Five-Year Review Report

for

Brookhaven National Laboratory Superfund Site (NY7890008975)

Town of Brookhaven, Hamlet of Upton
Suffolk County, New York

June 21, 2016

PREPARED FOR:
The United States Department of Energy
Office of Science

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Executive Summary

The U.S. Department of Energy (DOE) owns the Brookhaven National Laboratory (BNL) site in Upton, New York, and is the lead agency for the Five-Year Review. DOE entered into a Federal Facilities Agreement (also referred to as the Interagency Agreement, or IAG) for the BNL site, along with the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC). Brookhaven Science Associates (BSA), under contract with the DOE, manages and operates BNL.

The purpose of this Five-Year Review is to determine whether the remedies implemented at BNL continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews leading to such determinations are documented in *Five-Year Review Reports*. In addition, *Five-Year Review Reports* identify potential problems with the ability of the current remedial actions to meet the cleanup objectives, if any, and provide recommendations to address them.

The remedies for the BNL Superfund site in Upton include excavation and off-site disposal of contaminated soil, sediment, tanks, and structures, capping of landfills and other contaminated soil areas, installation and operation of groundwater treatment systems, groundwater monitoring, and implementation of institutional controls. DOE has invested approximately $580 million to date to implement the groundwater, soil, Peconic River, and reactor remedies. All of the remedies for the nine signed Records of Decision (RODs) and four Explanations of Significant Differences (ESDs) have been fully implemented except for remaining remedial actions at the High Flux Beam Reactor (HFBR).

The first comprehensive *Five-Year Review Report* was submitted to the regulatory agencies in July 2005, and issued as a final document in August 2006. The second *Five-Year Review Report* was submitted to the regulatory agencies in March 2011, and the Addendum addressing regulator comments was issued as final in November 2011. The 2016 *Five-Year Review Report* also covers all of the operable units (OUs) and Reactor-related *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) actions.

According to data reviewed from the closeout reports, the annual *BNL Groundwater Status Reports*, site inspections, and regulatory interviews, the remedies were implemented in accordance with the RODs and four *OU III Explanations of Significant Differences* (ESDs). The soil cleanup levels have been met and the groundwater remediation systems continue to meet the remedial action objectives identified in each ROD.

Since the last Five-Year Review, several additional remedy optimizations were accomplished. These include the addition of extraction wells associated with the Middle Road, OU III South Boundary, and Industrial Park groundwater treatment systems. These extraction wells were added to allow for the capture and treatment of the deeper VOC contamination identified. A new groundwater treatment system was added near the Building 96 treatment system in 2012 to capture and treat a plume of Freon-11 associated with Building 452. This system successfully remediated the plume and was shut down in March 2016. In 2013, the Former Hazardous Waste Management Facility (HWMF) Perimeter Soils were designated as Sub-Area of Concern 1J. The final phase of radiological soil cleanup at this area was completed in 2014. From 2014 through 2016, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically contaminated soil was completed. This action is expected to further reduce Sr-90 contamination in the soil, thus helping to meet the groundwater cleanup objective.

Long-term protectiveness of the Peconic River remedy has been verified by continued monitoring of the sediment, surface water, and fish, and by completing the revegetation in areas that underwent supplemental remediation during the winter of 2010/2011. One location, Area PR-WC-06 was identified as having significantly elevated mercury levels in the sediment based on 2014 and 2015 monitoring. Additional excavation is being proposed for this small area of approximately 0.06 acres. All other areas have met their long-term cleanup objectives identified in the ROD.

A comprehensive sitewide protectiveness determination covering all the OUs and the reactors (BGRR and HFBR) must be reserved at this time because work is not complete for the HFBR stack and reactor vessel removal.

The fourth comprehensive Five-Year Review in 2021 will include all OUs, the BGRR, HFBR, and the g-2/Brookhaven Linac Isotope Producer (BLIP) tritium plume remedy. The table below provides a summary of each OU's issues and recommendations from the 2016 Five-Year Review. The recommendations are subject to regulatory review, and implementation will be based on the availability of funding.

Table E-1: Recommendations and Follow-up Actions

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Sr-90 in OU I Former HWMF Groundwater	Enhance monitoring well network with a combination of permanent and temporary wells on a recurring basis to track Sr-90 attenuation. Compare attenuation data with model projections prior to the next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
OU III Building 96 Source Removal Effectiveness	Monitor plume and continued degradation of source area. Continue treatment system operations and if capture goals are met, submit *Petition for Shutdown*.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2018	N	N
OU III Western South Boundary deep VOC contamination	Characterize nature and extent of deep VOCs identified in 2016/run model.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2017	N	N
Continuing Sr-90 source at BGRR	Monitor plume and continued degradation of source area. Continue pumping of extraction well SR-3. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Continuing Sr-90 source at Chemical Holes	Continue attenuation monitoring of former source area. Continue pumping of extraction well EW-1. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Peconic River Remedy Optimization	Complete supplemental excavation of elevated mercury at Area PR-WC-06.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2018	N	N
HFBR	Remove stack by 2020 per the ROD.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2020	N	N

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier.	BNL	DOE, EPA, NYSDEC, SCDHS	Recurring	N	N
OUs III & VI - Deeds not reflecting operating treatment systems	Record property access agreements with County Clerk	BNL	DOE, EPA, NYSDEC, SCDHS	June 2017	N	Y
Soil contamination north of former Buildings 810/811	Add radiological soil contamination area to Building 811 Waste Concentration Facility LUIC fact sheet	BNL	DOE, EPA, NYSDEC, SCDHS	January 2017	N	N

Notes:
Recommendations are subject to regulatory review; implementation will be based on the availability of funding
BGRR = Brookhaven Graphite Research Reactor
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
HFBR = High Flux Beam Reactor
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services
VOC = volatile organic compound

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Brookhaven National Laboratory Superfund Site		
EPA ID *(from WasteLAN)*: NY7890008975		
Region: 2	**State:** NY	**City/County:** Upton, Suffolk
SITE STATUS		
NPL status: ☒ Final ☐ Deleted ☐ Other (specify)		
Remediation status (choose all that apply): ☒ Under Construction ☒ Operating ☒ Complete		
Multiple OUs?* ☒ YES ☐ NO	**Construction completion date:** ___ / ___ / ______	
Are the properties associated with this site in use or are they suitable for reuse? ☒ YES ☐ NO		
REVIEW STATUS		
Lead agency: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency (DOE)		
Author name: Frank Crescenzo		
Author title: DOE Site Manager	**Author affiliation:** U.S. DOE, Upton, NY	
Review period:** 1/1/2011 to 3/30/2016		
Date(s) of site inspection: 4/30/15 through 11/3/15		
Type of review: ☒Post-SARA ☐ Pre-SARA ☐ NPL-Removal only ☐Non-NPL Remedial Action-site ☐ NPL State/Tribe-lead ☐Regional Discretion		
Review number: ☐ 1 (first) ☐ 2 (second) ☒ 3 (third) ☐ Other (specify) __________		
Triggering action: ☐ Actual RA Onsite Construction at OU I ☐ Construction Completion ☐ Other (specify)	☐ Actual RA Start at OU#____ ☒ Previous Five-Year Review Report	
Triggering action date *(from WasteLAN)*: 8/9/2011		
Due date *(five years after triggering action date)*: 8/9/2016		

* [“OU” refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN]

Five-Year Review Report
Table of Contents

List of Tables

List of Figures

List of Attachments

List of Acronyms

ALARA	As Low As Reasonably Achievable
AOC	Area of Concern
AGS	Alternating Gradient Synchrotron
AS/SVE	Air Sparging/Soil Vapor Extraction
BER	Brookhaven Executive Round Table
BGD	below-ground duct
BGRR	Brookhaven Graphite Research Reactor
BHSO	Brookhaven Site Office
BLIP	Brookhaven Linac Isotope Producer
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CAC	Community Advisory Council
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DQO	Data Quality Objective
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
ESD	*Explanation of Significant Differences*
FFA	Federal Facilities Agreement
gpm	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Interagency Agreement
IP	Industrial Park
Linac	Linear Accelerator
LIPA	Long Island Power Authority
LUCMP	*Land Use Controls Management Plan*
LUIC	Land Use Institutional Controls
mCi	milliCuries
MCL	maximum contaminant level
mg/kg	milligrams per kilogram

mRem	milliRem
MTBE	methyl tertiary-butyl ether
NCP	*National Contingency Plan*
NEPA	*National Environmental Policy Act*
NPL	*National Priorities List*
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	operation and maintenance
ORISE	Oak Ridge Institute for Science and Education
OU	Operable Unit
pCi/L	picoCurie(s) per liter
pCi/g	picoCurie(s) per gram
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
ppm	part(s) per million
RA	Removal Action
RAO	Remedial Action Objective
ROD	Record of Decision
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
TBC	Items “to be considered”
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TSS	total suspended solids
TVOC	total volatile organic compound
UST	underground storage tank
VOC	volatile organic compound
WCF	Waste Concentration Facility
WSB	Western South Boundary
μg/L	microgram(s) per liter

Glossary

Administrative Record: A file that contains the documents, including technical reports, which forms the basis for selection of a final remedy and acts as a vehicle for public participation.

Area of Concern: A geographic area of BNL where there has been a release or the potential for a release of a hazardous substance, pollutant, or other contaminant. There are 32 areas of concern at BNL.

Closeout Report: A report that documents the completion of construction of the remedy and how it complies with the requirements of the remedial design plans, specifications, and the ROD. The report includes post-excavation confirmatory sampling results.

Institutional Controls: Measures or restrictions established to prevent exposure of workers or the public to hazards. These may include the establishment of fencing, posting of signs, prevention of unplanned alteration of contaminant plume flow pathways, etc.

Interagency Agreement: A legal binding document established under the *Comprehensive Environmental Response, Compensation, and Liability Act,* that presents the framework for implementing the cleanup activities at a particular site. At BNL, the IAG, also known as a Federal Facilities Agreement (EPA 1992), was signed in 1992 by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation.

Maximum Contaminant Level: A standard set by the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation for contaminants in drinking water. These contaminants represent levels that the regulatory agencies believe are safe for people to drink. NYSDEC standards often apply a safety factor and are more stringent than the Federal standards.

Operable Unit: Groups of areas within a site containing the same or similar contamination. The areas within one operable unit are not necessarily adjacent. BNL has six operable units.

PicoCurie Per Liter: A unit of measure of radioactivity per liter of water.

Record of Decision: Documents the decision by DOE and the regulators on a selected remedial action. It includes the responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the record of decision is finalized, the remedial design and construction can begin.

Brookhaven National Laboratory
Five-Year Review Report

1.0 Introduction

The purpose of this Five-Year Review is to determine whether the remedies implemented at Brookhaven National Laboratory (BNL) continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews leading to such determinations are documented in Five-Year Review Reports. In addition, Five-Year Review Reports identify potential problems with the ability of the current remedial actions to meet the cleanup objectives, if any, and provide recommendations to address them.

The U.S. Department of Energy (DOE) prepared this Five-Year Review Report pursuant to the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) §121 and the *National Contingency Plan* (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

DOE interpreted this requirement further in the NCP; *40 Code of Federal Regulations* (CFR) §300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

Brookhaven Science Associates (BSA), under contract with the DOE, manages and operates BNL. BSA's Environmental Protection Division (EPD) conducted this Five-Year Review of the remedial actions implemented at the BNL site under the direction of the DOE Brookhaven Site Office. This report documents the results of the review.

This is the third sitewide Five-Year Review for the BNL site and includes all the Operable Units (OUs), the Brookhaven Graphite Research Reactor (BGRR), the High Flux Beam Reactor (HFBR), and the g-2 Tritium Plume and Brookhaven Linac Isotope Producer (BLIP) Areas of Concern (AOCs). The triggering action for this 2016 sitewide statutory Five-Year Review is the completion of the second sitewide review in July 2011. This review is required because hazardous substances, pollutants, or contaminants at the site are above levels that allow for unlimited use and unrestricted exposure. This third sitewide Five-Year Review includes an evaluation of all the AOCs at BNL. Previous Five-Year Reviews were:

- Five-Year Evaluation Reports prepared for the Current and Former Landfills in 2001 and 2002 in accordance with New York State Part 360 requirements (BNL 2001a and 2002).
- A Five-Year Review focused specifically on the OU IV remedy in September 2003 (BNL 2003a).
- The first sitewide Five-Year Review submitted as draft to the regulators in July 2005, with the final Report issued in August 2006 (BNL 2006). The triggering action for this review was initiation of the remedial action for OU I contaminated landscape soils in July 2000. This Review did not include the g-2/BLIP or HFBR RODs.
- The second sitewide Five-Year Review was submitted to the regulators in March 2011, and the Addendum addressing regulator comments was issued as final in November 2011 (BNL 2011a). The triggering action for this review was the completion of the last review.

2.0 Site Chronology

Remedial actions at the BNL site are currently being addressed under RODs for six OUs, the BGRR, the HFBR, and g-2/BLIP, covering 32 AOCs. The chronology in **Table 2-1** first identifies general site information, and then breaks each OU down by major event. **Table 2-2** presents each OU and Removal Action AOC.

Table 2-1: Chronology of Site Events

General Site Information	
Site of future BNL serves as Army Camp Upton for World Wars I and II, operated by the Civilian Conservation Corps between wars	1917 – 1940s
Site transferred to the Atomic Energy Commission, BNL developed	1947
BNL transferred to the Energy Research and Development Administration	1975
BNL transferred to the DOE	1977
BNL added to NYSDEC list of Inactive Hazardous Waste Sites	1980
BNL listed on EPA National Priorities ("Superfund") List	1989
DOE entered into Interagency Agreement with EPA and NYSDEC under CERCLA	1992
Operable Unit I	
RA for "D-waste" tanks removal	1994
RA for Landfill capping	1995–1997
RA for South Boundary groundwater treatment system construction and public water hookups	1996
RA for Chemical/Animal Pits and Glass Holes excavation	1997
ROD signed	1999
Completed excavating landscape soil; Closeout Report issued	2000/2001
Completed excavating sludge from Building 811 USTs; Closeout Report issued	2001
Completed excavating soil and pipeline associated with Building 650; Closeout Report issued	2002
Completed capping Ash Pit; Closeout Report issued	2003/2004
Completed excavating soil and reconstructed Upland Recharge and Meadow Marsh; Closeout Report issued	2003/2004
Completed excavating former HWMF soil; Closeout Report issued	2005
Completed excavating Building 811 USTs/soils; Closeout Report issued	2005
Completed excavating former Chemical Holes residual surface soils; Addendum to Closeout Report issued	2005
Completed decontamination of the Merrimack Hole at the former HWMF	2006
RA completed for excavating the former HWMF Phase I Perimeter Soils; Completion Report issued	2009
Completed excavating the former HWMF Phase II Perimeter Soils; Completion Report Addendum issued	2010
Former HWMF Perimeter Soils designated as Sub-Area of Concern 1J	2013
Petition approved for shutdown of the South Boundary groundwater treatment system	2013
Completed excavating the former HWMF Phase III Perimeter Soils; Completion Report Addendum issued	2014
Demolition of former Waste Concentration Facility and soil removal in progress	2016
Operable Unit II/VII	
RA for BLIP Facility (AOC 16K) cap, drainage control, grout injection; Closeout Report issued	1998/2002
Remedial Investigation performed; RI Report issued	1999
Evaluation of alternatives included under OU I Feasibility Study	1999
Operable Unit III	
RA for Building 479 PCB-contaminated soil excavation	1992
RA for Building 464 mercury-contaminated soil excavation	1993
RA for cesspools/septic tanks completed; Closeout Report issued	1994–1999
RA for USTs completed; Closeout Report issued	1994–1999
RA for public water hookups	1996–1998
RA for South Boundary groundwater treatment system construction	1997
RA for HFBR tritium plume groundwater treatment system	1997
RA for Carbon Tetrachloride groundwater treatment system construction	1999
RA for Industrial Park groundwater treatment system construction	1999

Continued…

Table 2-1: Chronology of Site Events *(continued)*

ROD signed	2000
Completed constructing Building 96 groundwater treatment system	2000
Completed constructing Middle Road groundwater treatment system	2001
Completed constructing low-flow pumping system for HFBR tritium plume	2001
Completed constructing Western South Boundary groundwater treatment system	2002
Completed constructing Chemical Holes Sr-90 groundwater treatment system (Pilot Study)	2003
Petition approved for shutdown of the Carbon Tetrachloride treatment system	2004
Completed constructing four remaining off-site groundwater treatment systems: Industrial Park East, North Street, North Street East, LIPA/Airport	2004
Completed constructing BGRR/WCF Sr-90 groundwater treatment system	2004
Completed excavating and off-site disposal of Building 96 PCB-contaminated soil; Closeout Report issued	2005
ESD issued for Magothy, Sr-90, Bldg. 96 geophysical anomalies	2005
Building 96 Groundwater Treatment System Shutdown Petition Issued	2005
Completed construction of additional extraction wells for the HFBR, Chemical Holes, and Airport groundwater treatment systems	2007
ESD issued for Bldg. 96 VOC soil excavation	2009
Petition approved for shutdown of the Industrial Park East groundwater treatment system	2009
Petition approved for closure of the Carbon Tetrachloride groundwater treatment system; system dismantled	2009-2010
Completed excavating and off-site disposal of Building 96 VOC-contaminated soil	2010
Completed construction of additional extraction wells for the WCF Sr-90 groundwater treatment system	2011
Building 452 Freon-11 Source Area and Groundwater Plume designated as Area of Concern 32	2011
Issued ESD (BNL 2012a); completed construction of Building 452 Freon-11 groundwater treatment system	2012
Completed construction of additional deeper extraction wells for the OU III South Boundary and Middle Road groundwater treatment systems	2012-2013
Petition approved for shutdown of the Industrial Park groundwater treatment system	2013
Petition approved for closure of the Industrial Park East groundwater treatment system	2013
Petition approved for shutdown of the North Street groundwater treatment system	2013
Petition approved for shutdown of the HFBR Pump and Recharge groundwater system	2013
Petition approved for shutdown of the North Street East groundwater treatment system	2014
Completed construction of additional deeper extraction wells for the Industrial Park groundwater treatment system	2015
Petition approved for shutdown of the Building 452 Freon-11 groundwater treatment system	2016
Operable Unit IV	
RA for fence around Building 650 Sump Outfall area soil	1995
ROD signed	1996
Completed constructing AS/SVE remediation system	1997
Petition approved for shutdown of AS/SVE remediation system	2000
Five-Year Review submitted to EPA and NYSDEC	2002
Petition for closure of AS/SVE Remediation System approved by EPA and NYSDEC; system dismantled	2003
Final Five-Year Review Report issued	2003
Operable Unit V	
RA for Imhoff Tanks	1995
ROD signed for Sewage Treatment Plant (STP)	2002
Completed excavation of STP soils; Completion Report issued	2003/2004
RA for Peconic River sediment excavation on site (Phase 1); Completion Report issued	2004/2005
RA for Peconic River sediment excavation off site (Phase 2); Completion Report issued	2004/2005
ROD signed for Peconic River	2005
Closeout Report for Peconic River Phase 1 and 2 Remediation issued	2005
Initiated post-cleanup Peconic River monitoring program to demonstrate the effectiveness of the cleanup	2006
Completed sediment trap removal and Peconic River Supplemental Remediation: Closeout Report issued	2011/2012

Continued…

Table 2-1: Chronology of Site Events *(continued)*

Operable Unit VI	
RA for public water hookups	1996–1997
ROD signed	2001
Completed constructing EDB groundwater treatment system off site	2004
Brookhaven Graphite Research Reactor	
RA for BGRR primary cooling fans and equipment	1999
RA for pile fan sump	1999–2000
RA for above-grade ducts	2000–2002
RA for canal house and water treatment house	2001–2002
RA for coolers and filters	2002–2003
RA for BGD primary liner	2004
RA for fuel canal and subsurface soils	2005
ROD signed	2005
Graphite pile removal; Closeout Report issued	2010
Engineered cap installed; Closeout Report issued	2011
Issued ESD (BNL 2012b); Biological shield removed; Closeout Report issued	2012
Began Long-Term Surveillance and Maintenance	2012
g-2/BLIP/USTs	
Impermeable caps placed over BLIP and g-2 source areas	1997 and 1999
Groundwater monitoring, cap inspections and maintenance	1999-2010
ROD signed	2007
ROD contingency triggered; additional groundwater monitoring initiated in downgradient plume segment	2011
Downgradient plume monitoring complete	2015
High Flux Beam Reactor	
Dismantlement and removal of several ancillary buildings	2006
RA completed for excavating former HWMF Waste Loading Area soils; Completion Report issued	2007-2009
ROD signed	2009
Removal of Bldgs. 801-811 underground waste transfer lines (A/B waste lines with co-located piping) and associated soil; Closeout Report issued.	2009
RA for removal/disposal of control rod blades and beam plugs; Completion Report issued	2009-2010
Began Long-Term Surveillance and Maintenance for Confinement Building and Stack	2010 and 2012
Fan houses (Bldgs. 704 and 802), above- and below-ground structures, soil removal; Closeout Report issued	2011
Confinement Building stabilization; Closeout Report issued	2011
Underground utilities and associated soil removal; Closeout Report issued	2011
Stack Silencer Baffles and survey of outside areas; Closeout Report issued	2012

