monitored in the Holding Pond area (**Figure 4-15**).

Sampling Frequency and Analysis

The six STP Filter Bed and three Holding Pond area monitoring wells are usually sampled once each year (normally in December). However, due to weather related scheduling problems, the wells were sampled during the first week of January 2010. The samples from the Filter Bed area wells were analyzed for VOCs, anions (sulfate, chloride, and nitrate), metals, tritium, gross alpha, gross beta, and gamma emitting radionuclides and the wells positioned downgradient of the holding ponds were analyzed for VOCs, tritium, gross alpha, gross beta, and gamma emitting radionuclides (**Table 1-6**). To evaluate mercury levels in the filter bed area, samples were also collected from three wells (038-02, 039-86, and 039-87) in February 2009. During this period, filtered and unfiltered samples were analyzed for metals, including analyses for low-level mercury.

4.6.2 STP Monitoring Well Results

Radiological Analyses

Gross alpha and gross beta levels in samples collected from the STP wells were generally typical of ambient (background) levels. Tritium was not detected in any of the STP area wells, and no BNL-related gamma emitting radionuclides were detected in any of the STP groundwater monitoring wells.

Non-Radiological Analyses

All water quality and most metals concentrations were below the applicable NYS AWQS. Slightly elevated metals were detected in unfiltered groundwater samples collected from several Filter Bed area wells. Both the February 2009 and January 2010 samples from well 039-86 had sodium levels slightly above the 20 milligram per liter (mg/L) NYS AWQS, with concentrations of 35.5 and 23.4 mg/L, respectively. In the February 2009 sample from well 038-02, iron, aluminum and thallium levels exceeded the applicable standards, with levels of 17.9 mg/L, 12.6 mg/L and 0.0006 mg/L, respectively. The NYS AWQS for iron is 0.3 mg/L, the DWS (secondary MCL for aesthetic quality) for aluminum is 0.2 mg/L, and the AWQS for thallium is 0.0005 mg/L. In February 2009 and January 2010, low-level mercury analyses were also performed on samples collected from several of the Filter Bed area wells. Results of the low-level analyses indicated a maximum mercury concentration of 9.4 ng/L detected in well 038-02. The NYS AWQS for mercury is 700 ng/L. Low levels of nitrates continue to be detected in many of the STP Filter Bed area wells, with a maximum concentration of 4.6 mg/L detected in monitoring well 039-86. 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 2009 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 monitoring frequency or analyses are proposed for 2010.

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 4-16**). 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 4-16**).

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 2009, 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 also monitored semi-annually, and the samples were analyzed for VOCs.

4.7.2 Motor Pool Monitoring Well Results

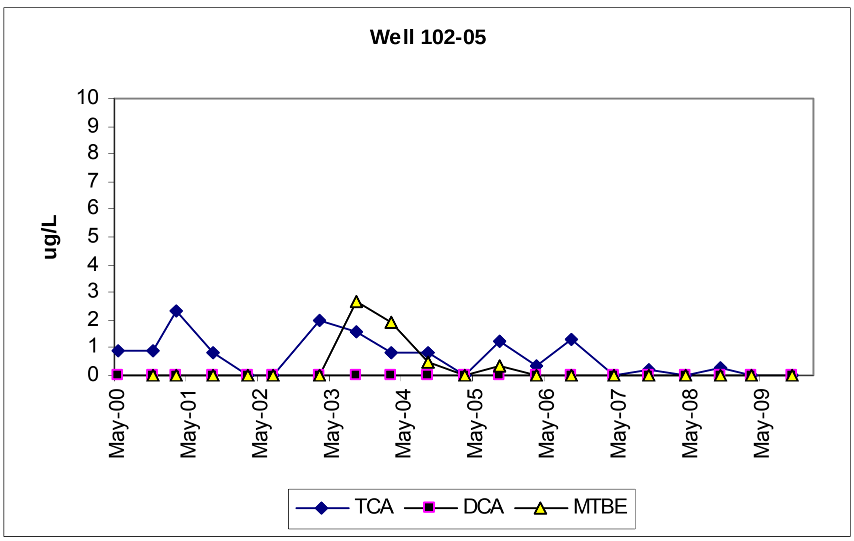
Underground Storage Tank Area

During 2009, no gasoline-related products were detected in groundwater downgradient of the gasoline UST area (**Figure 4-17**). Although the former gasoline additive MTBE concentrations had reached a maximum of nearly 34 µg/L in 2003, MTBE has not been detected in any samples since 2006. The NYS Ambient Water Quality Guidance Value for MTBE is 10 µg/L. 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. As in previous years, no floating product was observed in the monitoring wells.

Building 423/326 Area

During 2009, the solvent TCA was detected in well 102-11 at a concentration of 6.5 µg/L, slightly above the 5 µg/L NYS AWQS (**Figure 4-18**). As in 2007 and 2008, DCA levels remained less than the 5 µg/L standard. The gasoline additive MTBE was not detected in any of the Motor Pool wells. It is believed that the TCA and DCA originated from historical vehicle maintenance operations.