Notes
AOC = Area of Concern
AS/SVE = Air Sparging/Soil Vapor Extraction
BLIP = Brookhaven Linac Isotope Producer
BGD = below-ground duct
BNL = Brookhaven National Laboratory
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*
DOE = Department of Energy
EPA = U.S. Environmental Protection Agency
EDB = ethylene dibromide
ESD = Explanation of Significant Differences
FS = Feasibility Study
HFBR = High Flux Beam Reactor
HWMF = Hazardous Waste Management Facility
IAG = Interagency Agreement
LIPA = Long Island Power Authority
NYSDEC = New York State Department of Environmental Conservation

RA = Removal Action
RI = Remedial Investigation
ROD = Record of Decision
STP = Sewage Treatment Plant
USTs = underground storage tanks
VOC = volatile organic compound
WCF = Waste Concentration Facility

Table 2-2: Operable Unit (OU) AOCs

Category	AOC #	Description and Status
OU I (ROD approved)	AOC 1 (A,C,D,E,F,G,H,I,J)	Hazardous Waste Management Facility – complete
	AOC 1B	Spray Aeration site – removal action complete
	AOC 2 (A,B,C,D,E,F)	Former Landfill Area – complete
	AOC 3	Current Landfill – complete
	AOC 2 and 3	Former and Current Landfill Closures – removal actions complete
	AOC 6	Building 650 Sump and Sump Outfall – complete
	AOC 8	Upland Recharge/Meadow Marsh Area– complete
	AOC 10A	Waste Concentration Facility – Tanks D-1, D-2, and D-3 – complete
	AOC 10B,C	Waste Concentration Facility – Underground pipelines and Six A/B USTs - complete
	AOC 12	USTs at Bldg. 445 – removal action complete
	AOC 23	Off-Site Tritium Plume (southern component) – complete
	Sub AOC 24E	Recharge Basin HS, Outfall 005 – complete
	Sub AOC 24F	New Stormwater Runoff Recharge Basin – complete
OUs II/VII (addressed in OU I ROD; approved)	AOC 10A,B,C	Waste Concentration Facility (Building 811) – complete (building removed 2015; supplemental soil removal in progress)
	AOC 16 (A,B,C,D,E,F,G, H,I,J,L,M,N,O,P,Q,S)	Aerial Radioactive Monitoring System Results – complete
	AOC 17	Area Adjacent to Former Low-Mass Criticality Facility – complete
	AOC 18	AGS Scrapyard ("Boneyard") – complete
	AOC 20	Particle Beam Dump, north end of Linac – complete
OU III (ROD approved)	AOC 7	Paint Shop – groundwater monitoring ongoing
	AOC 9	BGRR (groundwater) – treatment system operating
	AOC 10	Waste Concentration Facility (groundwater) – treatment system operating
	AOC 11	Building 830 Pipe Leak – complete; groundwater monitoring ongoing
	AOC 12	USTs at Bldg. 830 – removal action complete
	AOC 13	Cesspools – removal action complete
	AOC 14	Bubble Chamber Spill Areas – groundwater monitoring ongoing
	Sub AOC 15A	Supply/Potable Wells 1, 2, 3, 4, 6, 7, 10, 11, 12
	Sub AOC 15B	Monitoring Well 130-02 – treatment system operating
	AOC 16R	Aerial Radioactive Monitoring System results– Nuclear Waste Management Facility, Building 830 – complete (covered under AOCs 11 and 12)
	AOC 18	AGS Scrapyard (groundwater) – groundwater monitoring ongoing
	AOC 19	TCE Spill Area, Building T-111 – groundwater monitoring ongoing
	AOC 20	Particle Beam Dump, north end of Linac (includes Basin HT) – monitor and maintain per SPDES permit/NRMP
	AOC 21	Leaking sewer pipes (sitewide, not investigated under other OU study areas) – groundwater monitoring ongoing
	AOC 22	Old Firehouse – no further action per ROD
	Sub AOC 24A	Process Supply Wells 104 and 105 – treatment systems operating, groundwater monitoring ongoing
	Sub AOC 24B	Recharge Basin HP, Outfall 004 – monitor & maintain per SPDES permit & NRMP
	Sub AOC 24C	Recharge Basin HN, Outfall 002 – monitor & maintain per SPDES permit & NRMP
	AOC 25	Building 479 PCB soil removal complete; groundwater monitoring underway

Continued…

Table 2-2: Operable Unit (OU) AOCs *(continued)*

Category	AOC #	Description and Status
	AOC 26	Building 208 – removal action complete
	AOC 26A	Building 208 (groundwater) - groundwater monitoring complete
	AOC 26B	Former Scrapyard/Storage Area south of Bldg. 96 – treatment system operating; soil removal complete
	AOC 27	Building 464 mercury soil removal complete; groundwater monitoring ongoing
	AOC 29	Spent fuel pool in HFBR and associated groundwater plume of tritium – pump and recharge system in standby mode; groundwater monitoring ongoing
	AOC 32	Building 452 Freon-11 Source Area and Groundwater Plume - treatment system in standby mode
OU IV (ROD approved)	AOC 5 (A,B,C,D)	Central Steam Facility – treatment system decommissioned
	AOC 6	Reclamation Facility Interim Action – complete
	AOC 12	USTs at Bldg. 650 – removal action complete
	AOC 21	Leaking Sewer Pipes (in study area) – complete
	Sub AOC 24D	Recharge Basin HO, Outfall 003 – complete
OU V – STP (ROD Approved)	AOC 4 (A,B,C,D,E)	Sewage Treatment Plant - complete
	AOC 21	Leaking sewer pipes (in the study area) – complete
	AOC 23	Off-site tritium plume (eastern component) – groundwater monitoring complete
OU V – Peconic River (ROD Approved)	AOC 30	Peconic River – cleanup on and off of BNL property complete; additional sediment removed in 2010/2011; river monitoring ongoing
OU VI (ROD approved)	AOC 28	EDB groundwater contamination – treatment system operating
BGRR (ROD Approved)	AOC 9	Graphite Pile – complete
		Biological Shield/Engineered Cap – complete
	AOC 9A	Fuel Canal – complete
	AOC 9B	Below-ground ducts – complete
	AOC 9C	Spill sites – complete
	AOC 9D	Pile Fan Sump – complete
g-2 and BLIP (ROD Approved)	AOC 12	USTs, Bldgs. 462, 463, 527, 703, 927, 931B – complete
	AOC 16K	Aerial Radioactive Monitoring System results – BLIP, Building 931B – Source area protection and groundwater monitoring ongoing
	AOC 16T	Aerial Radioactive Monitoring System results - g-2 Source Area and Tritium Groundwater Plume – source area protection and groundwater monitoring ongoing
HFBR (ROD Approved)	AOC 31	Waste Loading Area – complete
		Control Rod Blades and Beam Plugs – complete
		Buildings 801-811 Waste Transfer Lines - complete
		HFBR Stabilization – complete
		Fan Houses (Buildings 704 and 802) – complete
		Underground Utilities – complete
		Stack – in progress
Other Removal Action	Not applicable	Former HWMF Perimeter Soils – Phases I, II, and III – complete
	Not applicable	Central Steam Facility Lead-Contaminated Soil – complete

Continued…

Table 2-2: Operable Unit (OU) AOCs *(continued)*

Category	AOC #	Description and Status
	Not applicable	Shotgun Range Lead Contaminated Soil - complete

Notes:
AGS = Alternating Gradient Synchrotron
AOC = Area of Concern
BGRR = Brookhaven Graphite Research Reactor
BLIP = Brookhaven Linac Isotope Producer
HFBR = High Flux Beam Reactor
NRMP = *Natural Resource Management Plan*
ROD = Record of Decision
SPDES = State Pollutant Discharge Elimination System
STP = Sewage Treatment Plant
EDB = ethylene dibromide
TCE = trichloroethene
USTs = Underground Storage Tanks
VOC = volatile organic compound

3.0 Facility-Wide Background

3.1 Physical Characteristics

The BNL site is located in Upton, Suffolk County, New York, near the geographic center of Long Island. The BNL property approximates a square, 3 miles on each side, comprising an area of approximately 5,265 acres (about 8 square miles). The boundaries of BNL are either near or adjacent to neighboring communities. Approximately 150 people live in apartments on site, and many of the approximately 4,500 scientists and students who visit each year stay in the Lab's dormitories. The site's terrain is gently rolling, with elevations varying between 40 and 120 feet above mean sea level. The land lies on the western rim of the Peconic River watershed, with a tributary of the river rising in marshy areas in the northern part of the site.

3.2 Geology/Hydrogeology

BNL is underlain by unconsolidated glacial and deltaic deposits that overlie gently southward sloping, relatively impermeable, crystalline bedrock. The deposits are about 2,000 feet thick in central Suffolk County. The aquifer beneath BNL is comprised of three water-bearing units: the Upper Glacial, the Magothy, and the Lloyd aquifers. These units are hydraulically connected and make up a single zone of saturation with varying physical properties extending from a depth of 45 to 1,500 feet below the land surface. These three water-bearing units are designated as a "sole-source aquifer" by the EPA and serve as the primary source of drinking water for Nassau and Suffolk Counties.

3.3 Land and Resource Use and Institutional Controls

The site where BNL is located was formerly occupied by the U.S. Army as Camp Upton during World Wars I and II. Between the wars, the Civilian Conservation Corps operated the site. In 1947, the Atomic Energy Commission established BNL. The Laboratory was transferred to the Energy Research and Development Administration in 1975 and to the DOE in 1977. BNL is currently a federal facility that conducts cutting-edge research in physics, chemistry, biology, medicine, applied science, and advanced technologies.

The developed region of the site includes the principal BNL facilities which are near the center of the site on relatively high ground. These facilities comprise an area of approximately 1,800 acres, of which 500 acres were originally developed for Army use. Outlying facilities occupy approximately 550 acres and include an apartment area, Sewage Treatment Plant (STP), firebreaks, and former landfill areas. Approximately 500 acres of land on the eastern portion of the site has been designated as the Upton Ecological Reserve. DOE has granted an easement on approximately 200 acres of land on the east and southeast portion of the site for the operation of the Long Island Solar Farm. This 32 megawatt (MW) direct current solar photovoltaic power plant was constructed in 2011.

The current land-use designations for the BNL site as of March 2016 are shown on **Figure 3-1**. This includes industrial use in the central portion of the site, with open space borders. Further detail of the land-use designations for specific remediation areas is identified in the *BNL Land Use and Institutional Controls* (LUIC) website (https://luic.bnl.gov/LUIC/).

These land-use settings are projected to remain the same. These include:

- Soil Remediation Complete - Unrestricted Land Use (A)
- Soil Remediation Complete - Restricted Land Use (B)
- Capped/Controlled Contaminated Soils - Restricted Land Use (C)
- Known or Potentially Contaminated Soils, Remediation Pending - Restricted Land Use (D)
- Groundwater Contamination Areas - Restricted Groundwater Use (E)
- Radiological Facility, Decontamination & Demolition Pending - Restricted Land Use (F)
- Sensitive Areas, Biologically/Culturally Sensitive - Restricted Land Use (G)

Institutional controls are administered as per the *BNL Land Use Controls Management Plan* (LUCMP) (BNL 2013a) which was initially issued in 2003. LUICs will be maintained for as long as necessary in order to ensure performance of the completed remedies as described and documented in the BNL RODs. The AOC-specific institutional controls are documented on fact sheets stored on the *BNL* LUIC website (https://luic.bnl.gov/LUIC/). This is a secure website that is available for regulatory use but is not open to the general public. The website is BNL's tool for internally managing Institutional Controls (ICs) and consists of an interactive Graphic Information Systems (GIS) base map that is linked to the AOC-specific fact sheets. Planning for any work at the site that may potentially disturb a formerly remediated area requires a review of the website. ICs are deployed at BNL to prevent exposure to residual environmental contamination and to ensure the long-term effectiveness of the remedies.

This Plan is a living document and is periodically updated by BNL and reviewed by the regulators in an effort to stay current with evolving management techniques. The Plan was updated four times since 2003 with the latest update in April 2013 (BNL 2003b, 2005d, 2007a, 2009d, and 2013a). LUICs are evaluated from a sitewide standpoint on an annual basis and issues from the previous year are summarized in a letter report to the regulatory agencies. A summary of findings from the required annual inspections of former AOCs is included in this report. The Plan also details notification criteria in the event of a LUIC breach or unauthorized change in land use. Specific ICs for each area are detailed in the fact sheets and are summarized by OU in **Section 7.0** of this Report.

Because of chemical contamination in the Upper Glacial aquifer, DOE provided public water hookups for homes in the area south of BNL. Ten homeowners within the designated public water hookup area declined the free DOE hookup offer in 1996-1997 and continued to use their private wells for drinking purposes. That number was reduced to seven homeowners in 2005 and six in early 2006. In 2006, two additional homes and in 2011 one additional business were identified that were previously thought to be connected to public water. In 2012, two of the homeowners hooked-up to public water and one of the homeowner's well is no longer being used. This brings the number of homes not connected to public water to six (three in OU III, one in OU V, and two in OU VI). Annually, DOE formally offers those homeowners free testing of their private drinking water wells.

3.4 History of Contamination

Much of the environmental contamination at BNL is associated with past accidental spills and historical storage and disposal of chemical and radiological materials. These past operations, some of which may date back to when the site was an Army training camp, have caused soil and groundwater contamination that can be categorized into four main areas. These areas are 1) the groundwater contamination (primarily volatile organic compounds [VOCs], ethylene dibromide [EDB], strontium-90 [Sr-90], and tritium), 2) soils contamination (primarily polychlorinated biphenyls [PCBs], tetrachloroethylene [PCE], metals, cesium-137 [Cs-137], and Sr-90) and landfills, 3) the Peconic River sediment contamination (primarily metals and PCBs), and 4) the BGRR/HFBR (primarily radioactivity). Contamination in the Peconic River and VOC groundwater contamination have extended off the BNL property. The most significant environmental concern is that BNL lies above a sole-source aquifer that is used for drinking water purposes both on and off site. Brief descriptions of the nature of contamination associated with each OU, the BGRR, g-2/ BLIP/underground storage tanks (USTs), and the HFBR covered under this Five-Year Review are as follow:

- OU I – Former landfills, disposal pits, and soils contaminated with metals such as mercury and lead, and radionuclides including Cs-137 and Sr-90; above- and below-ground leaking storage tanks; and VOC-contaminated groundwater such as chloroethane and 1,1-dichloroethane on BNL property.

- OU II/VII – Radiologically contaminated soils on BNL property such as Cs-137 identified as part of aerial radiological surveys. The AOCs in this OU were documented under the OU I and III RODs (except for BLIP [AOC 16K] which was documented in the g-2/ BLIP/USTs ROD (BNL 2007b).
- OU III – Groundwater contaminated with VOCs such as carbon tetrachloride, 1,1,1-trichloroethane (TCA), and PCE, and radionuclides such as tritium and Sr-90 on BNL property; VOC-contaminated groundwater off of BNL property including PCE and carbon tetrachloride; and PCE soil contamination at one location on BNL property.
- OU IV – Soil and groundwater contaminated with VOCs such as toluene and ethylbenzene, and semivolatile organic compounds (SVOCs) from a former oil/solvent tank spill on BNL property. Groundwater contaminated with Sr-90 located in central portion of BNL property.
- OU V – Radiological- and metal-contaminated soil at the STP such as Cs-137, mercury, and silver; metal- (mercury, silver, copper) and PCB-contaminated sediment in the Peconic River; and VOC-contaminated groundwater including trichloroethene (TCE) on and off of BNL property.
- OU VI – EDB-contaminated groundwater off of BNL property.
- BGRR – Activated components including the pile and bioshield, radiologically contaminated soils, sumps, ducts, piping, and standing water including Cs-137 and Sr-90; and Sr-90 in groundwater on the BNL site.
- g-2/BLIP/USTs – Radioactive soil shielding and contaminated groundwater at the former g-2 experiment and BLIP facility areas, and removal of underground storage tanks.
- HFBR – Activated components, contaminated structures, systems, underground pipes/ducts, ancillary buildings, and associated soils. Tritium-contaminated groundwater on the BNL site.

3.5 Initial Response

In 1980, the BNL site was placed on the NYSDEC list of Inactive Hazardous Waste Disposal Sites. In 1989, BNL was also included on the EPA *National Priorities List* because of soil and groundwater contamination. Subsequently, EPA, NYSDEC, and DOE entered into a Federal Facilities Agreement (also referred to as the Interagency Agreement, or IAG). While not formal IAG partners, the Suffolk County Department of Health Services (SCDHS) and the New York State Department of Health (NYSDOH) are also actively involved with BNL cleanup decisions. The IAG became effective in 1992, and it identified AOCs that were grouped into OUs to be evaluated for response actions. The IAG established the framework and schedule for characterizing, assessing, and remediating the site in accordance with the requirements of CERCLA. There are 32 AOCs and six OUs at the BNL site.

As noted in **Table 2-1** in **Section 2.0**, prior to the approval of the RODs, DOE used its removal action authority in many situations to help reduce risks to human health and the environment. In most cases, these actions were taken to address source areas of contamination. These activities include the closure/capping of landfills, fencing to restrict access, tank removals, soils remediation, groundwater treatment, public water hookups, STP remediation, Peconic River sediment remediation, and response actions at the BGRR and HFBR. In several cases, the removal action ended up being the final remedial action. These actions are documented in the RODs.

3.6 Basis for Taking Action

The nature of the contamination as well as the risks to human health and the environment for each OU are summarized below.

Operable Unit I. Radioactively contaminated soil is the principal threat. In addition, several Removal Actions were conducted to address buried waste at several AOCs.

Soils: The former HWMF (AOC 1) contained most of the radioactively contaminated soil at BNL. The predominant radionuclide was Cs-137, which is the primary source of risk from direct exposure. Sr-90 was also present, and most of the contamination was at or near the surface although in some locations it extended to 12 feet below grade. The former HWMF Perimeter Area (AOC 1J) contained primarily Cs-137. Other contaminated soil areas included the Waste Concentration Facility (WCF, AOC 10) (which also contained leaking tanks), Building 650 Sump and Sump Outfall (AOC 6), and several areas throughout the site that were the result of contaminated soils that were unknowingly once used for landscaping purposes. The Former (AOC 2), Interim (AOC 2D), and Current (AOC 3) landfills, as well as the Chemical/Animal Pits and Glass Holes (AOC 2B and 2C), received waste generated at the BNL site from 1918 through 1990. These disposal areas were unlined and had a direct impact on groundwater quality prior to their being capped or excavated in the mid-1990s. Contaminants at the Former Landfill Area include VOCs, metals such as mercury, and Sr-90.

The ash pits (AOC 2F), which once received ash and slag from a solid-waste incinerator located on the BNL site, have lead concentrations above cleanup goals. The Upland Recharge/Meadow Marsh Area (AOC 8) contained sediment with low levels of pesticides and metals below cleanup standards for human health but presented an exposure risk to eastern tiger salamanders, an endangered species in New York State.

Groundwater: The groundwater beneath the Former Landfill area contained VOCs and Sr-90, while groundwater beneath the Current Landfill contains VOCs and metals. Sr-90 and VOCs have also entered the groundwater from the former HWMF. Volatile organic compound contamination from these areas has migrated beyond the site's boundary.

Operable Unit II/VII. The principal threat is from radioactively contaminated soils.

Soils: Cs-137 is the major radiological contaminant of concern in soil where it can exceed specified risk or radiation dose limits. Cs-137 was found in the WCF soils as well as several areas identified from the aerial radioactive monitoring system results (i.e., landscaping soils [AOC 16S]). During the remedial investigation, no Cs-137 soil contamination in the landscape soils was found greater than two feet below grade. This soil contamination was included under the OU I project. Sr-90 soil contamination was found deeper than two feet at the WCF, as was tritium contamination in soil at the BLIP.

Groundwater: The BLIP (AOC 16K) contains an area of soil and groundwater contamination. (See discussion on g-2 and BLIP areas below).

Operable Unit III. Groundwater contamination is the most significant concern; however, there are several soil AOCs.

Groundwater: VOC-contaminated groundwater extends south from the central portion of BNL off site to the Brookhaven Airport area, a distance of approximately three miles. The VOC plumes originated from a variety of sources including various small spill areas in the central industrial/research areas of the site, former Building 96, the Former Landfill, the Central Steam Facility (OU IV), Former Building 208 warehouse area, the former Carbon Tetrachloride UST, and maintenance Building 452. The primary contaminants are TCA, PCE, and carbon tetrachloride. Tritium and Sr-90 are also present above the maximum contaminant levels (MCLs) on the BNL site. There is no radiological contamination off of BNL property that exceeds MCLs. The potable drinking water supply wells on and off of the BNL site are currently not impacted, nor are they expected to be impacted from the contamination. Although these plumes were not found to have impacted any off-site private drinking water supply wells, in the 1990s DOE provided public water connections to most of the homes in the designated hook-up area downgradient of the site. Although currently three homeowners continue to use their private wells for drinking water purposes within the OU III area, DOE offers free annual testing of their well water, which is conducted by the SCDHS.

Soils: PCB-contaminated soils above the New York State Technical and Administrative Guidance Memorandum (TAGM) cleanup levels, as well as high concentrations of PCE in soil were found at the former Building 96 Scrapyard (AOC 26B). Other smaller contaminated soil areas included mercury at Building 464 (AOC 27) and PCBs at Building 479 (AOC 25).

Operable Unit IV. Soil and groundwater are the concerns.

Groundwater: VOCs and SVOCs, such as benzene, toluene, and ethylbenzene from an historical oil/solvent spill, contaminated the groundwater at this OU. Strontium-90 was released to groundwater at the Building 650 Sump Outfall and the plume is located in the central portion of the site.

Soil: VOCs and SVOCs were also present in the soils from the historical oil/solvent spill. Radiological contamination of soils was identified at the Building 650 Sump Outfall. This soil contamination was included under the OU I project.

Operable Unit V. Radioactively and metal-contaminated soil, and metal and PCB-contaminated river sediment are the principal threats.

Soil/Sediment: The STP berms soil (AOC 4) presented concern due to potential impacts to future on-site residents from Cs-137 and mercury. In addition, concentrations of mercury and PCBs in fish may have posed a health hazard to people consuming fish taken from certain locations on the Peconic River (AOC 30). Sediment within certain depositional areas of the Peconic River was contaminated with mercury, silver, and copper, and posed a potential ecological concern. Surface sediment in depositional areas up to 1.5 miles downstream of the STP contained the PCB Aroclor-1254. Trace amounts of cesium-137 were co-located in the sediment, but did not pose a risk to people or aquatic organisms.

Groundwater: VOCs (e.g., TCE) were the primary contaminants in the groundwater on and off of the BNL site. Low levels of tritium were also found, but at concentrations below the 20,000 picoCuries per liter (pCi/L) MCL. In the 1980s, one private well was impacted by site-related VOCs at concentrations exceeding drinking water standards. DOE provided a carbon filtration system to this home, and subsequently connected it to the public water supply. Although this action was not performed as part of a CERCLA remedy under the BNL Federal Facilities Agreement, it did help support the basis for investigation of the groundwater in OU V. DOE currently offers free annual testing to one other homeowner that continues to use their private well for drinking water purposes.

Operable Unit VI. Groundwater contamination is the primary threat.

Groundwater: The pesticide EDB is the contaminant of concern (AOC 28). It has been found in groundwater on and off of BNL property significantly above the MCL of 0.05 micrograms per liter (µg/L). The EDB originates from application in the Biology Fields in the 1970s. DOE offers free annual testing to one business and one homeowner that continue to use their private wells for drinking water purposes.

BGRR

Structures and Soils: There were several radiologically contaminated and activated structures and components at various locations within the BGRR complex (AOC 9). These include the graphite pile and surrounding biological shield, contaminated concrete within the fuel-handling system's deep pit and fuel canal (AOC 9A), and contaminated steel, concrete, air coolers, and filters within the below-ground ducts (BGD, AOC 9B). Additionally there are isolated pockets of contaminated soils adjacent to the BGD secondary cooling air bustle and expansion joints, fuel canal outer walls and construction joint, the reactor building pipe trench, and the reactor building drains. Concerns also include rainwater infiltration and subsequent leaching into the soil/groundwater. Most nonradiological hazardous materials associated with the BGRR were removed through previous interim stabilization measures. Isolated pockets of nonradiological hazardous material contamination are present within the reactor building pipe trench, and within embedded drain lines. Hazardous materials intrinsic to construction materials, such as floor tiles, paint, and insulating materials, remain within the reactor building.

Groundwater: Groundwater contaminated with Sr-90, included under OU III, is present beneath the BGRR complex, at concentrations significantly above the 8 pCi/L MCL. The Sr-90 contamination extends up to 1,500 feet south of this area.

g-2/BLIP/USTs

Structures and Soils: Particle accelerator operations at the former g-2 experiment area (AOC 16T) and BLIP facility (AOC 16K) have resulted in the activation of soil used for shielding. The primary contaminants of concern in the activated soils are tritium and sodium-22. The infiltration of rainwater through the activated soils can leach tritium and sodium-22 from the soils and carry them into the groundwater. To reduce the ability of rainwater to infiltrate the activated soils, a number of stormwater management controls have been implemented. In addition, eight USTs from several locations across the site were removed between 1988 and 1996, and confirmatory soil sampling following the tank removals indicated no environmental impacts.

Groundwater: Groundwater in the vicinity of the former g-2 experiment area (AOC 16T) and BLIP facility (AOC 16K) had been contaminated with tritium at concentrations that significantly exceed the 20,000 pCi/L MCL. Although sodium-22 concentrations had occasionally exceeded the 400 pCi/L MCL, it was found to decay to nearly non-detectable levels within a short distance from the source areas. There were no groundwater impacts associated with the former USTs.

HFBR

Activated Components, Contaminated Structures and Soils: Past operations resulted in the formation of radioactive material (i.e., activation products) within the metal and concrete of the large reactor components (reactor vessel/internals, thermal shield and biological shield). Smaller quantities of radioactive material were also found in ancillary structures (fan houses and stack), underground pipes/ducts, and associated soils.

Groundwater: Groundwater contaminated with tritium, including under OU III, was present beneath the HFBR and formerly extended several thousand feet to the south at concentrations significantly above the 20,000 pCi/L MCL. Tritium has not been detected above the MCL beyond the BNL property boundary.

4.0 Remedial Actions

4.1 Remedy Selection

To date, nine Records of Decision and four Explanations of Significant Differences have been signed at BNL. The first was signed in 1996 (OU IV ROD) and the last in 2012 (OU III ESD). The nine RODs are:

1. OU I – Radiologically contaminated soils on the BNL site
2. OU III – Groundwater on and off of the BNL site
3. OU IV – Soil and groundwater on site
4. OU V – STP
5. OU V – Peconic River
6. OU VI – EDB in groundwater off of the BNL site
7. BGRR – Radiologically contaminated structures and soil on site
8. g-2/BLIP/USTs – Radiologically contaminated soil shielding and groundwater
9. HFBR – Radiologically contaminated structures and soil

The four ESDs are:

1. OU III – Magothy and Sr-90 groundwater cleanup, institutional controls
2. OU III – Building 96 soil and groundwater remedy optimization
3. BGRR – Biological shield removal changes
4. OU III – Building 452 Freon-11 groundwater remedy

Individual site locations are shown on **Figure 4-1**. Brief descriptions of the ROD remedial action objectives and the major remedy components are described below.

<u>Operable Unit I ROD, signed August 1999 (BNL 1999)</u>

- Objectives are to prevent or minimize:
  - For radionuclides in soil, the cleanup goal is based on a total dose of 15 milliRem/yr (mRem) above background.
  - The NYSDEC guidance of 10mRem/yr above background has been adopted as an As Low As Reasonably Achievable (ALARA) goal which will be considered during the design and construction phase.
  - Leaching of contaminants (radiological and chemical) from soil into the groundwater.
  - Migration of contaminants present in surface soil via surface runoff and windblown dust.
  - Human exposure including direct external exposure, ingestion, inhalation, and dermal contact, and environmental exposure to contaminants in the surface and subsurface soils.
  - Uptake of contaminants present in the soil by ecological receptors.
- OU I Remedy Components:
  - Excavate soils that are radiologically and chemically contaminated above the selected cleanup goals at the former HWMF, WCF, Building 650 Sump and Sump Outfall, and the Chemical/Animal Pits and Glass Holes, and dispose of soil at an approved off-site facility. Reconstruct wetlands at the former HWMF.
  - Remove out-of-service facilities, tanks, piping, and equipment at the former HWMF and WCF.
  - Install soil caps to address metal contamination at ash pits.
  - Excavate chemically contaminated sediment from the Upland Recharge/Meadow Marsh Area and dispose of sediment at an approved facility off the BNL site. Reconstruct wetlands and monitor.
  - Implement long-term institutional controls and monitoring to ensure that planned uses are protective of public health.

    - All of the previous removal actions that were implemented, such as landfill capping, waste and soil excavation, groundwater pump and treat systems, and groundwater monitoring were selected as final remedies under the ROD.

Groundwater contamination associated with the Former Landfill Area and off-site groundwater associated with other Operable Unit I AOCs were addressed in the OU III ROD (BNL 2000a). An evaluation of remedial alternatives for contaminated soil and groundwater associated with the BLIP facility (AOC 16K) was completed. The final remedy for contaminated soils and groundwater at BLIP is documented in the g-2/ BLIP/USTs ROD (BNL 2007b).

<u>Operable Unit II Decisions</u>
Remedial actions for the OU II AOCs are documented in the OU I ROD (BNL 1999a), the OU III ROD (BNL 2000a), and the g-2/ BLIP/USTs ROD (BNL 2007b).

<u>Operable Unit III ROD, signed June 2000 (BNL 2000a)</u>

- Objectives are to:
    - Meet drinking water standards (i.e., maximum contaminant levels [MCLs]) for VOCs (5.0 μg/L for most VOCs), Sr-90 (8.0 pCi/L), and tritium (20,000 pCi/L) in groundwater.
    - Complete cleanup of the groundwater in the Upper Glacial aquifer within 30 years (by 2030) or less. [Note: the updated timeframe for Sr-90 is addressed in the 2005 ESD].
    - Prevent or minimize further migration of VOCs, Sr-90, and tritium in groundwater.
- OU III Remedy Components:
    - For VOCs – Install treatment systems at the Long Island Power Authority (LIPA) right-of-way, North Street, Airport, North Street East, Industrial Park East, Middle Road, and Western South Boundary. All of the previously implemented VOC removal actions (including treatment systems at the South Boundary and Industrial Park) were selected as final remedies under the OU III ROD.
    - For tritium (AOC 29) – Institute contingency plans to reactivate the Princeton Avenue pump and recharge system, and low-flow groundwater extraction of high tritium concentrations at the HFBR with approved off-site disposal of the water.
    - For Sr-90 – Install treatment systems using ion exchange at the Chemical Holes and the BGRR/WCF plumes. Prior to implementation, perform a pilot treatability study to evaluate the effectiveness of extraction and treatment, and modify the remedy, if needed.
    - Magothy aquifer – Perform additional characterization and determine the need for a remedy. If a remedy for the Magothy is necessary, either the OU III ROD would be modified or another decision document would establish the selected action (see OU III ESD below).
    - The previous removal action that was implemented for public water hookups was selected as a final remedy under the ROD.
    - Groundwater monitoring program to monitor and verify the cleanup over time.
    - Source Areas – Source removal system at Building 96 for VOCs in groundwater and PCBs in soil, remediation of groundwater at the former Carbon Tetrachloride UST spill area, and removal of Building 830 USTs (AOC 12).
    - Deferred Decisions – The final remedy for potential source areas such as the Building 96 geophysical anomalies (AOC 26B) was documented in a subsequent ROD (see OU III ESD below). The final remedy for AOC 9D, the Pile Fan Sump, was documented in the BGRR ROD.

Operable Unit III Explanation of Significant Differences, signed May 2005 (BNL 2005a)

- OU III Remedy Components:
    - Magothy aquifer – Add two Magothy aquifer extraction wells off of BNL property in addition to the three wells already installed. Meet drinking water standards within 65 years of the signing of the OU III ROD (by 2065).
    - Sr-90 – Continue to operate the "pilot study" remediation facility treatment system at the Chemical Holes and meet the drinking water standards within 40 years (by 2040). Install an ion exchange treatment system for the BGRR/WCF plume, and meet the drinking water standards within 70 years (by 2070).
    - Building 96 Scrapyard – No further action for the geophysical anomalies.
    - Implement long-term institutional controls and monitoring to ensure that planned uses are protective of public health.

Operable Unit III Explanation of Significant Differences, signed August 2009 (BNL 2009a)

- OU III Remedy Components:
    - Building 96 Scrapyard – Changes to the Building 96 groundwater remedy to include excavation and off-site disposal of PCE-contaminated soils. This will optimize the remedy by reducing the number of years of active treatment and enable BNL to achieve the ROD cleanup goal for this groundwater plume (by meeting drinking water standards for volatile organic compounds by 2030).

Operable Unit III Explanation of Significant Differences, signed May 2012 (BNL 2012a)

- OU III Remedy Components:
    - Building 452 Freon-11 Source Area and Groundwater Plume – Following the 2011 discovery of a Freon-11 plume near site maintenance Building 452, a new groundwater treatment system was installed in early 2012. This remedy will enable BNL to achieve the ROD cleanup goal for this groundwater plume (by meeting drinking water standards for volatile organic compounds by 2030).

Operable Unit IV ROD, signed March 1996 (BNL 1996a)

- Objectives are to restore the groundwater quality at the most contaminated portion of the AOC 5 plume to MCLs or background levels, and prevent or minimize:
    - Leaching of contaminants (radiological and chemical) from the soils into the groundwater.
    - Volatilization of contaminants from surface soils into the ambient air.
    - Migration of contaminants present in surface soil via surface runoff and windblown dust.
    - Human exposure including ingestion, inhalation, and dermal contact, and environmental exposure to contaminants in the surface and subsurface soil and groundwater.
    - Uptake of contaminants present in the soil and/or groundwater by plants and animals.
- OU IV Remedy Components:
    - Treat chemically contaminated soil in the vadose zone of the spill area (AOC 5A) and the fuel unloading area (AOC 5D) using soil vapor extraction (SVE).
    - Treat groundwater at the most contaminated portion of the spill area using SVE and air sparging (AS).
    - Use an engineering enhancement option for the groundwater if AS/SVE alone will not achieve the desired performance levels.
    - As an Interim Action, install a fence around the radiologically contaminated soil at Building 650 Sump and Sump Outfall area with institutional controls and monitoring. The final remedy for these soils is documented in the OU I ROD as discussed above.
    - Monitor the natural attenuation of Sr-90 contamination in groundwater originating from the former Sump Outfall area.

Operable Unit V Sewage Treatment Plant ROD, signed January 2002 (BNL 2001b)

- Objectives are to:
  - Protect public health and the sole-source aquifer, continue to monitor the groundwater, and to prevent or minimize:
    - Migration of contaminants present in surface soil via surface runoff and windblown dust.
    - Human and environmental exposure to contaminants in surface and subsurface soil.
    - Potential for uptake of contaminants present in the soil by ecological receptors.
    - Potential for migration of contaminants (radiological and chemical) from the soil to groundwater.
  - Reduce the levels of contamination in the sand filter beds (AOC 4B)/berms and adjacent areas.
- OU V STP Remedy Components:
  - Excavate radiologically and chemically contaminated soil at the sand filter beds and berms, firing range berms, and the sludge drying beds, and dispose of soil at an approved off-site facility.
  - Remove sludge from manholes along a retired section of the sanitary sewer line leading to the STP.
  - Monitor the groundwater for VOCs and tritium.
  - A previously implemented removal action for the Imhoff Tank is selected as the final remedy (AOC 4C).
  - Implement institutional controls on BNL property such as preventing the installation of pumping wells that may interfere with groundwater monitoring.
  - Any sale or transfer of BNL property will meet the requirements of 120(h) of CERCLA to ensure that future users are not exposed to unacceptable levels of contamination.

Operable Unit V Peconic River ROD, signed January 2005 (BNL 2004a)

- Objectives are to:
  - Reduce site-related contaminants (e.g., mercury) in sediment to levels that are protective of human health.
  - Following cleanup on Laboratory property, the average mercury concentration will be less than 1 part per million (ppm), with a goal that all mercury concentrations in the remediated areas are less than 2 ppm.
  - Following cleanup outside Laboratory property, the average mercury concentration will be less than 0.75 ppm, with a goal that all mercury concentrations in the remediated areas are less than 2 ppm.
  - Reduce or mitigate, to the extent practicable, existing and potential adverse ecological effects of contaminants in the Peconic River.
  - Prevent or reduce, to the extent practicable, the migration of contaminants off the BNL property.
- OU V Peconic River Remedy Components:
  - Removal and disposal of mercury-contaminated sediment above agreed upon cleanup levels from designated depositional areas on and off of BNL property.
  - Implement a monitoring program to demonstrate the effectiveness of the cleanup. Near-term monitoring results will establish the basis for the long-term monitoring program. The program includes monitoring for methyl mercury in the water-column, sediment sampling, and fish sampling on and off of BNL property.
  - Conduct an annual review for the first five years after commencement of the remedial action to ensure that the remedies continue to provide adequate protection of human health and the environment.

    - Sampling results for each annual review and the formal Five-Year Review will be evaluated with the regulators and appropriate modifications will be made, as necessary, for subsequent sampling.

<u>Operable Unit VI ROD, signed March 2001 (BNL 2000b)</u>

- Objectives are to:
    - Meet the MCL for EDB in groundwater (0.05 µg/L).
    - Complete cleanup of the groundwater in a timely manner. For the Upper Glacial aquifer, this goal is 30 years (by 2030) or less.
    - Prevent or minimize further migration of EDB in groundwater vertically and horizontally.
- OU VI Remedy Components:
    - Install a treatment system to extract EDB from the groundwater with subsequent treatment via activated carbon filtration.
    - The previous removal action that was implemented for public water hookups was selected as a final remedy under the ROD.
    - Develop groundwater monitoring program to monitor and verify the cleanup over time.
    - Implement institutional controls on the BNL property to prevent use of contaminated groundwater in the OU VI area.

<u>BGRR ROD, signed March 2005 (BNL 2005b)</u>

- Objectives are to:
    - Ensure protection of human health and the environment, without undue uncertainties, from the potential hazards posed by the radiological inventory that resides in the BGRR complex.
    - Use the ALARA principle while implementing the remedial action.
    - Following completion of the remedial activities, implement long-term monitoring, maintenance, and institutional controls to manage potential hazards to protect human health and the environment.
- BGRR Remedy Components:
    - Remove the BGD filters and primary liner.
    - Remove a portion of the fuel canal outside the structural footprint of the reactor building. Remove accessible subsurface contaminated soil in the vicinity of the fuel canal, BGD expansion joint #4, and the secondary cooling air bustle.
    - Isolate the BGD and demolish the instrument house.
    - Install water infiltration control (i.e., engineered cap) and monitoring system (including the installation of groundwater monitoring wells) for remaining structures and subsurface contaminated soil.
    - Remove the graphite pile and biological shield.
    - Complete final status surveys to document that cleanup objectives are met and to document final conditions.
    - Develop and implement land use and institutional controls that include routine inspection and surveillance of the BGRR complex, maintenance and upkeep of Building 701 and surrounding water infiltration control system, and reporting requirements to ensure that planned uses are protective of public health.
    - Submit an annual certification to NYSDEC that institutional and engineering controls are in place, are unchanged from the previous certification, and nothing has occurred that would impair the ability of the control to protect public health and the environment.
    - All of the previous removal actions that were implemented prior to the ROD signing, such as removal and disposition of accumulated contaminated water, Pile Fan Sump and soils, above-ground ducts, canal and water treatment house, accessible contaminated soils, and exhaust cooling coils and filters, were selected as final remedies under the ROD.