Figure 4-17.
Motor Pool Gasoline UST Area
VOC Concentration Trends in Downgradient Wells



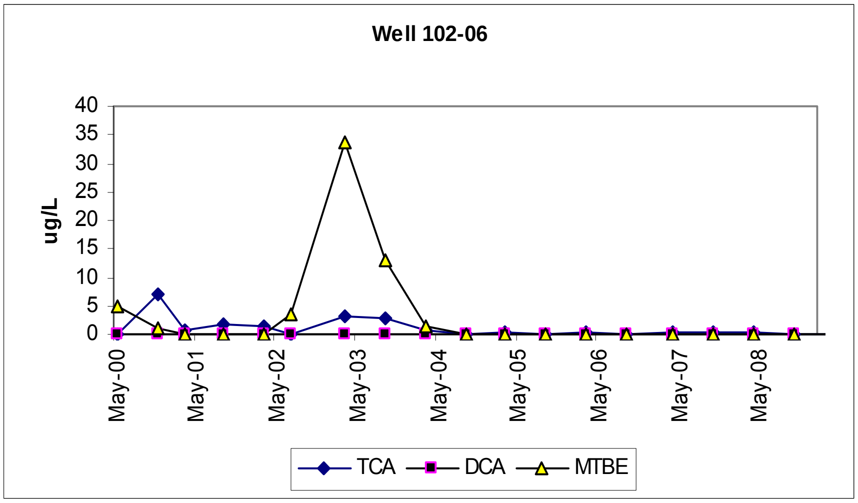
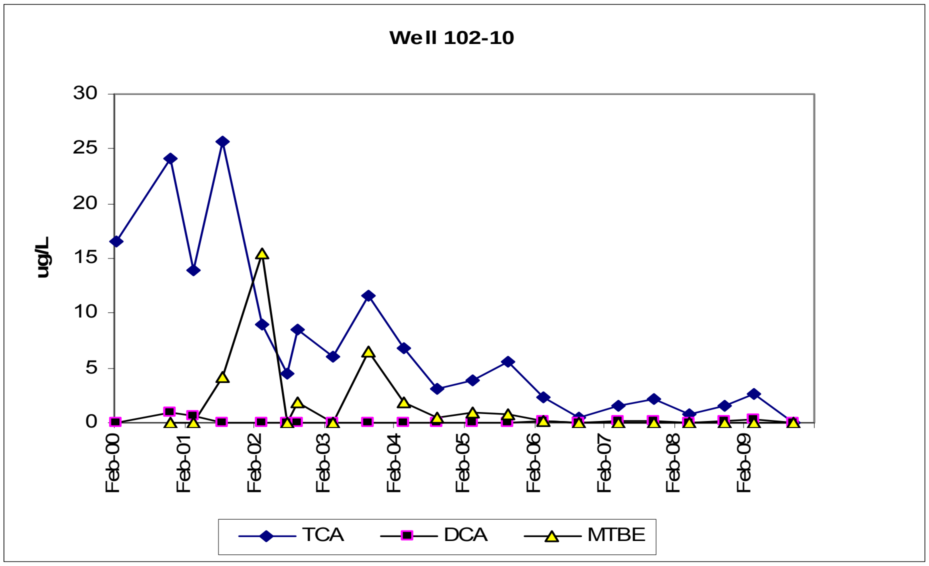
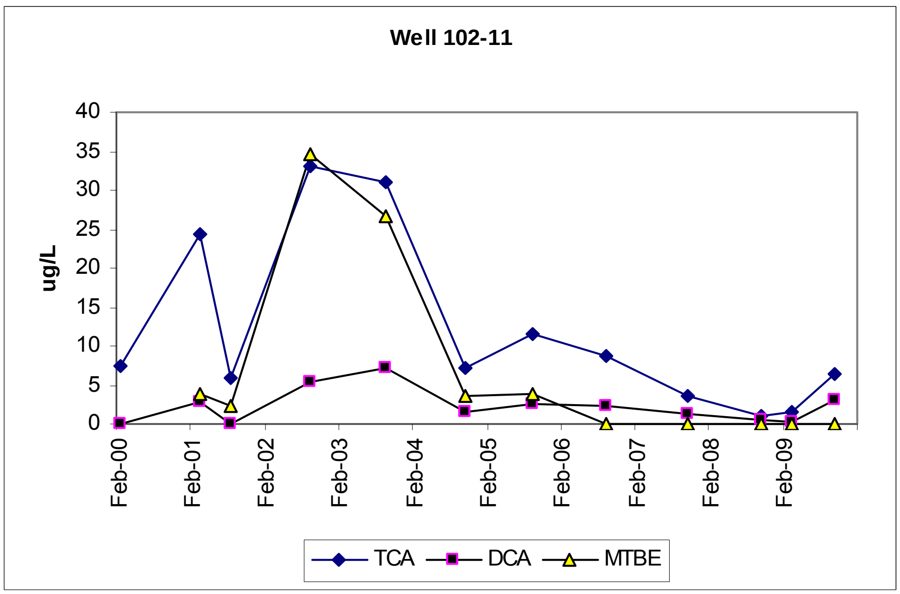
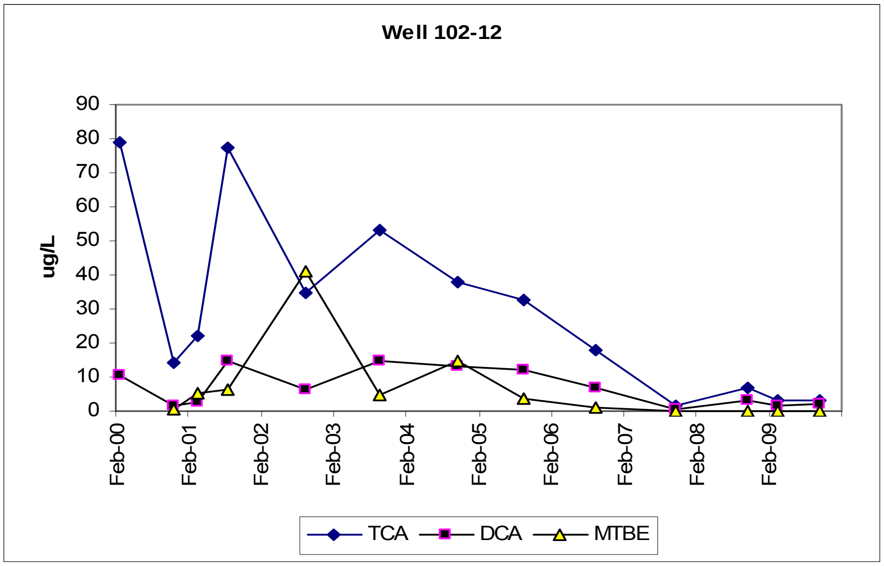
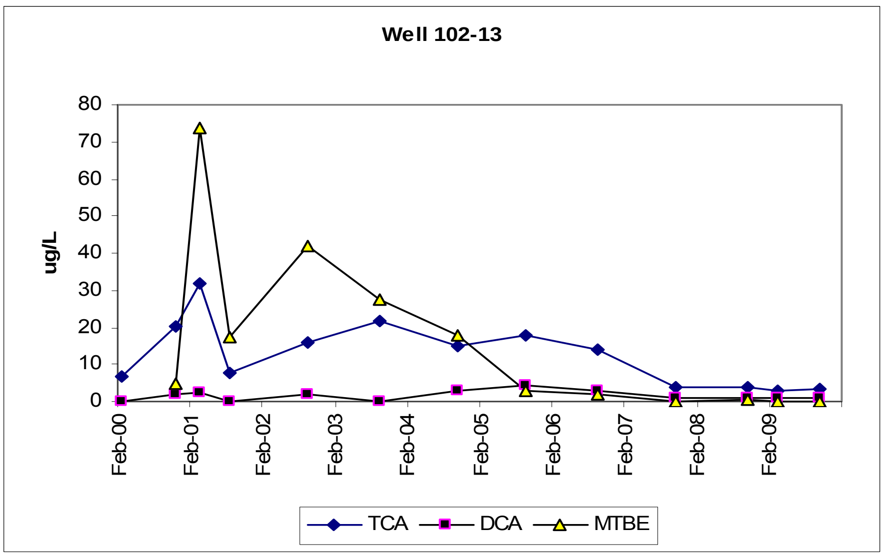

Well 102-06
ug/L
40
35
30
25
20
15
10
5
0
May-00
May-01
May-02
May-03
May-04
May-05
May-06
May-07
May-08
TCA
DCA
MTBE

Figure 4-18.
Motor Pool Building 423/326 Area
VOC Concentration Trends in Downgradient Wells









4.7.3 Motor Pool Groundwater 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 2009 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 2010.

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 4-19**).

Sampling Frequency and Analysis

During 2009, the service station facility wells were monitored two times, and 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.

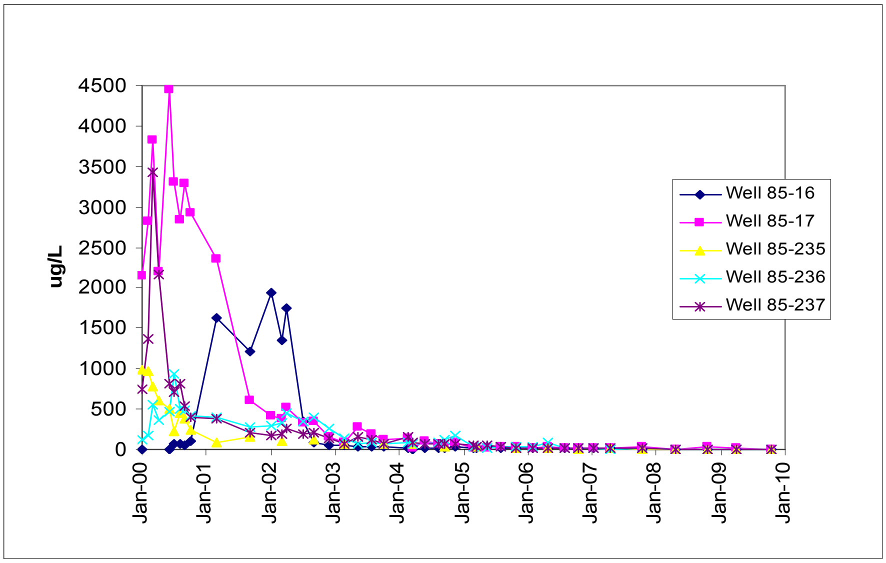
4.8.2 Service Station Monitoring Well Results

During 2009, carbon tetrachloride (and its breakdown product, chloroform) continued to be detected in the Service Station monitoring wells (**Figure 4-20**). The maximum carbon tetrachloride and chloroform concentrations were 13 μg/L and 5.9 μg/L, respectively. Carbon tetrachloride only exceeded its NYS AWQS of 5 μg/L in one well, 085-17. All chloroform detections were at concentrations below its NYS AWQS of 7 μg/L. 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, and is currently scheduled for full decommissioning (**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 2009, high levels of VOCs (with a TVOC concentration of 618 μg/L) continued to be detected in well 085-17. The contamination consisted primarily of xylenes (total) at 350 μg/L, 1,2,4-trimethylbenzene at 120 μg/L, 1,3,5-trimethylbenzene at 56 μg/L, and the solvent PCE at a concentration of 23 μg/L (**Figure 4-21**). VOC concentrations in wells 085-235, 085-236, and 085-237 have remained at low to trace levels (**Figures 4-**

22 and **4-23**). 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 4-20.
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 2009 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 4-21.
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.