BGRR Explanation of Significant Differences, signed June 2012 (BNL 2012b)

- OU III Remedy Components:
    - Biological Shield - Changes to the scope of work for removal of the BGRR biological shield include the removal of the outer steel walls, the inner steel walls, and the concrete between the inner and outer walls down to the existing floor level, rather than removing the approximately three vertical feet of biological shield embedded below the existing floor.

g-2/BLIP/USTs ROD, signed May 2007 (BNL 2007b)

- Objective is to:
    - Prevent additional rainwater infiltration into activated soil shielding at g-2 and BLIP.
- g-2/BLIP/USTs Remedy Components:
    - Inspect and maintain the caps and other stormwater controls at the g-2 and BLIP source areas. Submit an annual certification to NYSDEC that institutional and engineering controls are in place, are unchanged from the previous certification, and nothing has occurred that would impair the ability of the control to protect public health and the environment.
    - Conduct routine groundwater monitoring to verify the effectiveness of the stormwater controls. Monitor the downgradient portion of the g-2 plume until tritium concentrations decrease to below the 20,000 pCi/L MCL.
    - For the former UST areas, no additional remedial actions are required.

High Flux Beam Reactor ROD, signed April 2009 (BNL 2009b)

- Objectives are to control, minimize, or eliminate:
    - All routes of future human and/or environmental exposure to radiologically contaminated facilities or materials.
    - The potential for future release of non-fixed radiological or chemical contamination to the environment.
    - All routes of future human and/or environmental exposure to contaminated soils.
    - The future potential for contaminated soils to impact groundwater.
- HFBR Remedy Components:

  The HFBR remedy incorporates many completed interim actions, several near-term actions, and the segmentation, removal, and disposal of the remaining HFBR structures, systems, and components following a safe storage decay period (not to exceed 65 years).

  Completed interim actions:

    - The HFBR fuel was removed and sent to an off-site facility.
    - The primary coolant was drained and sent to an off-site facility.
    - Scientific equipment was removed and is being reused.
    - Shielding and chemicals were removed and are being reused at BNL and other facilities.
    - The cooling tower superstructure was dismantled and disposed of.
    - The confinement structure and spent fuel canal were modified to meet Suffolk County Article 12 requirements.
    - The Stack Monitoring Facility (Building 715) was dismantled and disposed of.
    - The Cooling Tower Basin and Pump/Switchgear House (Building 707/707A) was dismantled and disposed of.
    - The Water Treatment House (Building 707B) was dismantled and disposed of.
    - The Cold Neutron Facility (Building 751) contaminated systems were removed and the clean building has been transferred to another organization for re-use.
    - The Guard house (Building 753) was dismantled and disposed of.
    - Soil excavation and disposal of the former HWMF Waste Loading Area (WLA) was performed.
    - Control rod blades and beam plugs were removed and disposed of.

Near-term Actions:

- Removal of ancillary buildings and associated soils.
    - Stack (Building 705) by 2020
    - Fan houses (Buildings 704 and 802) - Complete
- Removal of contaminated underground pipes and ducts - Complete
- Preparation of Reactor Confinement Building (Building 750) for safe storage - Complete.

Removal after Safe Storage Decay Period:

- Large activated components (reactor vessel and internals, thermal shield and biological shield).
- Reactor Confinement Building structures, systems and components.
- Cleanup of associated soils.

In addition, the final remedy specifies the requirements for surveillance and maintenance to manage the inventory of radioactive material during the safe storage period. Land use and institutional controls, including periodic certification to EPA and NYSDEC, are also specified.

4.2 Remedy Implementation

With the exception of the decommissioning and decontamination (D&D) of the remaining HFBR structures (e.g., stack, large activated components including reactor vessel, systems, and confinement building), all soil, groundwater, and D&D remedies for the nine signed RODs at the site have been implemented. This includes the excavation and approved off-site disposal of all contaminated soil, sediment, and tanks, the installation and operation of all groundwater treatment systems, and Long-Term Surveillance and Maintenance of the BGRR and HFBR. A chronology of the previous removal actions undertaken for each OU, and post-ROD remedial actions, is presented in **Table 2-1** (see **Section 2.0**). A brief summary of the status of remedy implementation since the signing of each ROD is identified below.

Operable Unit I: Excavation and off-site disposal of radiologically contaminated soil was initiated in 2000 with the landscape soil (approximately 2,800 cubic yards), followed by the Building 650 Sump and Sump Outfall (approximately 1,800 cubic yards), and Upland Recharge/Meadow Marsh (approximately 500 cubic yards). In 2005, removal of the former HWMF (approximately 13,000 cubic yards), Building 811 soil (approximately 4,000 cubic yards), and former Chemical Holes residual surface soil (approximately 4,000 cubic yards) was completed. Of the total contaminated soil volume, approximately 24,000 cubic yards were disposed of at Envirocare of Utah, and 2,500 cubic yards were disposed of at Niagara Falls Landfill Facility. (Furthermore, approximately 11,000 cubic yards of soil were excavated from the Chemical/ Animal Pits and Glass Holes during 1997 as part of a Removal Action that was conducted prior to the ROD being signed.) In 2003, the ash pits were capped with a soil cover to prevent direct contact risks, and removal and disposal of the Building 811 USTs was completed in 2005. The Oak Ridge Institute for Science and Education (ORISE), an independent contractor to DOE, verified that the cleanup effort at these radiologically contaminated soils areas attained the cleanup goals defined in the ROD (ORISE 2008). Closeout reports were issued for the landscape soil, Building 650 Sump and Sump Outfall, Upland Recharge/Meadow Marsh, the former HWMF, and Building 811 soil, and an addendum to the existing Chemical Holes Closeout Report was issued. In March 2007, the decontamination of the Merrimack Holes at the former HWMF was completed. Between 2009 and 2014, three phases of cleanup of the former HWMF Perimeter Soils were performed (approximately 407 cubic yards were excavated). Closeout reports for each phase of the cleanup were issued. Starting in 2014 and continuing into 2016, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically-contaminated soil was initiated (approximately 1,800 cubic yards of waste).

As noted in the *Final Closeout Report for Area of Concern 16 Landscape Soils* (BNL 2001c), monitoring conducted after calendar year 2000 and the excavation of the landscape soil indicates that the potential exposure to workers and future site residents is less than the 15 mRem/year above background criteria. This cleanup also met the NYSDEC ALARA goal of less than 10 mRem/yr above background. Landscape soil from the Building 355 area (formerly the Contracts and Procurement Division) was excavated again in March 2010 as part of construction activities for the new Interdisciplinary Science Building (ISB) 734. The soil was transferred to the former HWMF to be used as fill. Three confirmatory soil samples identified remaining Cs-137 concentrations below 0.5 picoCuries per gram (pCi/g). The regulators were briefed on this work.

The South Boundary Treatment System, installed under a Removal Action, began operation in 1997 and was approved for shutdown in 2013.

Operable Unit III: Fourteen of BNL's 17 groundwater treatment systems are included under OU III. Following the signing of the OU III ROD in June 2000, the groundwater treatment systems were designed and installed between 2000 and 2012 both on and off of the BNL property. Twelve of the treatment systems were installed to address VOC groundwater contamination and two systems were installed to address Sr-90 groundwater contamination. The performance of these systems in meeting the overall groundwater cleanup goals is evaluated in the annual *BNL Groundwater Status Reports.* Through 2015, the OU III treatment systems have removed approximately 95 percent of the 7,387 pounds of VOCs removed by all of the BNL groundwater treatment systems.

In accordance with the ROD, several low-flow extraction events were performed between 2000 and 2001 for the high-concentration segments of the HFBR tritium plume. Approximately 100,000 gallons of tritium-contaminated water were pumped from the aquifer and disposed of at an approved off-site facility. Contingency remedies continue to remain in place for the HFBR tritium plume. In response to the November 2006 triggering of the OU III ROD contingency plan, the HFBR Pump and Recharge system was re-started in December 2007. As part of this action, a new extraction well was constructed to improve control and capture of the plume. This well began operation in November 2007 and was placed in standby mode in 2013.

The Building 96 treatment system was originally approved for shutdown in 2005. In 2008, the system was turned back on and Well RTW-1 was modified from a recirculation well to surface discharge of the effluent due to a rebound of VOC concentrations in source area monitoring wells. Subsequent investigations identified a localized source of VOC contamination within the vadose zone. In accordance with the OU III ESD approved in 2009, the VOC-contaminated soils were excavated in 2010 and disposed of at an approved off-site facility. Hexavalent chromium was also detected in Building 96 area monitoring wells in 2008 as a byproduct of earlier potassium permanganate injections in the source area. Well RTW-1 also included treatment for the hexavalent chromium from 2008 through 2010. Between 1999 and 2005, approximately 2,200 cubic yards of PCB-contaminated soil from the former Building 96 Scrapyard area were excavated and disposed of offsite. This was accomplished in accordance with the ROD to reduce the risk of direct contact with contaminated soils in this area.

In accordance with the OU III ESD approved in 2005, two additional Magothy aquifer groundwater extraction wells were installed to address VOC contamination at the LIPA and Industrial Park East treatment system areas. Between 2007 and 2015, additional extraction wells were installed at the LIPA/Airport, Chemical Holes Sr-90, HFBR Tritium Pump and Recharge, BGRR/WCF Sr-90, South Boundary, Middle Road, and the Industrial Park systems. These additional extraction wells were necessary to address changing plume conditions identified as part of the long-term groundwater monitoring program.

In accordance with the OU III ESD approved in 2012, one Upper Glacial aquifer groundwater extraction well was installed to address Freon-11 contamination detected near site maintenance Building 452. This well began operation in 2012 and was approved for shutdown by the regulators in March 2016.

The status of the *Petitions for Shutdown* of the OU III groundwater treatment systems are as follows:

- Carbon Tetrachloride: Approved for shutdown in 2004. Approved for closure in 2010.
- Industrial Park East: Approved for shutdown in 2009. Approved for closure in 2013. Infrastructure repurposed in 2014 to support deeper industrial park extraction wells.
- North Street: Approved for shutdown in 2013, however it was restarted in 2014 due to rebound of VOCs.
- HFBR Tritium Pump and Recharge: Approved for shutdown in 2013.
- Industrial Park: Approved for shutdown in 2013, however it was restarted in 2014 due to rebound of VOCs. Two additional extraction wells became operational in 2015 to address the deep VOCs.
- North Street East: Approved for shutdown in 2014.
- Building 452 Freon-11: Approved for shutdown March 2016.

Operable Unit IV: In accordance with the March 1996 OU IV ROD, a groundwater treatment system was installed in 1997 to remediate VOC and SVOC soil and groundwater contamination at a former oil/solvent spill area. A CERCLA Five-Year Review performed for OU IV in 2003 (BNL 2003a) found that the remedy was highly effective in remediating soil and groundwater contamination. The system met its cleanup objectives and the regulatory agencies approved its dismantlement in 2003.

Operable Unit V: Following issuance of the OU V STP ROD (BNL 2001b), the contaminated soil at the plant was excavated and disposed of offsite in 2003. A completion report for this effort was issued in 2004 (BNL 2004b). Following the 2012 regulatory approval of a *Final Petition to Discontinue Groundwater Monitoring* (BNL 2012d), natural attenuation monitoring of the low-level VOC groundwater plume that originated from the STP area was completed in 2013.

Prior to issuance of the OU V Peconic River ROD (BNL 2004a), on- and off-site contaminated sediments were excavated from the River (approximately 21,000 cubic yards) during 2004 and 2005 under the authority of a Removal Action (BNL 2004c). The closeout report for the Peconic River Phases 1 and 2 was issued in 2005 (BNL 2005c). Based on Peconic River monitoring data (approximately 1,700 sediment, surface water, and fish samples) collected between 2006 and 2010, DOE and the regulatory agencies determined that supplemental sediment removal in the River was necessary. In late 2010/early 2011, an additional 800 cubic yards of contaminated sediment were excavated. The final completion report was issued in 2012. Based on Peconic River annual sediment monitoring data collected between 2011 and 2015 at the three supplemental remediation areas, a small segment of the river was identified as requiring additional sediment remediation. In February 2016, DOE submitted a plan to the regulators for supplemental sediment removal at on-site Area WC-06. Regulatory comments on the plan are being addressed.

Operable Unit VI: In 2004, a groundwater treatment system was installed in accordance with the OU VI ROD and began operations to remediate the plume of EDB located beyond the site boundary. This was the last of the planned systems to be installed beyond the BNL site property. Per the OU III and VI RODs, DOE continues to offer homeowners not connected to public water free annual testing of their private wells.

BGRR: All of the cleanup actions performed at the BGRR prior to the ROD approval in 2005 were conducted through removal actions or *National Environmental Policy Act* (NEPA) categorically excluded actions. Since ROD approval, the cleanup actions at the BGRR (e.g., removal of the graphite pile) were performed as remedial actions under the ROD (BNL 2005b). Remedial activities associated with the

Graphite Pile Removal Project commenced in December 2009 and were completed in May 2010. The scope of these activities included removal and disposal of control rods, removal and disposal of boron shot, removal and disposal of shield plugs, removal and disposal of upper portion of air tight membrane, removal and disposal of Invar rods, and removal and disposal of Graphite Pile.

Installation of the final engineered cap adjacent to Building 701was completed in 2011. In 2012 the biological shield was removed in accordance with the ESD.

g-2/BLIP/USTs: BNL routinely inspects and maintains the caps and other stormwater controls at the g-2 and BLIP source areas. Routine groundwater monitoring at the source areas is conducted to verify the effectiveness of the stormwater controls. Following the detection of tritium in groundwater south of Brookhaven Avenue above the 20,000 pCi/L ROD contingency trigger level, BNL initiated additional monitoring in this area. During 2015, the tritium levels were found to have attenuated to below the 20,000 pCi/L MCL in the downgradient portion of the plume. Monitoring was subsequently discontinued in association with the leading plume edge. No additional remedial actions are required for the former UST areas.

HFBR: Prior to the ROD approval in 2009, all of the cleanup actions at the HFBR were performed through removal actions or NEPA categorically excluded actions. Since ROD approval, stabilization of the reactor confinement building for safe storage and the cleanup actions at the HFBR, such as the removal of Buildings 801-811 waste transfer lines (A/B waste lines with co-located piping) and associated soil, were performed as remedial actions under the ROD (BNL 2009b). Other remedial actions associated with the removal of ancillary structures were also performed: Fan houses, confinement building stabilization, underground utilities, soil (2011), and stack silencer baffles (2012).

The WLA was part of the former HWMF, AOC 1. It is an area (of about two acres) along the eastern boundary of the former HWMF that was left in place so that it could be used as a waste staging and railcar loading area for the BGRR and HFBR decommissioning projects. The WLA was transferred to the HFBR scope of work in September 2005 through a modification to the *Remedial Design Implementation Plan* (RDIP) for the former HWMF. In February 2009, AOC 31, comprising the HFBR complex and the WLA, was established. The cleanup of the WLA was performed as a non-time-critical removal action. The cleanup of this area used the same cleanup goals and methodology required for AOC 1 in the OU I ROD. Soil remediation was performed from November 2007 to May 2008, and the cleanup goals for both chemicals and radionuclides were achieved. This work is summarized in the document *High Flux Beam Reactor, Area of Concern 31, Final Completion Report for Waste Loading Area Soil Remediation* (BNL 2009c). The WLA continues to be used for waste rail car loading.

The stack demolition and reactor vessel are scheduled for removal by 2020 and 2072, respectively.

Groundwater Monitoring: An essential component of the groundwater remediation program is continued monitoring of the groundwater to ensure the cleanup is progressing as planned. An average of 1,500 samples were collected and analyzed annually from the groundwater monitoring wells between 2011 and 2015. The effectiveness of the groundwater remediation systems' performance is evaluated monthly, quarterly, and annually. Comprehensive summaries of the annual monitoring and evaluations of the systems and plumes are documented in quarterly progress reports and the annual *BNL Groundwater Status Reports* (Volume II of the *BNL Site Environmental Report*). Recommendations are made on an annual basis for modifications to groundwater monitoring programs in response to changing plume conditions. These recommendations are developed with regulatory agency input. The treatment systems and monitoring programs are optimized with the goal of meeting drinking water standards within 70 years (2070) for the BGRR/WCF Sr-90 plume, within 65 years (2065) for the Magothy aquifer, within 40 (2040) for the Chemical Holes Sr-90 plume, and within 30 years (2030) for VOCs in the Upper Glacial aquifer.

Property Access: Eight access agreements are currently in place with the county, town, local utility, college, and private landowners. Seven of these agreements enable BNL to perform groundwater remediation activities for contamination that has migrated beyond the property boundary of BNL. The eighth agreement is with Suffolk County and allowed for the supplemental remediation of the Peconic River sediment in 2011. The terms of these agreements must be adhered to by BNL, such as maintaining adequate liability insurance, and in some cases, making annual monetary payments.

4.3 System Operations/Operation and Maintenance

All 17 of the planned groundwater treatment systems have been constructed. The first system became operational in January 1997, and the last system was placed in service in early 2012. The location of each of the treatment systems and their operational status is shown on **Figure 4-2**. (Note that Brookhaven Airport and LIPA are one treatment system.) The operational status of each of the extraction wells is provided on **Figure 4-3**. The Industrial Park East, OU IV and Carbon Tetrachloride systems met their cleanup goals and were dismantled, and the OU I South Boundary, North Street East, HFBR and Building 452 systems are in standby mode awaiting closure. New extraction wells were installed in 2014 to address VOC contamination that was detected in the deep portion of the Upper Glacial aquifer in the Industrial Park. The remaining 10 systems are in active operation. The requirements for ongoing operation and maintenance (O&M), as well as performance monitoring frequencies of these systems, are identified in the O&M manuals (BNL 2002-2012). The O&M manuals are updated as needed to reflect changes to the treatment systems, such as the installation of additional extraction wells. BNL performs routine inspections and maintenance of these systems.

Groundwater has been extracted from the Upper Glacial and Magothy aquifers using 70 wells. Currently, 29 of these wells are in standby mode, 9 are in pulsed pumping mode, and 2 were decommissioned in 2014 (i.e., abandoned by sanding and grouting the well in place). Three extraction wells for the Carbon Tetrachloride system were previously decommissioned in 2010. Average individual extraction well flow rates range from approximately 5 gallons per minute (gpm) for the Sr-90 systems to up to 450 gpm for some of the VOC systems. System treatment for VOCs consists primarily of air stripping or carbon adsorption. Ion exchange is used for the Sr-90 groundwater contamination. To monitor system performance, the influent, midpoint (if appropriate), and effluent are routinely sampled. Treated water from the systems is returned to the Upper Glacial aquifer via recharge basins, injection wells, or dry wells. These discharges are regulated by New York State Pollutant Discharge Elimination System (SPDES) discharge equivalency permits, and the data are reported monthly.

The annual O&M costs for the treatment systems during 2011-2015 were as follow:

Table 4-1: Groundwater Treatment System O&M Costs for FY 2011 to 2015

System	FY 2011	FY 2012	($ in K) FY 2013	FY 2014	FY 2015	Comments
OU I South Boundary	136	130	105	58	59	Air stripping. Standby since 2013.
OU III South Boundary/ Middle Road	450	532	495	552	200	Air stripping. Only 5 of 15 wells running in 2015.
OU III Industrial Park	285	278	232	573	626	In-well air stripping with vapor phase carbon treatment, with recirculation wells. System in standby 2013, restarted in 2014. New extraction wells added 2014/2015.
OU III Building 96	326	96	73	107	90	Air stripping treatment. Source area excavation in early 2011.
Bldg. 452 Freon-11	NA	55	60	55	52	Air stripping treatment. Began pulsed pumping in February 2015.
OU III Western South Boundary	147	87	89	83	88	Air stripping treatment. Additional characterization in 2011.
OU III Industrial Park East	28	23	3	62	7	Carbon treatment. Wells abandoned in early 2014.
OU III North Street	296	247	182	187	199	Carbon treatment. Standby in late 2013, restarted in mid 2014. Includes property access costs.
OU III North Street East	151	79	72	34	33	Carbon treatment. Additional characterization in 2011. Standby in 2014.
OU III Airport/LIPA	285	341	260	237	312	Carbon treatment.
OU III HFBR Tritium	297	139	35	54	40	Pump and recharge. 2011 includes temporary wells. Standby since 2013.
OU III Sr-90 Chemical Holes	97	92	95	78	83	Ion-exchange treatment
OU III Sr-90 BGRR/WCF	1088	569	242	231	243	Ion-exchange treatment. Four wells installed in late 2010, became operational in 2011. Started pulse pumping wells in late 2011.
OU VI EDB	225	235	283	197	191	Carbon treatment. Monitoring wells installed in 2013. Includes property access costs.