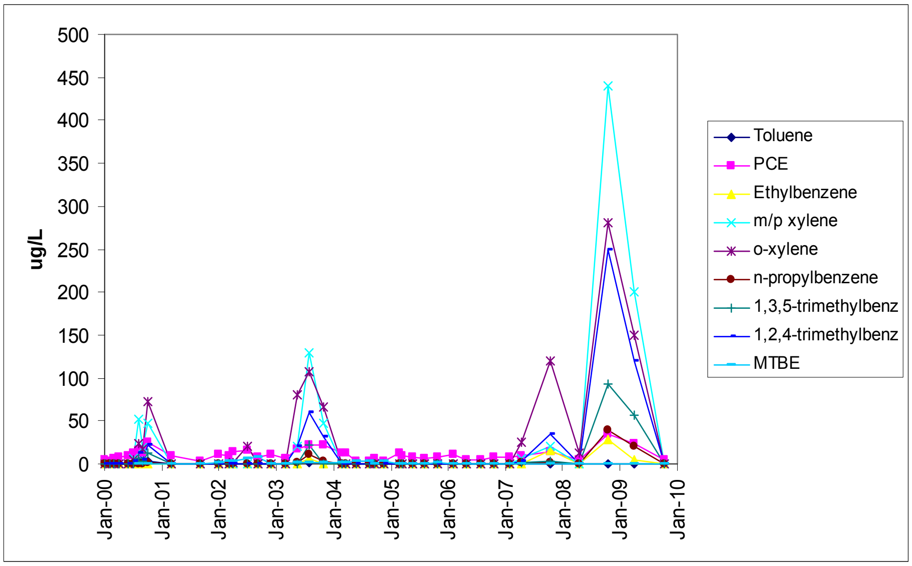
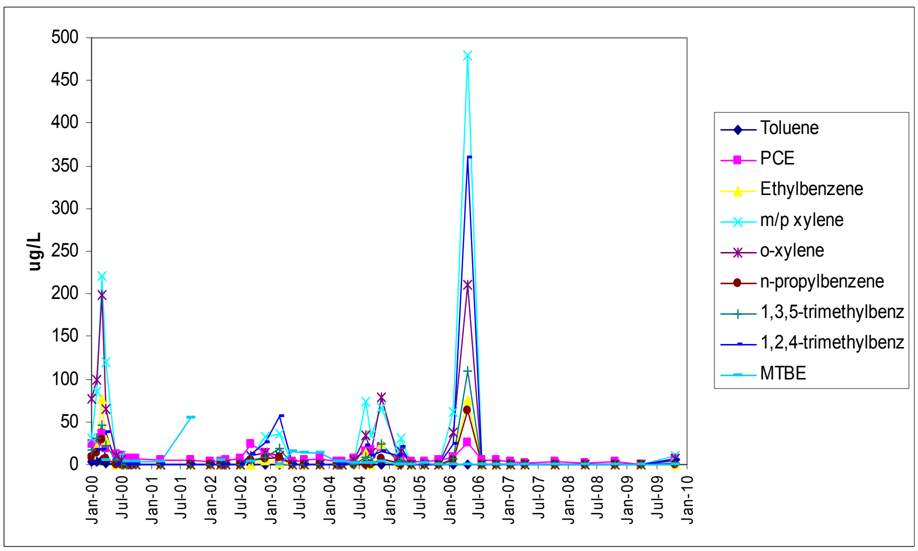


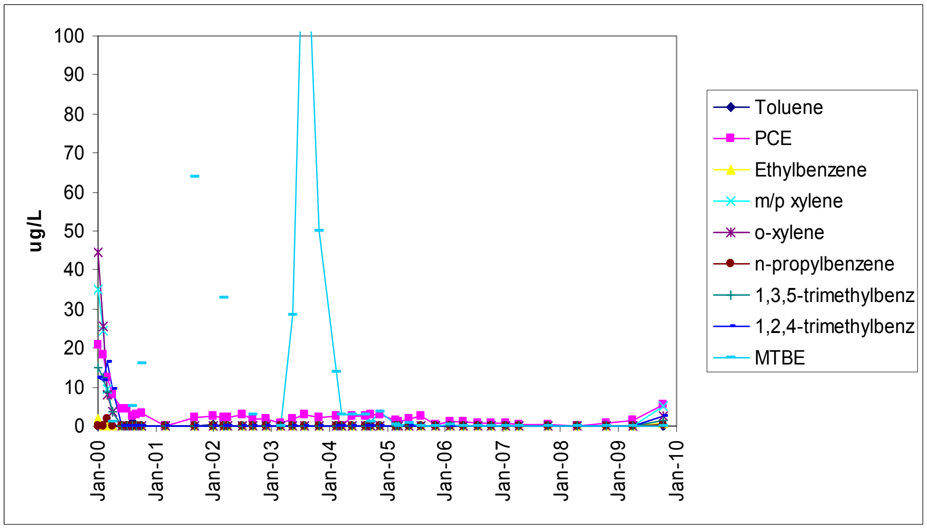
Figure 4-22.
Service Station
Trend of Service Station-Related VOCs in Downgradient Well 085-236
Carbon tetrachloride from the upgradient carbon tetrachloride UST source area is not included.



4.8.4 Service Station Recommendation

No changes to the monitoring program are proposed for 2010.

Figure 4-23.
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 4-24**).

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 monitored monthly for the presence of floating petroleum, and were sampled in April and October 2009. The samples were analyzed 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. The highest VOC concentrations continue to be detected in well 076-380, where PCE was detected at concentrations up to 69 μg/L, well above the NYS AWQS of 5 μg/L. TCE (6.3 μg/L) was detected above its standard of 5 μg/L and low levels of TCA (up to 2.6 μg/L) were also detected in this well. Levels of the PCE breakdown product trans-1,2-dichloroethylene (1,2-DCE) dropped to trace to non-detectable levels by the end of 2005 (**Figure 4-25**). 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 up to 23 μg/L and PCE breakdown product cis-1,2-DCE at concentrations up to 19 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.

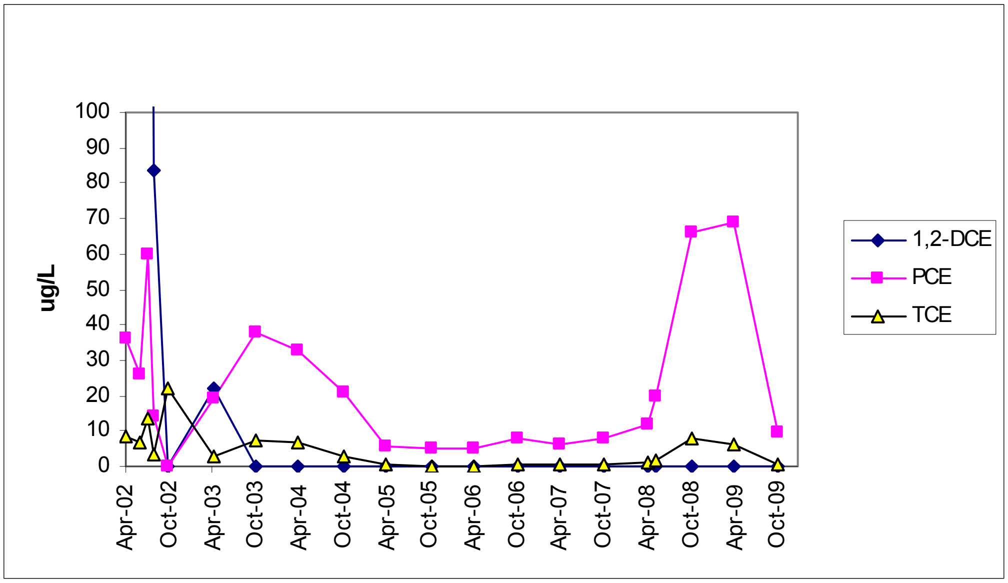
4.9.3 MPF Groundwater Monitoring Program Evaluation

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 2009 are likely to have originated from historical solvent spills near the Central Steam Facility (Building 610) (**Figure 4-24**). 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 2010, monitoring will continue as required by the NYS operating permit.

Figure 4-25.
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 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 4-26**.

Sampling Frequency and Analysis

During 2009, 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 *2009 Groundwater Monitoring Report for the Waste Management Facility* (BNL 2010d).

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. During the February sample period, tritium was detected in Reclamation Building area well 066-223 at a trace concentration of 440 pCi/L.

Non-Radiological Analyses

The anions (chlorides, sulfates, and nitrates) and most metals concentrations were below applicable NYS AWQS. Sodium was detected at concentrations above the 20 mg/L NYS AWQS in upgradient wells 055-03 and 055-10 at concentrations up to 54.2 mg/L, and in downgradient well 066-221 at a concentration of 48.5 mg/L. 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.

4.10.3 WMF Groundwater Monitoring Program Evaluation

Groundwater monitoring results for 2009 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. 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 2010, 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 2009, Building 801 monitoring well 065-325 was sampled one time under the Facility Monitoring Program (**Table 1-6**). The samples were analyzed for gross alpha, gross beta, gamma-emitting radionuclides (e.g., Cs-137), and tritium. Monitoring wells 065-37, 065-169, and 065-170 were sampled one time under the CERCLA program, and the samples were analyzed for Sr-90 and gamma emitting radionuclides. The sample from well 065-37 was also analyzed for tritium (**Table 1-5**).

4.11.2 Building 801 Monitoring Well Results

During 2009, Sr-90 concentrations in samples collected from shallow groundwater monitoring wells downgradient of Building 801 were consistent with pre-December 2001 values, with a maximum concentration of 52.3 pCi/L detected in well 065-37 (**Figure 4-27**). Although the samples from well 065-325 were not analyzed for Sr-90, the gross beta result (39.8 pCi/L) indicates that the Sr-90 level would have been consistent with past results. No tritium or Cs-137 were detected in either well 065-37 or 065-325. Lower levels of Sr-90 were detected in slightly deeper wells 065-169 and 065-170, with maximum concentrations of 13.9 pCi/L and 1.38 pCi/L, respectively.