The largest components of the annual O&M cost for the treatment systems are electric, system sampling and analysis, maintenance, spent carbon or ion exchange resin disposal, and property access payments (if applicable). These are direct costs of operation and do not include monitoring well sampling and analysis, and project oversight/management.

5.0 Progress Since the Last Review

This is the third sitewide Five-Year Review for the BNL site that covers all of the OUs. The protectiveness statement for each OU, the BGRR, the HFBR, and progress in accomplishing the cleanup goals since the previous Five-Year Review (BNL 2011a) are discussed below:

Operable Unit I: The remedy is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

Soil Remediation:

- The third and final phase of cleanup of the former HWMF Perimeter Soils (Sub-AOC 1J) was completed in 2014.
- Starting in 2014 and continuing into 2016, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically contaminated soil was initiated. This action is expected to further reduce Sr-90 contamination in the soil, thus helping to meet the groundwater cleanup objective.

Groundwater Remediation:

- Hydraulic control of the VOC plumes was accomplished by the OU I South Boundary treatment system. The off-site segment of the plume was controlled by the North Street East system (discussed under OU III). The South Boundary treatment system, capping of the Current Landfill, remediation of the former HWMF, and natural attenuation have all contributed to a significant reduction in the overall extent and concentrations of the VOC plume, as shown on **Figure 5-1**. As a result, the regulators approved the *Petition for Shutdown* of the treatment system in 2013 (BNL 2013b). Elevated VOCs previously seen in an area located approximately 500 feet to the north of the extraction wells, have declined to less than the system capture goal of 50 µg/L total VOCs since 2013. As a result, the ROD cleanup goals are expected to be achieved.
- Characterization was initiated in 2015 and is continuing to determine the current extent of Sr-90 groundwater contamination migrating from the Former HWMF, and to determine if there is a significant continuing source remaining. Targeted soil sampling, continued groundwater monitoring, and fate and transport analysis will be used to evaluate the need for any further actions. See **Section 7.1**.
- The groundwater quality downgradient of the capped landfills continues to improve. VOCs were not detected above MCLs at the Former Landfill over the previous two years. VOCs continue to be detected at fluctuating levels above MCLs immediately east of the Current Landfill. Characterization of the groundwater in this area is in progress to confirm the extent of the contamination.

Operable Unit III: The remedy is expected to be protective of human health and the environment upon meeting groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The extent of the high-concentration segments of the OU III VOC plumes have decreased both on and off site as the result of groundwater remediation system operations and the effects of natural attenuation (see **Figure 5-1**).
- Changes to the treatment systems status since 2011 are as follow:
    - The Industrial Park East system met MCLs and was approved for closure in 2013.
    - The North Street system was originally approved for shutdown in 2013; however it was restarted in 2014 due to rebound of VOCs.
    - The HFBR Tritium Pump and Recharge system was approved for shutdown in 2013.

- The Industrial Park system was approved for shutdown in 2013; however it was restarted in 2014 due to rebound of VOCs. Two additional extraction wells were added in 2014 to address deeper VOC contamination.
- The North Street East system was approved for shutdown in 2014.
- The Western South Boundary system expected operational period was extended to 2019 to ensure capture of upgradient VOCs.
- The Building 96 system expected operational period was extended to 2018 to address residual high VOC concentrations in the former source area.
- The South Boundary system – an additional deep extraction well was added in 2012 and the expected operational period was extended to 2019 to ensure capture of upgradient VOCs.
- The Middle Road system – an additional deep extraction well was added in 2013 to capture deeper VOCs on the west side of the plume.
- The LIPA and Airport system expected operational period was extended to 2019 and 2021, respectively to ensure capture of upgradient VOCs.
- The Chemical Holes Sr-90 system expected operational period was extended to 2019 to ensure capture of upgradient Sr-90.

- **Figure 4-3** provides the operational status of each of the treatment systems including extraction wells that were shut down and placed in standby mode, and wells that are in pulsed pumping mode.
- Following the 2011 detection of Freon-11 in groundwater downgradient of Building 452, an extraction well and Freon-11 treatment system was installed in 2012. Existing Building 96 extraction well RTW-1 was also used to capture the downgradient lower level Freon-11 concentrations. This system met its cleanup goals by reducing Freon-11 concentrations in groundwater to less than 50 µg/L, and was placed in standby mode in March 2016.
- The BGRR/WCF Sr-90 treatment system captures and treats Sr-90-contaminated groundwater originating from several source areas utilizing a network of nine extraction wells. Source area characterization indicates that elevated concentrations of Sr-90 are still present in the BGRR and WCF source areas. The system was designed based on the source no longer being present due to capping of the area via both the BGRR building structure and an engineered cap. It is likely that Sr-90 contamination below the facility structures in the vadose zone is being periodically mobilized to the aquifer by water-table elevation increases. This water-table flushing process has been observed at several other BNL source areas including the HFBR and g-2. Characterization of the groundwater conducted immediately downgradient of the WCF identified elevated Sr-90 concentrations. It is expected that these concentrations will attenuate since Buildings 810 and 811 were removed in 2015, along with contaminated soil. Monitoring of the source areas will continue.
- The Chemical Holes system has been effectively addressing the Sr-90 groundwater plume. However, due to elevated Sr-90 concentrations remaining upgradient of extraction well EW-1, the submittal of the *Petition for Shutdown* of the system was postponed in 2015. Soil and groundwater characterization of this former source area was performed in 2015 and early 2016. No significant Sr-90 contamination was detected. Monitoring of the former source area will continue.
- As shown on **Figure 5-2**, the HFBR tritium plume has significantly attenuated over the previous five years. Tritium concentrations immediately downgradient of the facility have continued to decline to slightly above to below the MCL of 20,000 pCi/L since 2011. Tritium did not exceed the MCL in 2015. The downgradient segment of the HFBR plume is no longer monitored because tritium concentrations have declined to below the 20,000 pCi/L MCL.

Operable Unit IV: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- Post-closure groundwater monitoring was completed in 2011 for the OU IV air sparging/soil vapor extraction (AS/SVE) system.
- Monitoring continues for a plume of Sr-90 which originated at the Building 650 Sump Outfall and is slowly migrating and attenuating within the central portion of the site (see **Figure 4-2**).

<u>Operable Unit V</u>: The remedy currently protects human health and the environment because the contaminated soil at the STP filter beds and contaminated sediment in the Peconic River have been excavated in 2004/2005 and in 2011 to meet the appropriate cleanup levels. The Completion Report for the 2011 supplemental remediation was approved by the regulators in March 2012. Re-vegetation of the remediated areas has been completed and the State wetland equivalency permit requirements were met, as well as the federal requirements.

- Peconic River sediment monitoring from the three remaining areas during 2011 through 2015 indicated that additional sediment removal is needed at one on-site location to meet the cleanup goals for mercury. In February 2016, a remedy optimization plan for remediation of Area WC-06 was submitted to the regulators for review.
- Based on the recommendation in the 2012 *Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012d), two additional years of VOC data were collected at one monitoring well. Since the 2013 results were less than MCLs, the groundwater sampling requirements were met and no additional sampling is required.

<u>Operable Unit VI</u>: The remedy is expected to be protective of human health and the environment upon attainment of the groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The EDB treatment system continues to effectively remediate the EDB plume (see **Figure 4-2**). The plume is moving slower than originally simulated by the groundwater model during the system design. Therefore, the expected system operational period was extended to 2019 to ensure capture of the upgradient EDB.

<u>BGRR</u>: The BGRR ROD was finalized in March 2005. The removal and disposal of the Graphite Pile was completed in 2010. The remaining work required under the ROD, including installation of an engineered cap and removal of the biological shield, were completed in 2011 and 2012, respectively. Land-use and institutional controls and monitoring of groundwater are underway in accordance with the Operable Unit III ROD, and are part of the final remedy. The remedy is protective of human health and the environment, and exposure pathways that could result in unacceptable risks are being controlled. Long-term surveillance and maintenance activities are conducted to ensure effectiveness of the remedy. The activities included periodic structural inspections of Building 701, water intrusion monitoring, preventive maintenance of Building 701 and the infiltration management system, groundwater monitoring, semi-annual inspections of the below-ground ducts, and periodic maintenance and repairs as identified during the inspections, such as the window replacements in the former offices on the second and third floor, sealing of precipitation infiltration areas, roof repairs performed in 2014 and 2015, and minor repairs to the cap.

<u>g-2/BLIP/USTs</u>: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- Groundwater monitoring in the downgradient portion of the plume is complete, however monitoring of the source area continues.

<u>HFBR</u>: The HFBR ROD was finalized in April 2009. The final remedy incorporates many completed interim actions, several near-term actions, and the long-term segmentation, removal, and disposal of the remaining HFBR structures, systems, and components, including the reactor vessel. The near-term actions included dismantling the remaining ancillary buildings, removing contaminated underground utilities, and preparing the reactor confinement building for safe storage. The ROD requires that these near-term actions be completed no later than 2020. Activities completed for the HFBR since 2011 include:

- Dismantling of Buildings 704 and 802 (Fan Houses) and above- and below-ground structures (2011).
- Stabilization of the confinement building 2011).
- Removal of underground utilities and associated soil (2011).
- Removal of stack silencer baffles and survey of outside areas (2012).

Long-term surveillance and maintenance activities are conducted to ensure effectiveness of the remedy. The activities included, routine environmental health and safety monitoring, secure access via locked doors, periodic structural inspections of Building 750, water intrusion monitoring, preventive maintenance of Building 750 and the infiltration management system, and groundwater monitoring. Repairs have been performed on the facility including the replacement of light bulbs, roof repairs over the former machine shop area located outside of the confinement dome, re-caulking of a vent on the outside of the dome outside the generator room, and paving of the access road to the stack.

The WLA continues to be used for waste rail car loading.

The ROD also lays out a plan for the long-term segmentation, removal, and disposal of the remaining HFBR structures, systems, and components (including the reactor vessel and thermal and biological shields). These long-term actions will be conducted following a safe storage period (not to exceed 65 years) to allow for the natural reduction of high radiation levels to a point where conventional demolition techniques can be used to dismantle these reactor components. Land-use and institutional controls and monitoring of groundwater in accordance with the Operable Unit III ROD are also part of the final remedy. The completed remedy is expected to be protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

Table 5-1 shows the status of the actions recommended in the 2011 Five-Year Review.

Table 5-1: Follow-Up Actions to the 2011 Five-Year Review Recommendations

Issue	Recommendations/ Follow-Up Actions	Milestone Date	Action Taken/Current Status
Capture of remaining VOCs in OU I Plume	Implement Pulse Pumping of extraction wells. Continue pumping until 2015 to meet VOC capture goal.	July 2011	Began pulse pumping July 2011. Treatment system shut down in July 2013, in standby mode. Monitoring continues.
Sr-90 in OU I Groundwater	Enhance monitoring well network to track Sr-90.	June 2011	In March 2011, two sentinel monitoring wells were installed. In 2015/2016, Geoprobes® were installed at former HWMF to further characterize Sr-90. Sr-90 up to 302 pCi/L was detected. Further characterization and modeling in progress.
OU III Building 96 Source Removal Effectiveness	Continue treatment system operations. Monitor plume and determine if continuing source remains.	September 2012	RTW-1 continues to operate. RTW-4 was shut down in 2012; RTW-2 and RTW-3 shut down January 2016. VOCs concentrations downgradient of source area continue to decline. May achieve capture goals for system shut down by 2018. Performed soil vapor survey and soil borings for elevated VOCs in western plume segment. No VOCs detected. RTW-1 also captures downgradient portion of Freon-11 plume.
Monitoring of downgradient OU III Industrial Park East Plume	Install additional downgradient monitoring well.	August 2011	A new downgradient Magothy monitoring well was installed in September 2011. According to the *Petition for Closure,* downgradient VOCs are expected to attenuate to below MCLs before 2065. Monitoring continues. Bldg. OS-2 now being used to treat deep Industrial Park VOCs.

Issue	Recommendations/ Follow-Up Actions	Milestone Date	Action Taken/Current Status
OU III Industrial Park Treatment System Shutdown	Install additional temporary well between UVB-3 and UVB-4 in support of anticipated system shutdown.	August 2011	Two temporary wells were installed in March 2011 and May 2012, and two permanent wells were installed in 2012 to support the *Petition for Shutdown* (BNL 2013g). Following approval of the *Petition for Shutdown*, the system was shut down May 2013. Due to elevated VOCs, wells UVB-3 through UVB-6 were restarted in March 2014. Deep VOCs are being remediated via two extraction wells installed in late 2014.
OU III North Street Treatment System Shutdown	Increase system operation through 2013 due to continued high VOCs	October 2012	Following approval of the *Petition for Shutdown* (BNL 2013c), the system was shut down August 2013. Due to elevated VOCs slightly above the capture goal, the system was restarted in June 2014 and again in July 2015.
OU III North Street East Treatment System Shutdown	Characterize contamination upgradient of NSE-1 and monitor for achievement of capture goal. Extend system operation through 2013 to achieve capture goal.	September 2011	From 2010 through 2013, five temporary wells and a permanent monitoring well were installed to help monitor the upgradient portion of the plume. Following approval of the *Petition for Shutdown* (BNL 2013d), the system was shut down in June 2014.
OU III Middle Road Treatment System	Assess contamination to west of RW-1 and need for an additional extraction well.	September 2012	Two temporary wells were installed in April 2013 to evaluate deeper VOCs on the west portion of the plume. A new extraction well (RW-7) was installed and started operation in November 2013. Temporary wells were installed near Weaver Drive to define the northern extent of the plume.
OU III South Boundary deep VOC contamination	Install additional extraction well(s) to capture and treat deeper contamination. Extend system operation until 2017.	September 2012	New extraction well EW-17 became operational in July 2012 to capture the deep VOCs.
OU III Western South Boundary TCA/Freon contamination	Extend operation of extraction well WSB-1 to 2019 to capture high TCA concentrations. Characterize extent of Freon contamination and develop path forward.	November 2012	Continuous operation of one extraction well, WSB-1, and pulsed operation of WSB-2. A monitoring well was installed in June 2012 to monitor the downgradient extent of Freon-12. Low Freon-12 was detected. Continue monitoring of the deeper VOCs identified in 2016, then update the model.
OU III HFBR contingency pumping termination	Determine shutdown of pump and recharge system based on characterization of high–concentration slug.	March 2012	Following approval of the *Petition for Shutdown* (BNL 2013e), the system was shut down May 2013.
OU IV Sump Outfall Sr-90	Install additional monitoring wells as per 2009 *Groundwater Status Report* recommendations.	October 2011	Three new monitoring wells were installed in March 2011. Additional temporary wells have been added periodically (latest in 2015). Plume projected to attenuate to less than the Drinking Water Standard by 2034.
OU V Groundwater	Petition regulatory agency to conclude groundwater monitoring program pending 2011 perchlorate results.	December 2011	*Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012e) was submitted to the regulators in March 2012. As of 2014, all wells were below standards and monitoring was discontinued.
Potential continuing Sr-90 source at BGRR	Monitor to determine existence and assess feasibility of in-situ source stabilization. Monitor the effectiveness of new extraction wells.	July 2012	As discussed in the 2012 *Groundwater Status Report*, periodic flushing of Sr-90 from the deep vadose zone into groundwater results in spikes of Sr-90 downgradient of the BGRR. The extraction wells are successfully capturing the plume. Source area options, such as a permeable reactive barrier, are not feasible. Continue to operate the treatment system and monitor and evaluate the data.

Issue	Recommendations/ Follow-Up Actions	Milestone Date	Action Taken/Current Status
Potential continuing Sr-90 source at Chemical Holes	Monitor to determine existence and assess feasibility of in-situ source stabilization and/or removal.	July 2012	Nine temporary wells installed in June 2012 upgradient of EW-1 identified Sr-90 up to 134 pCi/L. Three permanent monitoring wells, numerous soil borings, and temporary groundwater wells were installed in 2015. No source area was identified. Treatment system operations are projected to continue until 2019.
Peconic River Monitoring Program	Modify monitoring program following remedy optimization.	September 2011	Changed to biannual fish monitoring in 2011, reduced annual sediment sampling locations from 30 to 3, reduced surface-water monitoring from 30 to 15 locations, 2x/year, and eliminated water quality monitoring in 2012. Supplemental monitoring performed in late 2014 through October 2015 at Area WC-06 to determine extent of elevated mercury in sediment. Perform supplemental cleanup at this area.
OU VI EDB	Add new monitoring well to bound the east side of the plume.	September 2011	Two additional monitoring wells were installed in March 2011 and September 2012 to monitor the eastern extent of the plume. EDB concentrations in the eastern perimeter well are below the standard.
BGRR Decommissioning	Complete remaining remedial actions and submit closeout report(s) to the regulators.	October 2012	The Closeout Report for the Bioshield removal was submitted to the regulators in September 2012. The BGRR building was put in long-term safe storage in July 2012.
HFBR	Complete remaining remedial actions and submit closeout report(s) to the regulators.	October 2011	The Closeout Reports for the Fan Houses and Stack Silencer Baffles were submitted to the regulators in November 2011 and May 2012. Stack to be removed by 2020.
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier.	Recurring	A 2015 review determined that based on the evaluation criteria specified in the ROD and the match between the predicted and measured dose rates, there is no reason to alter the current remedial action plan.
OU III and VI – Deeds not reflecting operating treatment systems	Complete survey/mapping of treatment systems off of BNL property and record updated deeds with the County.	June 2005 (survey mapping completed)	The easement figures were completed in 2014. BSA Legal issued the State TP-584 Form and letters to the property owners 8/12/14. Two of the five property owners signed the forms and were subsequently signed by the DOE Brookhaven Site Office. BSA has the action to record the deeds with the County Clerk.
Former HWMF Perimeter Soils	Phase III - Assess soil contamination. Additional cleanup if necessary.	September 2012 September 2014	The Phase III soil remediation was completed in September 2014. The Closeout Report was submitted to the regulators in February 2015. Project is complete.

There is one issue that was identified in **Table 5-1** above from the 2011 Five-Year Review that affected future protectiveness.

The issue was to complete surveying/mapping of the groundwater treatment systems off of BNL property and to record the license or access agreements with the Suffolk County Clerk's Office. The survey and mapping of the treatment systems was completed in June 2005 and forwarded to the property owners. All seven property license/access agreements have a requirement for recording except for LIPA, but there is a conveyance provision in that agreement. The only agreement that has been recorded to date is for the original Industrial Park system. Two of the remaining five property owners signed the New York State Transfer Tax Form TP-584, which were subsequently signed by DOE in 2014. BNL is responsible for completing the endorsement forms for these two properties for filing with the County Clerk. BNL will record the remaining agreements with the County Clerk.

6.0 Five-Year Review Process

6.1 Administrative Components

The activities scheduled for this Five-Year Review included regulator and community stakeholder notification, site inspections, interviews with stakeholders and regulatory officials, development of the Five-Year Review Report including review by DOE, EPA, NYSDEC, NYSDOH, and SCDHS, and a briefing on the results to the Community Advisory Council (CAC) and Brookhaven Executive Round Table (BER). The review was led by BSA's Environmental Protection Division (EPD) Groundwater Protection Group. The Five-Year Review team consisted of:

- BSA staff – W. Dorsch, V. Racaniello, J. Burke, D. Paquette, R. Howe, J. Remien, T. Green, T. Sullivan, S. Johnson (recently retired), and N. Sundin
- DOE staff – T. Kneitel, G. Granzen, and J. Carter
- Regulatory staff – J. Mollin (EPA), B. Jankauskas (NYSDEC), and A. Rapiejko (SCDHS)

The team included Hydrogeologists, Environmental Scientists, Engineers, Community Involvement Coordinators, and a Technical Editor.

6.2 Community Notification and Involvement

A Communications Plan for the Five-Year Review was prepared, and on October 1, 2015 was distributed to the project team including the regulatory agencies. The plan identifies specific outreach activities to be conducted, such as initial notification, interviews, report updates, and report issuance/notification.

An initial notification announcement was published in *Newsday* newspaper on September 30, 2015. It informed the public of the start of the review, as well as the purpose, schedule for completion, and how to contact DOE for more information. A copy of the announcement is available at https://www.bnl.gov/gpg/5year-review.php

The CAC was briefed on the start of the Five-Year Review on October 8, 2015. The BER was informed via email. In addition, an announcement on October 2, 2015 in the BNL weekly email newsletter *Brookhaven This Week* and a BNL website update were made to inform the BNL employees and the community that the Five-Year Review was being conducted.