4.11.3 Building 801 Groundwater Monitoring Program Evaluation

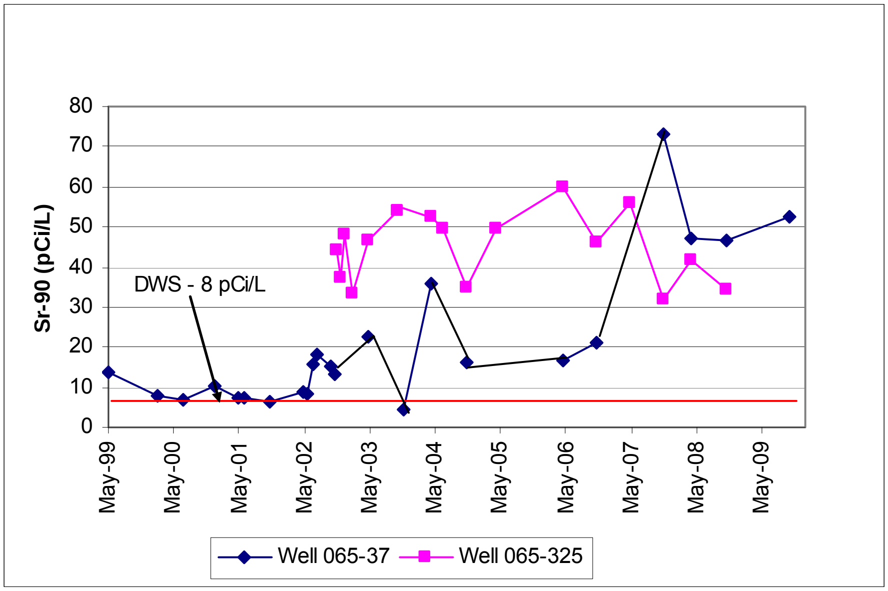
During 2009, Sr-90 concentrations in samples collected from shallow groundwater downgradient of Building 801 were consistent with pre-December 2001 values. Additionally, Cs-137 has not been detected in any of the groundwater samples since the floodwater event. It is estimated that from the December 2001 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 and/or the nearby former Pile Fan Sump (**Section 3.2.15**).

4.11.4 Building 801 Recommendations

The following is recommended for the Building 801 groundwater monitoring program:

- For 2010, the monitoring frequency for well 065-325 will be decreased from semiannually to annually, whereas the remainder of the wells will continue to be monitored annually.

Figure 4-27.
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:

- Install a permanent well approximately 75 feet north of EW-1 and EW-2. Data from this well will be used to determine when the higher concentration segment of the plume has been completely captured.
- Based on data from the new monitoring well (above recommendation), evaluate increasing the operational duration of EW-1 and EW-2 to ensure meeting the cleanup goal for this project.
- Install two new sentinel wells approximately 200 feet south of the Princeton Avenue firebreak road to monitor for the leading edge of the Sr-90 plume.

5.2 Carbon Tetrachloride Pump and Treat System

The following is the recommendation for the OU III Carbon Tetrachloride Groundwater Remediation System and monitoring program:

- Continue monitoring the remaining Groundwater Monitoring wells until MCLs are achieved.

5.3 Building 96 Air Stripping System

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

- Maintain full time operation of treatment well RTW-1.
- Install temporary wells upgradient of recirculation wells RTW-2, RTW-3, and RTW-4. If TVOCs in these wells and the recirculation wells are below 50 μg/L, then wells RTW-2, RTW-3, and RTW-4 will be placed in standby mode. Maintain a monthly sampling frequency of the influent and effluent for each well.
- Maintain integrity of the plastic liner covering the PCE-contaminated soils. Excavate the source area in the summer/fall of 2010. 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 contaminated soil removal, including a replacement for well 085-353.
- Continue to analyze for total chromium and hexavalent chromium in the monitoring wells quarterly, and in the effluent to RTW-1 two times per month.
- Continue to maintain the resin treatment in standby mode, and if concentrations of hexavalent chromium increase to over 50 ug/L in RTW-1, treatment would resume.
- Based on the results of the data from the three temporary wells installed along Weaver Drive, a permanent well will be installed.

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 is currently in effect.
- Maintain extraction wells RW-4, and RW-6 in standby mode during 2010. Restart well RW-5 and operate until TVOC concentrations drop below 50 µg/L for two consecutive quarterly extraction well sampling events. Restart the wells if extraction or monitoring well data indicate that TVOC concentrations exceed the 50 µg/L capture goal. Maintain a minimum pumping rate of 250 gpm on well RW-2.
- Install one temporary well approximately 300 feet east of monitoring well 104-36 and based upon the results install a monitoring well to monitor the progression of higher upgradient concentrations of TVOCs to the treatment system.
- Install a monitoring well centered on the high concentrations identified in the recent temporary well near well RW-1.

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 implemented last year.
- It is recommended that a temporary well be installed near well EW-4 to evaluate how deep the high concentrations of VOCs are near the extraction well. This well should be installed to a depth of approximately -160 feet below MSL, until the Magothy Brown Clay is encountered. This will help evaluate whether the VOCs detected in well 121-43 are caught in the stagnation zone or may be passing under well EW-4.