A brief summary of the CAC members' input/responses to the following four questions given during the October 8, 2015 meeting is provided below.

1. *What is your overall impression of BNL's cleanup and do you feel well informed about the cleanup activities and progress?*
   All feedback was very positive. Most felt that there has been a good continuing effort to keep the status of the cleanup in the forefront via presentations and reports. Some new members feel better-informed about the cleanup and appreciate BNL's willingness to provide follow-up information as requested.
2. *Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. RODs, cleanup goals, community input, etc.)*
   One member wanted to see the decommissioning of the former Medical Research Reactor and the HFBR vessel move forward, as well as acceleration of the 70-year remediation timeframe for the BGRR/WCF Sr-90 groundwater plume. Some members wanted focus on progress in meeting the ROD cleanup goals and timelines, while another wanted to see a section describing any new techniques, procedures, equipment or methods that evolved over the last five years that are now standard procedures. One requested more focus on radionuclide cleanup.

3. *Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?*
   Overall feedback was positive that BNL and DOE have demonstrated a management commitment and have been openly candid regarding all aspects of the cleanup. Several are confident that BNL and DOE management will commit to funding the site cleanup for the long-term. Deviating from the past performance would be significantly detrimental to the Laboratory. One member would also like to see more input from DOE and the regulators during the CAC meetings.
4. *Do you have any comments, suggestions, or recommendations regarding BNL/DOE's management and communications of the cleanup?*
   Several members wanted to see a chart/timeline summarizing the progress made over time for all cleanup projects in comparison the ROD goals. Others requested that updates on the cleanup should also be communicated to the surrounding community/civic associations. One member also suggested a published history of the cleanup, written in layman's terms, would be helpful and should be made available in local libraries.

   The CAC survey is included as **Attachment 1**. It should be noted that over the last couple of years, many new members have joined the CAC and are relatively new to BNL's environmental cleanup. As a result, an environmental cleanup background presentation was provided to the CAC in February 2016 that discussed the history of the cleanup program and what work remains to meet the ROD requirements.

Following regulator review/concurrence and EPA concurrence on the final protectiveness determination, the community will be notified that the Five-Year Review was completed and it will be made available to the public. A public notice will be issued in *Newsday* at that time. The notice will include a brief summary of the results, the protectiveness statements, post-ROD information, repository locations where the report is available for viewing, and the timeframe of the next Five-Year Review. The repositories are:

- BNL Research Library, Upton, NY
- EPA Region II Office, New York City, NY
- Stony Brook University, Melville Library, Stony Brook, NY

The CAC and BER will be briefed on any changes to the report's conclusions and recommendations as a result of regulator review. The Report will also be added to the BNL website.

6.3 Document Review

The Five-Year Review consisted of a review of relevant documents including the following:

- Records of Decision for OUs I, III, IV, V (two), VI, BGRR, g-2/BLIP, and HFBR
- OU III ESDs (BNL 2005a, 2009a, and two in 2012 [2012a, b])
- Annual BNL Groundwater Status Reports (e.g., BNL 2016a)
- Annual landfill reports (e.g., BNL 2016c)
- Annual Peconic River Monitoring Reports (e.g., BNL 2010f)
- *Final Five-Year Review Report* (BNL 2011a)
- Closeout/Completion reports for soil (BNL 1997, 2005c, 2005e, 2005f)
- *Final Closeout Report for the Meadow Marsh Operable Unit I Area of Concern 8* (BNL 2004d)
- *Final Closeout Report for the Ash Pit Operable Unit I Area of Concern 2F* (BNL 2004e)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor, Graphite Pile Removal, Area of Concern 9* (BNL 2010c)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor, Final Canal and Deep Soil Pockets Excavation and Removal* (BNL 2005h)
- *BNL High Flux Beam Reactor Characterization Summary Report, Rev 1* (BNL 2007e)

- *Final Completion Report for the Former Hazardous Waste Management Facility Perimeter Area Soil Remediation* (BNL 2010a)
- *Addendum to the Former Hazardous Waste Management Facility Perimeter Area Completion Report* (BNL 2010b)
- *High Flux Beam Reactor, Area of Concern 31, Final Completion Report for Waste Loading Area Soil Remediation* (BNL 2009c)
- *Final Closeout Report for Removal of the Buildings 801-811 Waste Transfer Lines (A/B Waste Lines with Co-Located Piping), Area of Concern 31* (BNL 2010d)
- *Central Steam Facility Storm Water Outfall Remediation Closeout Report* (BNL 2007c)
- *Environmental Monitoring Plan,* Annual Updates (BNL 2016b)
- O&M manuals for the groundwater treatment systems (BNL 2002-2012)
- *BNL Land Use Controls Management Plan* (BNL 2013a)
- *EPA Five-Year Review Guidance* (EPA 2001)
- *Five-Year Review Recommended Template* (EPA 2016)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor Engineered Cap and Monitoring System Installation, Area of Concern 9* (BNL 2011b)
- *Final Closeout Report for the Brookhaven Graphite Research Reactor Biological Shield Removal, Area of Concern 9* (BNL 2012c)
- *Final Closeout Report for the High Flux Beam Reactor Underground Utilities Removal, Area of Concern 31* (BNL 2011c)
- *Final Closeout Report for the High Flux Beam Reactor Stabilization, Area of Concern 31* (BNL 2011d)
- *Final Closeout Report for the High Flux Beam Reactor Fan Houses (Building 704 and Building 802) Decontamination and Dismantlement (D&D), Area of Concern 31* (BNL 2011e)
- *Final Closeout Report for the High Flux Beam Reactor Removal of the Stack Silencer Baffles and Final Status Survey for Remaining Outside Areas, Area of Concern 31* (BNL 2012f)
- *Addendum to the Final Completion Report for the Former Hazardous Waste Management Facility Perimeter Area Soil Remediation* (BNL 2015a)
- *Field Sampling Plan/Quality Assurance Project Plan for the Waste Concentration Facility (AOC 10) and Surrounding Area* (BNL 2015b)

As noted in **Section 4.1** above, the remedial action objectives for the projects are identified in the RODs and the OU III ESDs.

6.4 Data Review

This section provides a brief summary review of analytical data and trends for each OU, the HFBR, BGRR, g-2 and BLIP areas over the previous five years. Figures are provided which display historical trends for key groundwater monitoring wells by plume over the last several years. A detailed discussion of the status of the groundwater plumes and the progress of the 17 groundwater remediation systems is provided in the *2015 BNL Groundwater Status Report* (BNL 2016a—see **Attachment 2** for the CD version or https://www.bnl.gov/gpg/gw-reports.php). The Groundwater Status Reports are published on an annual basis and are a source of comprehensive information on the groundwater remediation systems and contaminant plumes.

Since the start of active groundwater remediation in 1997, approximately 7,370 pounds of VOCs have been removed, and over 25 billion gallons of treated groundwater have been returned to the aquifer. Additionally, the Chemical Holes Sr-90 treatment system and the BGRR/WCF treatment system have removed approximately 31 milliCuries (mCi) of Sr-90 while returning nearly 168 million gallons of treated water to the aquifer.

Figure 4-2 shows the location of the 17 groundwater treatment systems. **Table 6-1** provides a summary of the treatment system status through March 2016.

Table 6-1: Groundwater Treatment System Status

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU I					
OU I South Boundary (RA V)	VOCs	Standby	P&T with AS	2013 (Complete)	VOCs remain low.
Current Landfill	VOCs tritium	Long-Term Monitoring & Maintenance	Landfill capping	NA	Characterization underway for elevated VOCs downgradient of one well.
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	2015/2016 characterization completed for elevated Sr-90 in former source area. Maximum Sr-90 detected at 302 pCi/L in a temporary well. Attenuation modeling is in progress and will be used to help evaluate future actions.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-2 and EW-3 pulsed pumping)	P&T with IE	2019	Persistent elevated Sr-90 in former source area postponed Shutdown Petition submittal. Performed extensive soil and groundwater characterization in former source area. No elevated Sr-90 detected. Continue system operations.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Decommis-sioned	P&T with carbon	2004 (Complete)	Petition for closure approved in 2009. Decommissioned in 2010.
Building 96 source control	VOCs	Operational (RTW-2, RTW-3, and RTW-4 on standby)	Recirculation wells with AS for 3 of 4 wells. RTW-1 is P&T with AS.	2018	High VOCs in former source area dropping significantly following source area soil remediation in 2010. RTW-1 also capturing downgradient portion of Freon-11 plume.
South Boundary	VOCs	Operational (EW-3, EW-5, EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2019	Continued decline in monitoring well VOC concentrations at the site boundary. Beginning to see decline in deeper VOCs being addressed by EW-17 which was installed in 2012.
Middle Road	VOCs	Operational (RW-1,RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	RW-7 was installed in 2013 to capture elevated deep VOCs. *Continued...*

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
Western South Boundary	VOCs	Operational (WSB-2 pulsed pumping)	P&T with AS	2019	Elevated VOCs detected in 2016 temporary wells in upgradient portion of plume, but no Freon-12 was detected. Characterization is continuing in this area.
Industrial Park	VOCs	Operational (UVB-1, UVB-2, and UVB-7 on standby)	In-well stripping P&T with carbon for deep wells	2020	Wells UVB-3, UVB-4, UVB-5, and UVB-6 restarted 2015. Two EWs (IP-EW-8 and IP-EW-9) installed in late 2014 to address deep VOCs.
Industrial Park East	VOCs	Decommis-sioned	P&T with carbon	2009 (Complete)	Decommissioned in 2014. Building infrastructure repurposed for the treatment of the deep Industrial Park VOCs..
North Street	VOCs	Operational (NS-2 on standby)	P&T with carbon	2016	EWs restarted 2014 due to elevated VOCs.
North Street East	VOCs	Standby	P&T with carbon	2014 (Complete)	VOC concentrations remain low since 2014 shutdown. EDB detected above standard in one well in 2015.
LIPA Right-of-Way/ Airport	VOCs	Operational (LIPA wells EW-1L, 2L, 3L on Standby/ Airport wells RTW-2A, 3A, 5A Pulsed pumping)	P&T and recirculation wells with carbon	2019 (LIPA) 2021 (Airport)	Three Airport wells are operational (RTW-1A, 4A, 6A) and three continued pulsed pumping. LIPA well EW-4 remains operational.
Building 452 Freon-11	VOCs	Standby	Air stripping	2016 (Complete)	Approximately 100 pounds of Freon-11 removed since 2012. Cleanup goals for treatment system have been reached. *Petition for Shutdown* approved in 2016.
HFBR Tritium	Tritium	Standby	Pump and recharge	2013 (Complete)	Tritium remains low. Downgradient monitoring discontinued. Expected system decommissioning in 2018.
BGRR/WCF	Sr-90	Operational (Wells SR-4, 5, 6 Pulsed pumping)	P&T with IE	2026	Sr-90 detected in 2015 up to 100 pCi/L in WCF yard.
OU IV					
OU IV AS/SVE system	VOCs	Decommis-sioned	AS/SVE	2003 (Complete)	Decommissioned in 2003.
Building 650 Sump Outfall	Sr-90	Long-Term Response Action	MNA	NA	132 pCi/L of Sr-90 detected in 2014. Additional plume characterization in 2015 were less than DWS. Maximum Sr-90 in 2015 was 37 pCi/L. Continue monitoring.

Continued...

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU V					
STP	VOCs, tritium	Long-Term Response Action (Complete)	MNA	NA	VOC plume has attenuated to below MCLs. No further monitoring.
OU VI					
EDB	EDB	Operational	P&T with carbon	2019	The EDB plume is migrating slower than predicted so system operations were extended to 2019.

Notes:
AS = Air Stripping
AS/SVE = Air Sparging/Soil Vapor Extraction
BGRR/WCF = Brookhaven Graphite Research Reactor/Waste Concentration Facility
EDB = ethylene dibromide
EW = Extraction wells
HFBR = High Flux Beam Reactor
HWMF = Hazardous Waste Management Facility
IE = Ion Exchange
In-Well = The air stripper in these wells is located in the well vault.
LIPA = Long Island Power Authority
MCLs = Maximum Contaminant Limits
MNA = Monitored Natural Attenuation
NA = Not Applicable
P&T = Pump and Treat
Recirculation = Double screened well with discharge of treated water back to the same well in a shallow recharge screen

6.4.1 Operable Unit I

Soils: The third and final phase of cleanup was completed in 2014 for the former HWMF Perimeter Soils. The residual soil concentrations met the radiological cleanup level for residential land use. A Closeout Report was issued in 2015. The average and maximum residual Cs-137 concentrations following cleanup for the Phase III perimeter soils were 1.33 pCi/g and 7.4 pCi/g, respectively.

Starting in 2014 and continuing into 2016, the former WCF Buildings 810 and 811 were decommissioned and demolished, waste transfer lines were removed, and radiologically contaminated soil was excavated. The soil excavation activities were also a follow-up to the 2005 *Waste Concentration Facility Closeout Report* that identified two residual areas of radiological soil contamination that were left behind at that time due to the proximity of the soil to operating facilities Buildings 810 and 811. The Closeout Report stated that these two areas would be remediated when the operating facilities are decommissioned. A final status survey and dose assessment is being prepared to ensure that the residential land-use cleanup goals have been met. A Closeout Report will be issued. During the 2015/2016 excavation of the former WCF, an area of radiologically contaminated soil was identified along the north fenceline to the adjacent storage yard. This yard contains activated steel, lead and equipment that are being stored for potential reuse by the Collider-Accelerator Facility complex. Based on preliminary surveys, the contaminated soil is believed to be surficial. This area will be placed under institutional controls, added to the LUIC contaminated soil map and will be remediated as funds become available in the future. The BNL soil cleanup levels for principal radiological contaminants, based on the selected land use for each area, are provided in **Table 6-2**.

Table 6-2: BNL OU I Soil Cleanup Levels

Radionuclide	Soil Cleanup Level (pCi/g) Residential Land Use	Industrial Land Use
Cesium-137	23	67
Strontium-90	15	15
Radium-226	5	5

Note: A post-cleanup dose assessment is required to determine compliance with the 15 Rem/yr above background cleanup level with 50 years of institutional control.

Landfills: Monitoring at the Current Landfill continues to identify methane soil gas exceeding 100% of the lower explosive limit in several monitoring wells immediately to the southeast. This indicates that decomposition is still occurring. At the request of the NYSDEC, in 2016 soil-gas samples were obtained southeast of the Current Landfill to ensure that contaminant concentrations are not migrating beyond the existing well network. Soil-gas samples were collected at two depths for each of three locations using the Geoprobe®. There were no detections of soil gas in any of the samples. (See 2015 Report https://www.bnl.gov/gpg/landfills.php). However, another round will be collected during a dry period to confirm the readings. The four outpost monitoring wells, located immediately north of the Current Landfill along the south side of Brookhaven Avenue, showed no methane during 2015. These wells ensure there is no impact to the closest facility, the National Weather Service building. Soil-gas monitoring at the Former Landfill Area indicates that there are only minimal detections of hydrogen sulfide, with no detectable levels of methane present. The soil-gas monitoring well networks are sufficient to monitor both landfill areas.

As part of the compliance monitoring for the Current Landfill, beginning in 2009 the frequency for the collection of inorganic surface-water and sediment samples from the adjacent wooded wetland was reduced from annually to once every two years. Although elevated lead and mercury average concentrations were identified in sediment at the North Pond in two of the last three sampling rounds (2010 and 2014), the data are consistent with previous years' average metals concentrations. Average inorganic surface-water data from the last three sampling rounds (2010, 2012, 2014) have remained low (except for iron). Since metals in water are the primary source of absorption by tiger salamanders, no significant change in dissolved metals indicates that the wooded wetland is not experiencing an increase in metals concentrations. At the request of the NYSDEC during their review of the *2014 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2015e), eight sediment samples were collected around two of the routine sample locations at the North Pond in December 2015. The data indicate that mercury was identified slightly above the benchmark maximum concentration in five of the eight samples, but below the BNL background concentration. Lead was only identified in two of the eight sediment samples above the benchmark maximum concentration and background. The 2014 concentration of lead in the water column at this elevated sediment sample location was well below the critical benchmark water concentration. This may indicate that the lead is mainly insoluble and not available for uptake into the Tiger Salamanders (https://www.bnl.gov/gpg/landfills.php).

Groundwater: The landfill areas were capped between 1995 and 1997. Monitoring data presented in the *2015 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2016c) indicate that, in general, contaminant concentrations have decreased following the capping of the landfills and landfill controls continue to be effective. VOCs and metals continue to be detected downgradient of the Current Landfill. The most prevalent VOCs detected above standards are chloroethane and benzene, at maximum concentrations in 2015 of 124 µg/L and 2 µg/L, respectively. **Figure 6-1** depicts VOC trends for individual wells near the Current Landfill. As with previous years, iron, manganese, and arsenic were detected downgradient from the Current Landfill at concentrations above applicable standards. Concentrations of these metals were similar to those detected in 2014. Maximum concentrations of iron, manganese, and arsenic in downgradient wells in 2015 were 75,900 µg/L, 5,220 µg/L, and 29 µg/L, respectively. Between

January and March 2016, 12 temporary wells were installed downgradient of monitoring well 088-109 (located on the east side of the landfill), where elevated chloroethane continues to be detected in the groundwater at the Current Landfill. The maximum chloroethane concentration of 158 µg/L was detected as part of this characterization in the northern-most temporary well adjacent to well 088-109. The four temporary wells located approximately 300 feet downgradient detected significantly lower concentrations. Additional temporary wells are currently being sampled. Following this characterization, the groundwater model will be updated to project the attenuation of VOCs from this area. These data are discussed in detail in the *2015 Groundwater Status Report* (BNL 2016a).

VOCs were not detected above standards in Former Landfill Area monitoring wells in 2015. Water chemistry parameters and metals concentrations were equivalent to historical background levels.

The OU I pump and treat system continued to maintain hydraulic control and treat contaminants originating from the Current Landfill and former HWMF, and prevent further contaminant migration across a portion of the site's southern boundary. In 2011, an additional monitoring well was installed to monitor VOC concentrations immediately upgradient of the extraction wells. Due to the reduction of VOCs in the plume, in July 2013 the regulators approved the *Petition for Shutdown* of the groundwater treatment system. VOC concentrations in one core monitoring well (107-40) hovered around the treatment system capture goal of 50 µg/L total volatile organic compounds (TVOCs) through January 2013. Since then, the TVOC concentrations have remained below 50 µg/L (**Figure 6-2**).

Groundwater monitoring continues for an area of Sr-90 contamination that originated at the former HWMF and is now located approximately 2,200 feet to the south (approximately 1,000 feet north of the site boundary and OU I extraction wells). The maximum Sr-90 concentration detected in these downgradient wells since 2011 was 20 pCi/L. However, based on the occasional increases and subsequent decline in Sr-90 concentrations for wells 088-26 and 098-30 (located immediately downgradient of the former HWMF source area) there appears to be some remnant contamination in the source area that is periodically released to the water table and subsequently migrates south. From April 2015 through March 2016, several transects consisting of 58 temporary wells were installed to determine the magnitude and extent of Sr-90 continuing to migrate from the former source area. The maximum Sr-90 concentration observed in groundwater from the temporary wells was 302 pCi/L at 14 feet below grade from a location near the center of the former HWMF. Additional groundwater samples obtained in April 2016 from three locations where the highest concentrations were observed, identified Sr-90 up to 234 pCi/L. A soil sample at the highest location did not detect Sr-90. Detailed discussion of the characterization is presented in Section 3.1 of the *2015 Groundwater Status Report* https://www.bnl.gov/gpg/gw-reports.php. An update to the groundwater model was performed in March/April 2016 to project the attenuation of Sr-90 from this area. A discussion of the modeling results is presented in **Section 7.1** below. The rate of migration of Sr-90 in this area of this site is approximately 45 feet per year.

6.4.2 Operable Unit II

The remedial actions for the OU II AOCs are documented in the OU I, OU III and the g-2/BLIP/USTs RODs (see **Sections 6.4.1**, **6.4.3**, and **6.4.8**).

6.4.3 Operable Unit III

Soil: Due to elevated VOCs in groundwater located west of the main Building 96 plume, in July 2015 a soil-vapor survey was performed upgradient of well 095-307 to determine any residual source areas. Of the 39 locations, three points identified stable elevated soil-gas readings. In August, follow-up soil samples were obtained via Geoprobe® at three locations, sampled at depths of every two feet from ground surface to the top of the water table, and analyzed for VOCs. A soil sample was also obtained at the top of the water table at each Geoprobe® location. No VOCs above the reporting limit were detected in the soil samples and there were no detections of VOCs in the three groundwater samples.

Groundwater: Over the past five years, the OU III groundwater remediation systems continued to maintain hydraulic control of contaminants originating from the central portion of the BNL site. Nine of these systems are currently in active operation. The Carbon Tetrachloride and Industrial Park East systems met their cleanup goals and were dismantled, and the HFBR, North Street East, and Building 452 Freon-11 systems are in standby mode and could be restarted if necessary. The extent of the high-concentration segments of the OU III VOC plumes have decreased as the result of active groundwater remediation and the effects of natural attenuation. Hydraulic control of the plume segments near the Middle Road, South Boundary, Industrial Park, Industrial Park East, and LIPA/Airport treatment systems can be seen on **Figure 5-1**. Complete breaks in the plumes, where contaminant concentrations have dropped below MCLs, are discernable near the South Boundary and the LIPA systems. The southernmost segment of the OU III plume has been hydraulically controlled by the Airport treatment system. As the plumes continue to decrease in size, a number of the extraction wells have been placed in either a pulsed pumping mode or a standby mode (**Figure 4-3**).

A review and evaluation of the performance data for the treatment systems is conducted monthly for most of the systems and quarterly for all of the systems, as well as annually for all systems. An evaluation of all the groundwater monitoring data collected for the year is documented in the annual *BNL Groundwater Status Report*.

The following is a brief status summary of OU III plume data through 2015.

Carbon Tetrachloride Treatment System

The Carbon Tetrachloride treatment system was successful in remediating the source area and was decommissioned in 2010. Although one well, 105-23, continues to detect carbon tetrachloride just above the MCL of 5 µg/L, the source area where the groundwater cleanup took place has met MCLs. Well 105-23 is over 2,000 feet downgradient of the former source area and this contamination is expected to attenuate before it reaches the Middle Road Treatment System. Monitoring of the source area was discontinued in 2013.

Building 96 Treatment System

In October 2012 and in January 2016, respectively, Building 96 recirculation wells RTW-4 and RTW-2/RTW-3 were shut down and placed in standby mode due to low VOC concentrations in adjacent monitoring wells. Starting in 2012, treatment well RTW-1 was also being used to treat the downgradient portion of the Building 452 Freon-11 plume. Since 2011, VOCs in the Building 96 plume core monitoring wells have significantly declined (See trends on **Figure 6-3**). The system is expected to continue operating until 2018. Due to the significant reduction of hexavalent chromium in the monitoring wells over the last five years, it was agreed in 2015 that no further sampling will be performed.

Building 452 Freon-11 Treatment System

A groundwater treatment system was installed in 2012 to remediate a Freon-11 plume that originated from the Building 452 area. From 2012 through 2015, the system removed approximately 100 pounds of Freon-11 from the aquifer. In 2015, all Freon-11 concentrations in groundwater monitoring wells and the extraction wells were below the cleanup goal of 50 µg/L. As a result, a *Petition for Shutdown* was submitted to the regulatory agencies in January 2016. Following regulatory agency approval, the treatment system was shut down and placed in standby mode in March 2016. Freon-11 trend graphs are shown on **Figure 6-4**. As noted above, Building 96 treatment well RTW-1 is still being used to remediate the remaining downgradient portion of the Building 452 Freon-11 plume.

Middle Road Treatment System

The three eastern-most of the six extraction wells (RW-4, RW-5 and RW-6) remain in standby as TVOC concentrations have decreased below the system capture goal of 50 µg/L over the past several years. Groundwater characterization was performed in 2013 for an area immediately to the west of the extraction wells to determine whether an area of elevated VOC concentrations migrating from the north will be captured by the Middle Road wells. Based on the characterization and subsequent modeling, it was determined that the deep VOCs identified were not being captured by the existing extraction wells. As a result, a new extraction well (RW-7) was installed in 2013 to capture the elevated deep VOCs. In 2013 and 2014, a series of temporary and permanent monitoring wells were installed along Weaver Drive and to the north to identify the northern extent of the deeper VOCs observed at the Middle Road and South Boundary. Since the VOC results were relatively low at Weaver Drive, it is believed that the concentrations observed along Princeton Avenue represent the "tail end" of higher concentrations that should begin to drop within the next several years. See **Figure 6-5** for the monitoring well trends. In November 2015, shallow western extraction well RW-1 was placed in standby mode due to low concentrations of VOCs.

South Boundary Treatment System

The five easternmost extraction wells (EW-5, EW-6, EW-7, EW-8, and EW-12) and one westernmost well (EW-3) remain in standby as TVOC concentrations have decreased below the system capture goal of 50 µg/L over the past several years. Well EW-4 continues to operate although VOC concentrations in this extraction well and surrounding monitoring wells have shown marked declines (**Figure 6-5**). As a result of elevated VOCs identified along the south boundary in temporary and permanent monitoring wells below the capture zone of the existing extraction wells, a new deeper extraction well (EW-17) was installed near EW-4 in 2012. This well remains operational.

Western South Boundary Treatment System

Plume and extraction well data show that elevated VOC concentrations continue to be observed in the western portion of the OU III South Boundary area (**Figure 6-6**). Extraction well WSB-2, located in the eastern portion of this area, remains in a pulsed pumping mode due to the decreased VOC concentrations observed both in this well and area monitoring wells. Due to TVOC concentrations that continue to be detected upgradient of the extraction well just above the capture goal of 20 µg/L, WSB-1 remains in full-time operation.

Two temporary wells were installed in 2011 south of East Princeton Avenue to better define the extent of the Freon-12 contamination. The maximum TVOC value detected was 28 µg/L at 150 feet below grade. The maximum value of Freon-12 detected was 2.1 µg/L. Although Freon-12 was detected up to 35 µg/L in an upgradient monitoring well between East Princeton Avenue and Middle Road in 2015, the maximum concentration immediately upgradient of WSB-1 was 9 µg/L. Additional temporary well samples were obtained in February 2016 to determine the extent of this Freon contamination. Freon-12 was not identified above the standard; however significant concentrations of other VOCs were detected at 180 feet below grade. These data are presented in the *2015 Groundwater Status Report*. Further characterization will be performed.

Industrial Park Treatment System

Three of the seven extraction wells remain in standby mode (UVB-1, UVB-2, and UVB-7) as shown on **Figure 4-3.** Two temporary and permanent wells were installed in March 2011 and May 2012 to support the *Petition for Shutdown*. Following approval of the *Petition for Shutdown*, the system was shut down in 2013. Due to elevated VOCs, extraction wells UVB-3 through UVB-6 were restarted in March 2014. In 2014, several temporary wells were installed to evaluate the extent of migration of the deep VOC plume beneath the Industrial Park area. The maximum TVOC concentration detected was 268 µg/L approximately 225 feet below land surface. Since the contamination is beneath the capture zone of the existing Industrial Park extraction wells, two additional extraction wells (IP-EW-8 and IP-EW-9) and several monitoring wells were installed in late 2014. See **Figure 6-5** and **Figure 6-7** for the monitoring well trends in this area. Data from deep monitoring wells 000-538 and 127-09 depict the elevated VOCs in the Magothy aquifer.

Industrial Park East Treatment System

There have been no rebound of VOCs in the monitoring or extraction wells since the Industrial Park East treatment system was shut down in 2009. See **Figure 6-8** for the monitoring well trends. As a result, the regulators approved the *Petition for Closure* of the system in 2013. In late 2013, the extraction and several of the monitoring wells were decommissioned in accordance with State protocols. Starting in late 2014, the building and related infrastructure are being used for the remediation of the deep VOC contamination in the Industrial Park.

North Street Treatment System

In June 2013 a *Petition for Shutdown OU III North Street Groundwater Treatment System* (BNL 2013c) was submitted to the regulators for review and approval. The system was shut down in August 2013 after receiving approval from the regulators. The system was restarted two times since June 2014 due to a rebound in VOC concentrations in upgradient monitoring wells above the 50 µg/L TVOC concentration capture goal. See **Figure 6-9** for the trends. Only one monitoring well remained above the capture goal in 2015. Well 000-465, located upgradient of extraction well NS-1 detected TVOC concentrations up to 78 µg/L in August 2015. Extraction well NS-1 is currently operating and NS-2 has been in standby mode since June 2015.

North Street East Treatment System

The off-site segment of the OU I VOC plume is captured and treated by the North Street East System. Two additional temporary wells and a monitoring well were installed in 2012 and 2013 to evaluate VOC concentrations upgradient of extraction well NSE-1. Due to the low VOC concentrations identified in the temporary and permanent monitoring wells, following approval from the regulators, the system was shut down in June 2014. No rebound in VOCs have been observed since. However, on two occasions in 2015, EDB was detected in one monitoring well above the standard of 0.05 µg/L. In accordance with the BNL Groundwater Contingency Plan, BNL collected additional samples from his well and confirmed these detections. Monitoring for EDB will continue. These data are presented in the *2015 BNL Groundwater Status Repor*t (BNL 2016). See monitoring well trends on **Figure 6-2**.

LIPA/Airport Treatment System

The LIPA extraction well EW-4L is capturing and treating VOCs in the upper Magothy aquifer. Although influent TVOC concentrations in this extraction well remained less than 20 µg/L since 2011, two upgradient Magothy monitoring wells have had periodic detections above the 50 µg/L capture goal. The closest monitoring well to EW-4L is 000-460, which contained TVOC concentrations of 166 µg/L in 2012 and 65 µg/L in late 2013. See **Figure 6-10** for Magothy monitoring well trends. The nearest upgradient plume core monitoring well is 000-130. This well displayed peak TVOC concentrations of 5,000 µg/L in 1999 and has declined to less than 50 µg/L since 2013. In 2013 there was a detection of toluene at 530 µg/L in well 000-130. Previous elevated detections of toluene in this well were believed to be due to sample contamination from surface run-off. As a follow-up to the 530 µg/L detection, the protective cover of this flush-mount well was replaced to reduce the potential for contamination by street run-off entering the well. Following the repair, well 000-130 was sampled again (after purging four well volumes), and there were no detectable levels of toluene. Since then, the well continues to be sampled (after pumping one well volume) and toluene has not been detected. The remaining three LIPA extraction wells, EW-1L, EW-2L, and EW-3L, remain in standby mode.

Although TVOC concentrations in the six Airport extraction wells have been slightly increasing since 2011, only RW-6A has exceeded the capture goal of 10 µg/L during this time. In 2015, the maximum TVOC concentration in RW-6A was 15 µg/L. VOC reductions in upgradient monitoring wells at the western portion of the plume indicate that the trailing edge of the high-concentration area is along Crestwood Drive approximately 1,500 feet north of RW-6A. Monitoring well 800-92, located in the eastern portion of the plume approximately 2,000 feet north of the Airport, has been showing TVOC concentrations steadily declining since 2012. Magothy monitoring well 800-90, located adjacent to but deeper than 800-92, has experienced spikes in TVOC concentrations in 2013 and 2015. The 2015 range of TVOC concentrations was 23 µg/L to 123 µg/L (See trends on **Figure 6-10 and Figure 6-11**). This contamination will be captured by Airport extraction well RTW-4A. Extraction wells RTW-1A, RTW-4A, and RW-6A continue to operate full time, while wells RTW-2A, RTW-3A, and RTW-5A are in pulsed pumping mode (pumping one week per month).

HFBR Pump and Recharge System/Plume

Since 2011, considerable progress has been observed in the attenuation of the HFBR tritium plume both at the source area and at the downgradient portion of the plume. See **Figure 6-12** for tritium trends in the monitoring wells near the HFBR. The most recent exceedance of the standard in a monitoring well near the HFBR was in 2014 with a concentration of 28,700 pCi/L. Since 2011, the highest concentration observed in the downgradient portion of the plume was 7,850 pCi/L in 2013. The last exceedance of the standard was in 2009 in both a monitoring well and a temporary well. A well located adjacent to extraction well EW-16 detected 27,800 pCi/L in 2009 and a temporary well located in this same area detected 56,600 pCi/L also in 2009. The permanent well network was supplemented in 2013 with 11 temporary wells located between Weaver Drive and EW-16 as per a recommendation in the *Petition for Shutdown, High Flux Beam Reactor, Tritium Plume Pump and Recharge System* (BNL 2013e). The peak tritium concentration in these temporary wells was 9,050 pCi/L.

Groundwater modeling results predicted that the pump and recharge system would have to operate until approximately 2013. In March 2013, a *Petition for Shutdown, High Flux Beam Reactor, Tritium Plume Pump and Recharge System* (BNL 2013e) was submitted to the regulators for review and approval. The system was shut down in May 2013 after receiving approval from the regulators. No rebound in tritium concentrations in the downgradient portion of the plume has been observed.

BGRR/WCF Treatment System

This treatment system began operations 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. SR-4 and SR-5 have been in a pulsed pumping mode since 2011. They are pulsed on a monthly basis of one month on and one month off. Four extraction wells (SR-6, SR-7, SR-8, and SR-9) were installed in 2010 to address higher Sr-90 concentrations located in the downgradient portion of the WCF plume (in the vicinity of the HFBR) and they began operation in 2011. SR-6 was placed in a pulsed pumping mode in 2013 due to low Sr-90 concentrations. See trends on **Figure 6-13**.

A number of temporary wells were sampled in 2013 and 2014 to assess the eastward shift of the plume in the area south of Rutherford Drive. Characterization of this segment of the plume is hindered by the presence of the HFBR. The highest Sr-90 concentration detected in the vicinity of the extraction wells was 117 pCi/L in 2013. This temporary well location is approximately 80 feet east of SR-9. See Section 3.2.16 of the *2014 Groundwater Status Report* for details of the characterization. There are currently no permanent monitoring well locations in this area. In 2015, the highest concentration of Sr-90 in this area was 54 pCi/L (BNL 2016). This is to the east of the most easterly extraction well and shows the eastward shift of the plume in this area. Geoprobe® groundwater sampling was also performed in the vicinity of the WCF in April 2015 near extraction wells SR-1 and SR-2. The highest concentration identified in the Geoprobe® samples was 103 pCi/L, which will be captured by extraction wells SR-1 and SR-2. During 2015, Buildings 810 and 811 were removed and contaminated soils in this area were excavated and disposed of. The removal of this contaminated soil, which was believed to be a continuing source, is expected to enhance the groundwater cleanup in this area.

The other source area for Sr-90 contamination in this part of the site is the BGRR. This source is effectively captured and treated by extraction wells SR-3, SR-4, and SR-5. Sr-90 influent concentrations in SR-3 have shown a steady decline over the past several years. Over the past several years the highest concentration of Sr-90 in SR-3 has been 43 pCi/L in April 2014. This lower concentration shows some correlation with and demonstrates the effectiveness of the engineered cap around Building 701 and is immediately upgradient of well SR-3.

Chemical Holes Treatment System

Sr-90 migrating south from the former source area is captured and treated by extraction well EW-1. Two additional extraction wells (EW-2 and EW-3) were installed south of EW-1 in 2007 to capture and treat an area of higher Sr-90 concentrations that had migrated south of EW-1 prior to startup. See trends on **Figure 6-14**. Concentrations in wells EW-2 and EW-3 have steadily declined. Due to low Sr-90 concentrations, extraction wells EW-2 and EW-3 are now in pulsed pumping mode on a schedule of two months off and one month on. EW-1 continues full-time operation. The shutdown of the treatment system was planned for 2015; however, due to the slower than expected drop in concentrations in the source area, it is estimated from groundwater modeling that the treatment system will need to operate until 2019. A source area investigation was conducted in 2015 and extensive groundwater and soil sampling was performed. The results of this investigation indicated that there were only low levels of Sr-90 in several soil samples, and only one of the groundwater samples collected was above the drinking water standard of 8 pCi/L, at a concentration of 9.7 pCi/L). These data are presented in the *2015 BNL Groundwater Status Report* (BNL 2016).

6.4.4 Operable Unit IV

Soil: Remediated radiologically contaminated soil at the Building 650 Sump Outfall is included under OU I.

Groundwater: The OU IV AS/SVE treatment system was dismantled in 2003 and post-closure groundwater monitoring was completed in 2011.

Groundwater monitoring continues to evaluate the natural attenuation of an area of Sr-90 contamination which originated at the Sump Outfall and is slowly migrating to the south. Sr-90 concentrations for key wells are shown on **Figure 6-15**. Three new monitoring wells were installed in March 2011 and additional temporary wells were added periodically (latest in 2015) to enhance the monitoring well network. The most recent observed data are consistent with the attenuation model in terms of the extent and magnitude of Sr-90 contamination in groundwater. The plume is projected to attenuate to less than the Drinking Water Standard (DWS) by 2034. This is a conservative estimate and the maximum southward extent of the leading edge of this area (defined by 8 pCi/L) will be approximately 200 feet south of Brookhaven Avenue.

6.4.5 Operable Unit V

Peconic River: Annual data for the 2011 Peconic River sediment, surface-water, and fish monitoring program are detailed in the *Final 2011 Peconic River Monitoring Report* (BNL 2012g) (https://www.bnl.gov/gpg/peconic-reports.php). Beginning in 2012, preparation of a separate annual Peconic River Monitoring Report was discontinued and the annual monitoring results are now summarized in the annual BNL *Site Environmental Report* which can be found at https://www.bnl.gov/esh/env/ser/. The annual data are routinely reviewed with the regulators. Following agreement reached during the 2011 Five-Year Review, Peconic River post-cleanup monitoring was reduced:

- From 30 sediment locations per year to 3 locations per year (WC-06, SS-15, Sediment Trap)
- 15 surface-water locations two times per year
- Fish collection every other year
- Wetland monitoring to ensure vegetation success

The 2011 to 2015 mercury concentration data for sediment, surface water and fish each indicate substantial improvements relative to pre-cleanup conditions and the sediment cleanup goals or other criteria (surface water and fish concentrations). Sediment is the only matrix in the ROD where a specific goal is provided. The ROD identifies a goal that all mercury concentrations in the remediated areas are less than 2.0 milligram per kilogram (mg/kg) following the cleanup. [Note: There is no specific action level for mercury in sediment in the ROD. The originally proposed excavation areas were based on the removal of sediment in depositional areas and other areas that promote methyl mercury production.] The ROD also identifies that the average mercury concentrations in the remediated areas will be less than 1.0 mg/kg and 0.75 mg/kg on and off of BNL property, respectively. EPA's mercury criterion[1] for fresh waters is 0.3 mg/kg mercury in fish tissue residue. Although this is not a ROD-required goal, Peconic River fish tissue mercury concentrations were measured and compared to this criterion as both a reference and as a benchmark for water quality improvement.

Peconic River Sediment: The *Peconic River Supplemental Sediment Removal Completion Report*, March 2012 (BNL 2012h), documented that the 2011 supplemental sediment cleanup at the three areas (SS-15, the Sediment Trap, and WC-06) was effective. See **Figure 6-16** for the location of these areas. In accordance with the *Soil and Peconic River Surveillance and Maintenance Plan* dated March 2013 (BNL 2013f), post-cleanup sediment samples were obtained annually from 2011 through 2015 at the location of the maximum historical pre-cleanup mercury detection for each of these areas. The following summarizes the monitoring during this period:

- Area PR-SS-15-U1-L65-O: This area is located off of BNL property approximately 0.1 miles downstream of the former Sediment Trap. The mercury results were:

2011	0.049 mg/kg
2012	0.25 mg/kg
2013	0.064 mg/kg
2014	0.23 mg/kg
2015	0.20 mg/kg

- Former Sediment Trap (ST1-80-U20): This area is located on BNL property approximately 0.3 miles downstream of Area PR-WC-06. The mercury results were:

2011	0.41 mg/kg
2012	0.38 mg/kg
2013	0.50 mg/kg
2014	0.33 mg/kg
2015	0.017 mg/kg

- Area PR-WC-06-D1-L50: This area is located on BNL property approximately one mile downstream of the former Sewage Treatment Plant outfall. The mercury results were:

2011	1.90 mg/kg
2012	3.60 mg/kg

[1] *Final Water Quality Criterion for the Protection of Human Health: Methylmercury*, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, Washington, DC, 20460, EPA-823-R-01-001, January 2001. All mercury within a fish is assumed to be methyl mercury.

2013	1.50 mg/kg
2014	7.40 mg/kg
2015	0.77 mg/kg

Following review of the elevated 2014 data, a decision was made to collect additional sediment samples at the PR-WC-06-D1-L50 location to determine the extent of contamination.