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 bypass detection wells show increasing VOC trends, the need to take further action will be evaluated.
- Due to indications of increased TVOC concentrations in plume core monitoring wells in close proximity to extraction well WSB-1, installation of a permanent monitoring well should be implemented during 2010. The well should be located approximately 700 feet north of WSB-1 to provide a data point between this well and the Middle Road.
- To better define the northerly portion of the core area of the plume where higher concentrations of dichlorodifluoromethane have been detected, two temporary wells should be installed in the vicinity of Princeton Avenue.
- Maintain the routine O&M monitoring frequency that began in 2005.

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 2010. The system will continue operations at 60 gpm per well except for well UVB-1, and UVB-7 which are to remain in a standby mode. It is recommended that well UVB-2 be placed in standby as TVOC concentrations have dropped to below 5 µg/L in this well and all of the monitoring wells in the vicinity are below 50 µg/L TVOC. Monthly recovery well sampling will continue, and if TVOC concentrations greater than 50 µg/L are observed, wells UVB-1, UVB-2 or UVB-7 will be restarted.
- Currently all the monitoring wells except 000-262 are below the capture goal of 50 µg/L. All of the extraction wells now have influent concentrations below the capture goal of 50 µg/L. If concentrations in well 000-262 drop below the TVOC 50 µg/L capture goal a petition to shutdown this system may be submitted to the regulators.
- A temporary well should be installed and sampled between wells UVB-3 and UVB-4 to evaluate the VOC concentrations in this area since no monitoring wells are present in this area.

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:

- Continue the current groundwater monitoring post shutdown monitoring schedule.
- It is recommended that one additional downgradient monitoring well be installed in the vicinity of monitoring well 000-107 on Stratler Drive to monitor Magothy contamination identified in well 000-494.

5.9 North Street Pump and Treat System

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 well 000-476 will be reduced from semiannual to annual.
- Due to the location of well 086-43 north of the Former Landfill (with respect to the plume) and since groundwater samples have not exceeded AWQS since it was installed, it is recommended that this well be dropped from the North Street monitoring program.
- VOCs have remained below AWQS for wells 115-33, 115-34, and 115-35 since they were installed in 1996, and there have been no detections above AWQS 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.
- It is recommended to begin pulse-pumping extraction well NS-1, one month on and one month off during 2010, due to TVOC concentrations below 50 µg/L in upgradient monitoring wells. If

there is any rebounding of higher TVOC concentrations, the extraction well will be placed back in to full-time operation.

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:

- Extraction well NSE-1 will remain in full time operation. Shut off extraction well NSE-2, placing it in a stand-by mode. If concentrations above the capture goal of 50 µg/L TVOCs are observed in either the core monitoring wells or the extraction wells, NSE-2 will be put back into full-time operation.
- Install a temporary well northwest (upgradient) of monitoring well 000-477 to determine the extent of VOC concentrations in this area.
- Drop monitoring well 800-54, located south of Moriches Middle Island Road, from the North Street East sampling program.
- Sample for Tritium only once per year in all wells.
- Following the review of additional monitoring well data, specifically evaluating 000-477, a Petition for Shutdown of the system will be prepared during 2010.
- Continue the shutdown monitoring frequency (sampled quarterly) for the NSE monitoring wells through 2010.

5.11 LIPA/Airport Pump and Treat System

The following are recommendations for the LIPA/Airport Groundwater 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. 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.
- Place LIPA Well EW-2 in standby as this well was below AWQS throughout 2009.

5.12 Magothy Monitoring

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

5.13 Central Monitoring

No changes to the OU III Central groundwater monitoring program are warranted at this time.

5.14 Off-Site Monitoring

No changes to the OU III Off-Site Groundwater Monitoring Program are warranted at this time.

5.15 South Boundary Radionuclide Monitoring Program

The following is the recommendation for the OU III South Boundary Radionuclide groundwater monitoring program:

- Since there are wells directly upgradient of monitoring wells 121-43, 122-24, 122-25, 122-34, and 122-35 and there have been no radionuclide detections reported, sampling of these wells for radionuclides should be discontinued.

5.16 BGRR/WCF Strontium-90 Treatment System

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

- Implement the installation of four additional extraction wells during 2010 to address the Sr-90 hot spots identified in the WCF plume.
- Install several temporary wells to characterize Sr-90 concentrations in the WCF source area.
- For the BGRR Sr-90 plume, install sentinel wells on the south side of Brookhaven Avenue to monitor the leading edge of the plume.
- Characterize the width of the plume at the well 075-664 location and install a new permanent monitoring well for the BGRR Sr-90 plume adjacent to monitoring well 075-664 screened at a shallower depth.
- Install temporary wells at Brookhaven Avenue to characterize the leading edge of the Pile-Fan Sump 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:

- Continue to operate extraction wells EW-1, EW-2 and EW-3 in full time mode.
- Maintain the operations and maintenance phase monitoring well sampling frequency begun in 2009.
- Drop wells 106-24, 106-25 and 114-01 from the monitoring program since there have been no historical detections of Sr-90 in this well.
- Complete temporary well investigations in the vicinity of monitoring well 106-48 to determine the current plume perimeter.

5.18 HFBR Tritium Pump and Recharge System

The following are recommendations for the HFBR AOC 29 Tritium Pump and Recharge System and monitoring program:

- Increase the sampling frequency for monitoring wells 075-42, 075-43, 075-44, and 075-45 to monthly as a result of the historical high water-table elevations during 2010 to monitor for any corresponding source area tritium releases. Continue monitoring for six months and then re-evaluate based on water-table conditions and observed tritium data.

- Continue to install and sample temporary wells as necessary 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 2010. 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 EW-16 has captured concentrations of tritium greater than 20,000 pCi/L in this area. 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 Program

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

- Due to the increasing concentrations of cis-1,2-dichloroethylene and tetrachloroethylene, the sampling frequency of monitoring well 076-185 should increase to semi-annual.

5.20 Building 650 (Sump Outfall) Strontium-90 Monitoring

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

- Drop monitoring wells 066-17, 076-167, 076-20, 076-26, and 076-183 from the monitoring program. The sampling frequency is currently annual in these wells. This recommendation is based on both the long history of very low Sr-90 detections in these wells along with the fact that they are clearly outside of the Sr-90 plume area based on the latest comprehensive plume characterization. The sampling of wells can be resumed and sampling frequencies increased if warranted by future changes in groundwater flow conditions.
- Re-instate an annual sampling frequency for well 076-182 in light of the latest plume characterization as it appears to be positioned as a sentinel well for the leading edge of the plume.
- Update the groundwater model with the 2009/2010 characterization data and run a new simulation to predict the expected time frame for achieving drinking water standards by natural attenuation of the plume.
- Install two monitoring wells in the downgradient plume core area and a sentinel well near the leading edge of the plume.

5.21 Operable Unit V

The following recommendations are 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 or 2009. It was recommended in the *2008 BNL Groundwater Status Report* that the monitoring well network be sampled on an annual basis for one more year. If individual VOC concentrations and tritium remained below NYS AWQS during 2009, BNL could recommend reducing the number of wells being monitored. It is recommended that monitoring for VOCs and tritium be discontinued based on the observation that there have been no detections of either constituent above NYS AWQS dating back to 1997 and 1998 (the timeframe in which these wells were installed) in the following wells: 037-02, 037-04, 041-01, 041-02, 041-03, 049-05, 050-02, 061-03, 061-04, 000-123, 000-147, 000-141, 000-142, 000-143, 000-144, 000-145, 000-146, 600-15, 600-16, 600-18.
- There have been no detections of percholorate in wells 000-122, 000-123, and 049-06 since sampling began in 2004. Based on the absence of perchlorate in these wells over the previous six years analysis for perchlorate will be discontinued. Continue perchlorate sampling in the five remaining monitoring wells for one more year. If perchlorate concentrations are below standards for two consecutive years, sampling for perchlorate will be discontinued.
- If individual VOCs remain below NYS AWQS in monitoring wells during 2010 a petition will be prepared and submitted to the regulatory agencies to conclude the monitoring program.

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.
- Change the sampling frequency of the extraction wells from monthly to quarterly.

5.23 Site Background Monitoring

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

5.24 Current Landfill Groundwater Monitoring

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

5.25 Former Landfill Groundwater Monitoring

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

5.26 Alternating Gradient Synchrotron (AGS) Complex

The following recommendations are made for the AGS Complex groundwater monitoring programs:

- The monitoring frequency for the Booster area, NSRL, E-20 Catcher, Building 914, g-2 Beam Stop, J-10 Beam Stop, and former U-Line area monitoring wells will continue to be annually.
- 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.

5.27 g-2 Tritium Source Area and Groundwater Plume

As required by the ROD, BNL will continue to conduct routine inspections of the g-2 cap, and to monitor groundwater quality downgradient of this facility. The downgradient sections of the g-2 plume will be monitored until tritium concentrations drop below the 20,000 pCi/L DWS. The following are recommended for the g-2 groundwater monitoring program:

- The source area monitoring wells will continue to be sampled quarterly for tritium and annually for sodium-22, and the downgradient sections of the tritium plume will continue to be monitored using a combination of permanent and temporary wells.
- During the spring of 2010, additional temporary wells will be installed along Transect F to verify the western margin of the g-2 tritium plume and establish new Transect G. During the fall of 2010, additional temporary wells will be installed along Transects D, E, F and G to track the g-2 plume and evaluate its attenuation in the aquifer.
- Re-run the groundwater model for the downgradient portion of the plume using 2010 monitoring data.

5.28 Brookhaven Linac Isotope Producer Facility

As required by the ROD, BNL will continue to conduct routine inspections of the BLIP cap, and to monitor groundwater quality downgradient of the 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, the monitoring frequency for the downgradient monitoring wells 064-47, 064-48, and 064-67 will continue to be semiannually.
- Sampling frequency for the two upgradient (054-61 and 064-46) and two downgradient wells (064-49 and 064-50) will continue to be annually.

5.29 Relativistic Heavy Ion Collider Facility

No changes to the Relativistic Heavy Ion Collider Facility groundwater monitoring program are warranted at this time.

5.30 Brookhaven Medical Research Reactor Facility

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.

5.31 Sewage Treatment Plant

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

5.32 Motor Pool Maintenance Area

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

5.33 On-Site Service Station

No changes to the On-Site Service Station groundwater monitoring program are warranted at this time.

5.34 Major Petroleum Facility Area

No changes to the Major Petroleum Facility Area groundwater monitoring program are warranted at this time.

5.35 Waste Management Facility

No changes to the Waste Management Facility groundwater monitoring program are warranted at this time.

5.36 Building 801

The following is recommended for the Building 801 groundwater monitoring program:

- For 2010, the monitoring frequency for well 065-325 will be decreased from semiannually to annually, whereas the remainder of the wells will continue to be monitored annually.

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