In November 2014, the regulators agreed with a plan to collect four samples (five feet upstream, five feet downstream, five feet to the left, and five feet to the right of the original sample) to delineate the area. The samples were obtained in December 2014 and the maximum mercury detection was 5.6 mg/kg, with an average of the four samples being 2.6 mg/kg. The regulators were briefed on the results as well as proposed additional sample locations. Due to elevated mercury detected, this process continued through 2015 with nine additional sampling events culminating with the October 21, 2015 collection. A total of 140 sediment samples were collected during this time to delineate the area of elevated mercury. The maximum mercury concentration was 23 mg/kg at location PR-WC-06-D1-L50-101, with an average concentration of 2.7 mg/kg. The regulators were briefed on the results of each collection event during the monthly IAG teleconferences.

For additional detail on the sediment characterization effort and BNL/DOE proposed excavation of this area, see the *Draft Plan for Optimization of the Peconic River Remedy PR-WC-06 Area,* (BNL, 2016d). The Plan was submitted to the regulators for their review in February 2016. Based on feedback received from the regulators and the Community Advisory Council in March 2016, the area proposed for excavation will include all WC-06 locations exceeding 2.0 mg/kg and extend the area approximately five feet beyond the most downstream sample point PR-WC-06-D1-L50-145. The Plan is currently being revised based on regulator comments.

Peconic River Water Column: Mercury concentrations in the 80 Peconic River water samples collected between 2011 and 2015 were less than 70 nanograms per liter (ng/L; equivalent to parts of mercury per trillion parts of water) with the exception of one sample. Sample point PR-WC-06 detected 140 ng/L of mercury in the July 2014 sample. This sample contained significant vegetation throughout the water column and is not considered representative of the water column.

Mercury data for the water-column samples from 2011 through 2015 are plotted on **Figure 6-17**. The plan was to sample each of the 15 stations twice per year (when the water depth is greater than one foot to help assure a representative sample). In 2011, 29 samples were collected; however due to the low water levels, the number of samples collected since then have significantly dropped off. In 2015, only six samples were obtained. The STP effluent samples were collected through 2014 from about 30 feet before the effluent enters the Peconic River. Starting in the fall of 2014, the STP effluent no longer discharges to the River, but is discharged to groundwater via recharge basins. As shown on **Figure 6-17**, the mercury concentrations downstream of the STP (i.e., to the right of the STP-EFF-UVG sampling station) are clearly elevated relative to the station upstream of the STP (PR-WC-12-D7). A downward trend in mercury concentration between STP-EFF-UVG and PR-WC-02 is evident. The STP effluent mercury concentrations have significantly declined over the years with a maximum detection of 58 ng/L in 2013. The maximum mercury concentration for the last year of sampling at this location was 32 ng/L in 2014. The data is presented in the 2013 and 2014 Site Environmental Reports (BNL 2014b and 2015c) located at https://www.bnl.gov/esh/env/ser/. The average mercury concentration for all 80 samples from 2011 through 2015 is 24 ngL and is presented on **Figure 6-18**. This is a significant reduction from the average mercury concentration from 2006 through 2010 of 45 ng/L. As a follow-up to a comment from SCDHS during the previous Five-Year Review, water samples from station PR-WCS-04 (east of Manor Road) continued to be collected in 2011 and 2012. Since the average mercury value for the four samples was below 7.0 ng/L, monitoring of this location was discontinued in 2013.

Methyl mercury data for the 80 water-column samples collected between 2011 and 2015 are plotted on **Figure 6-19.** The maximum methyl mercury concentration detected during this period was 5.9 ng/L at the station located upstream of the former STP outfall. **Figure 6-20** presents the annual mean concentration of methyl mercury from 2011 through 2015. The average methyl mercury concentration for all 80 samples from 2011 through 2015 is 1.1 ngL. This is a significant decrease from the average methyl mercury concentration from 2006 through 2010 of 3.5 ng/L.

Peconic River Fish: A total of 219 fish samples were analyzed in 2011, 2013, and 2015 as part of the post-cleanup monitoring program. Due to the decreasing river water levels over the last few years, the number of fish collected has declined between 50% and 70% since 2011. As shown on **Figure 6-21**, fish tissue mercury concentrations have varied significantly since 2011. The annual average fish tissue mercury concentrations for the three sampling events were; 0.31 mg/kg in 2011, 0.69 mg/kg in 2013, and 0.40 mg/kg in 2015. These are higher than the 2006 through 2010 average of 0.28 mg/kg, but the 2011 and 2015 values are still lower than the 1997 and 2001 pre-cleanup concentration (0.58 mg/kg)[2]. For reference purposes, the EPA mercury criterion for fish is 0.3 mg/kg. Factors that may have contributed to the increased mercury levels in fish over the last five years include reduced sample size, fish age, fish size, food consumed, and limited open water areas. Consequently, fish were isolated to the BNL site in areas with high methylation of mercury and no dilution by river flow.

Groundwater: Active treatment of the low-level VOC plume that originated from the BNL Sewage Treatment Plant (STP) was not required by the ROD. However, the groundwater continued to be monitored to verify the expected natural attenuation of the low-level VOCs. As a follow-up to the recommendation in the 2011 Five-Year Review, perchlorate was detected in two of five monitoring wells in 2011, but at concentrations below the reporting limit of 4 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L, and in 2012 EPA initiated the process of proposing a national primary drinking water regulation for perchlorate. Subsequently, EPA established an Interim Lifetime Drinking Water Health Advisory of 15 µg/L. A *Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012e) was therefore submitted to the regulators in March 2012. Based on the recommendations and the regulatory comments, the groundwater monitoring program was reduced to one monitoring well (000-122) in 2012. The last round of data from this well in 2013 indicated that all VOC concentrations were below MCLs. Based on the recommendation in the *2013 Groundwater Status Report* (BNL 2013h), sampling of well 000-122 was discontinued. This completed the groundwater sampling requirements for OU V. Groundwater quality in the immediate vicinity of the STP is currently monitored under the Facility Monitoring Program.

6.4.6 Operable Unit VI

Groundwater: As shown on trend **Figure 6-22**, monitoring over the past five years continues to show a steady decline in ethylene dibromide (EDB) concentrations as the plume migrates south and is captured and treated by the EDB treatment system. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 to 1.2 µg/L in 2015. The drinking water standard for EDB is 0.05 µg/L. A monitoring well was installed in 2011 to ensure that the eastern extent of the plume is defined. In addition, a new bypass monitoring well was installed in 2013 south of extraction well EW-2E to verify capture of the deeper contamination. EDB was not detected in the three bypass wells in 2013 and 2014. The plume is moving slower than originally simulated by the groundwater model during the system design. Therefore, the expected system operational period was extended to 2019 to ensure capture of the upgradient EDB.

[2] The 2006-2011 fish data sets are described in each of the respective annual Peconic River Monitoring Reports. The 2012 through 2015 fish data are presented in the annual Site Environmental Reports (e.g., BNL 2015c).

6.4.7 BGRR

Structures and Soil: Following cleanup, the maximum residual Cs-137 and Sr-90 concentrations were 89,000 pCi/g and 11,200 pCi/g, respectively. These samples were located adjacent to the secondary bustle on the northeast side of the below ground duct where it exits from Building 701. Excavation of these soil contamination pockets was not possible without compromising the building structure. Radiological surveys were completed to measure the extent of, and document, residual contamination. Soil samples were obtained to document the as-left conditions. The excavated areas have been backfilled, compacted and covered with an engineered asphalt cap to minimize water infiltration.

The installation of the final engineered cap was completed in May 2011. Removal of the bioshield was completed in May 2012. The completion and closeout reports document the final status of the various cleanup activities at the BGRR. For a complete list of these reports, see the reference list at the end of this report.

Repairs performed since 2013 as a result of surveillance and maintenance inspections include, window replacements in the former offices on the second and third floor, sealing of precipitation infiltration areas, roof repairs, and minor repairs to the cap.

Groundwater: See OU III Groundwater **Section 6.4.3** for groundwater data review.

6.4.8 g-2/BLIP/USTs

Groundwater: Groundwater monitoring at the g-2 and BLIP source areas has shown that the stormwater controls have been effective in preventing additional leaching of radionuclides from the activated soil shielding. At the BLIP facility, all tritium concentrations have been less than the 20,000 pCi/L MCL since early 2006. However, tritium concentrations continue to routinely exceed the 20,000 pCi/L MCL in the g-2 source area monitoring wells. During 2015, the maximum tritium concentration at the g-2 source area was 55,000 pCi/L. The continued detection of tritium at concentrations above the MCL appears to be related to water-table fluctuations and the flushing of residual tritium from the deep portion of the vadose (unsaturated) zone below the g-2 source area. The overall reductions in tritium concentrations observed in the source area wells suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing with time. See trend **Figure 6-23**. Contingency actions were developed in the ROD for the g-2 tritium plume. If tritium levels in the g-2 plume were to exceed 1,000,000 pCi/L anywhere in the plume or if the tritium plume did not attenuate to less than 20,000 pCi/L before reaching Brookhaven Avenue, an assessment would be made to determine whether additional remedial actions would be necessary.

From 1999 through 2015, a g-2 tritium plume segment (as defined by concentrations >20,000 pCi/L) was tracked from the source area to the vicinity of the National Synchrotron Light Source II facility, a distance of approximately 4,000 feet. In December 2011, tritium was detected above the 20,000 pCi/L contingency trigger level in several temporary wells installed south of Brookhaven Avenue, with a maximum concentration of 58,000 pCi/L. In response, BNL informed the regulatory agencies about the monitoring results, and recommended continued monitoring of the plume segment. Monitoring conducted from 2011 through 2015 verified that tritium levels in the plume segment attenuated to concentrations below the 20,000 pCi/L MCL.

No groundwater monitoring is required for the former UST areas.

Structures and Soil: BNL routinely inspects and maintains the caps and other stormwater controls at the g-2 and BLIP source areas. Over the last five years only minor repairs have been required for the BLIP and g-2 caps. During 2015, the Linac Y cap, which adjoins the BLIP cap to the north, was extended in several areas to provide protection of soil shielding that are expected to become activated following planned changes in beam line operations. For the former UST areas, no additional remedial actions were required.

6.4.9 HFBR

Groundwater: See OU III Groundwater **Section 6.4.3** for groundwater data review.

Structures and Soil: The report, *BNL High Flux Beam Reactor Characterization Summary Report, Rev 1* (BNL 2007e) summarizes the historical characterizations of the facility, including the reactor itself, systems and components, ancillary support structures, and the surrounding soil. These characterizations have involved direct radiation surveys, samples for radioactivity, and calculations of activated materials over a period of several years. The data summarized in this report have helped provide the basis for many of the actions taken to prepare the HFBR for decommissioning including; dismantling ancillary buildings in the HFBR complex in 2006; the removal and disposal of the HFBR control rod blades and beam plugs in 2008 and 2009; confinement building stabilization; removal of fan house, above and below ground structures, and associated soil removal; and underground utilities and associated soil removal. The removal of the Stack Silencer Baffles and Final Status Survey for remaining HFBR Outside areas was completed in November 2011. Completion and closeout reports document the final status of the various decommissioning activities at the HFBR (including BNL 2009c and 2010e). For a complete list of these reports, see the reference list at the end of this report.

Cleanup of the Waste Loading Area, and removal of Buildings 801-811 waste transfer lines (A/B waste lines with co-located piping) and associated soil were completed and documented in completion/closeout reports (BNL 2009c and 2010d). Sampling and analysis were conducted in accordance with the dose-based cleanup goal (15 mRem/year above background with 50 years of institutional control) and methodology specified in the OU I ROD to verify that the remaining soils meet the cleanup goal. The results were presented in the completion/closeout reports. Following cleanup, the average and maximum residual Cs-137 concentrations for the Waste Loading Area were 7.4 pCi/g and 61.3 pCi/g, respectively. Following cleanup, the average and maximum residual Cs-137 concentrations for the A/B waste line soils were 0.15 pCi/g and 1.0 pCi/g, respectively.

Repairs performed since 2013 as a result of surveillance and maintenance inspections include, building security system upgrades, roof repairs over the former machine shop area located outside of the confinement dome, re-caulking of a vent on the outside of the dome outside the generator room, and paving of the access road to the stack and minor repairs to the cap.

6.4.10 Groundwater Monitoring

Section 5.0 of the *BNL Groundwater Status Reports* identify changes to the well monitoring network at BNL (https://www.bnl.gov/gpg/gw-reports.php). Changes include the installation of additional temporary and permanent monitoring wells, well decommissioning, and modifications to monitoring frequency and analytical parameters. As shown in **Table 6-3**, from 2011 through 2015, 70 permanent wells were installed to enhance the monitoring networks for the various plumes. **Table 6-4** identifies the 25 monitoring wells that were decommissioned between 2011 and 2015 in accordance with State policy.

6.5 Inspections

Representative site inspections took place between April 30 and November 3, 2015 for the landfills, soils, Peconic River, and groundwater. Representatives from BNL and DOE attended. The purpose of the inspections was to assess the protectiveness of the various sites, including operating treatment systems and controls. No significant issues were identified during the site inspections. Since 2011, several changes have been made to the LUIC inspection process. These include recommending to no longer perform inspections of the former Building 355 landscape soils (since they were previously excavated and moved to the former

HWMF, as previously documented to the regulators) and the Old Firehouse (since the ROD calls for no further monitoring/maintenance of this area). Following remediation of the former A/B waste transfer lines and the former HWMF Perimeter Soils, these areas were added to the inspection process. The completed inspection checklists are included in **Attachment 3**. All of the groundwater systems are routinely inspected as part of the ongoing O&M. In addition, Tier 1 assessments that evaluate primarily safety and operational concerns are performed on all of the systems annually. Representatives of EPA also performed an inspection of the BNL site on June 9, 2016.

For the HFBR confinement dome, the frequency of the routine surveillances were changed from monthly to quarterly in 2011 as part of the long-term surveillance and maintenance program for this facility. There have been no significant issues during the inspections; however, routine repairs and maintenance have been performed over the last five years including roof repairs, collection of paint chips on the ground, collection and disposal of precipitation water generated from the stack, and paving of the stack access road. Structural inspections of the HFBR and the stack are performed annually. Overall the interior and exterior of the building and stack remain in good condition. Work planning is underway for safety improvements to the stack ladder and platforms in 2016.

The scope of routine surveillance activities at the BGRR includes radiological and environmental monitoring, house and grounds keeping, testing, inspection, and preventive maintenance and repair of required systems and equipment, removal of liquid waste, and verification of conditions throughout the BGRR complex. The surveillance frequencies are quarterly for the former offices and high bay, semi-annually for the engineered cap and below ground ducts, and annually for structural integrity. Repairs and maintenance performed over the last five years includes roof repair, office windows replacement, minor cap repair, and infiltration management.

The caps and other stormwater controls at the g-2 and BLIP source areas are inspected two times per year and inspection reports are submitted to the regulatory agencies annually. There have been no significant issues identified. Minor cap maintenance is performed on a routine basis.

6.6 Interviews

Interviews conducted in September and October 2015 consisted of discussions with the EPA, NYSDEC, NYSDOH, SCDHS, and DOE representatives. Questions from the list below were asked during the interview; however, each representative was not asked all of the questions on the list. Potential interview questions included:

- What is your overall impression of the cleanup at BNL?
- Are there any specific aspects of the cleanup that you feel should be of particular focus during the review?
- Do you feel well informed about BNL's cleanup activities and progress?
- Do you believe the public is sufficiently informed of the cleanup progress?
- Do you believe the remedies are functioning as expected by the RODs?
- Are you aware of any particular component of the cleanup decisions that pose a higher degree of difficulty in achieving?
- Are you aware of any recent or upcoming changes to federal or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health and the environment at BNL?
- Do you believe there are current opportunities to optimize operations and maintenance or sampling efforts at BNL that could result in cost savings or improved efficiency?
- What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL?

- Do you feel that BNL and DOE are actively managing the long-term cleanup operations for the site and are properly maintaining appropriate institutional controls?
- Do you have any comments, suggestions, or recommendations regarding BNL/DOE's management of the cleanup?

The following individuals were specifically contacted for interviews concerning the BNL site:

- Ms. Jessica Mollin - EPA Region 2
- Ms. Mindy Pensak, EPA Region 2
- Mr. Brian Jankauskas - NYSDEC
- Mr. Steve Karpinski - NYSDOH
- Mr. David O'Hehir - NYSDOH
- Mr. Andy Rapiejko- SCDHS
- Ms. Terri Kneitel - DOE

Most of the regulators interviewed were impressed with the progress of the cleanup and thought BNL and DOE have been very responsive to questions and issues identified by the regulators. They believe that BNL and DOE are actively managing the cleanup in accordance with the RODs, and do not believe there are any significant obstacles with achieving the ROD goals. Most of the regulators felt that the elevated mercury concentrations in one area of the Peconic River should be a particular focus during this review. In addition to concerns on the Peconic River path forward, the EPA Project Manager, a NYSDOH representative, and the SCDHS representative feel that BNL and DOE are properly maintaining appropriate institutional controls. NYSDOH also wants to see focus on the plans for moving forward with the removal of the HFBR stack by 2020, and believes the biggest risk in achieving the cleanup goals are unknown source areas for groundwater contamination. The NYSDEC Project Manager has positive impressions of the BNL cleanup, would like to see the sensitive environment of the Peconic River assessed when determining the path forward, and is also concerned with potential future unknown groundwater contamination that could impact meeting the ROD goals. SCDHS was very positive about the progress of the cleanup, and BNL and DOE are diligently monitoring the groundwater to help avoid any unknowns. The County also feels it is important for the Laboratory to have the funding and staff to continue the cleanup and long-term monitoring effort. The DOE representative believes that the cleanup is progressing as expected and that the Laboratory is doing a good job. She feels that focus should continue to be placed on the Peconic River sediment and believes that the biggest risk would be the identification of a continuing source of Sr-90. The interview summaries are included under **Attachment 4**.

7.0 Technical Assessment

The following subsections assess both the soil and groundwater remedies by Operable Unit and address the three EPA-designated questions. Information on the majority of the soil cleanup work was completed prior to the last two Five-Year Reviews and can be found in those documents (https://www.bnl.gov/gpg/5year-review.php). BNL performs a comprehensive assessment of each of the groundwater treatment systems' operation, performance, plume monitoring information and opportunities for optimization as part of the annual Groundwater Status Report. The 2015 Report (*2015 BNL Groundwater Status Report* [BNL 2016a]) and reports from prior years are available for review.

The only significant institutional control issues noted over the previous five years are as follow:

- A key institutional control for the groundwater treatment systems located off of the BNL property is to ensure that the property access agreements are in place and have not been violated. To date, all requirements of the access agreements have been met, including communicating the LUICs and restrictions to the property owners. To date, the use of the properties has conformed to these controls. However, the recording of the deeds for these properties with the Suffolk County Clerk's Office to reflect the controls and restrictions (i.e., easements) related to operation of the treatment systems is not complete. All seven property license/access agreements have a requirement for recording except for LIPA, but there is a conveyance provision in that agreement. The only agreement that has been recorded to date is for the original Industrial Park system. Two of the remaining five property owners signed the New York State Transfer Tax Form TP-584 and were subsequently signed by DOE in 2014. BSA is responsible for completing the endorsement forms for these two properties for filing with the County Clerk. Efforts by BSA will continue to be made to record the remaining agreements with the County Clerk.
- During a 2013 LUIC inspection, topsoil was observed being temporarily staged along the road between the former Chemical Holes and the Long Island Solar Farm. The work was being performed by a subcontractor to the solar farm maintenance DOE contractor. The soil piles were infringing on a portion of the former Chemical Holes area. Although there was evidence that the ground surface was slightly scraped, no signs of digging were evident. Following discussions between the inspection team and the subcontractor, worked ceased and DOE was informed of the incident. It was determined that this was not a breach of institutional controls; however, BSA and DOE conducted a follow-up investigation as to why the subcontractor did not communicate to DOE/BSA the work that was performed outside of the solar farm easement areas as stipulated in the Easement Management Agreement. A formal *Lessons Learned* was published which identified recommended actions to ensure better communication and coordination of any work activity associated with the solar farm. An additional LUIC information sign was installed at the former Chemical Holes area.

7.1 Operable Unit I

OU I Question A: Is the remedy functioning as intended by the decision documents?

OU I Remedial Action Performance

- Based on a review of the closeout reports completed for the soil/disposal pit cleanups and wetland restoration, site inspections, and regulatory interviews, the remedies were implemented in accordance with the OU I ROD and the soil cleanup levels were met. This achieved the objectives of preventing human exposure including direct external exposure, ingestion, inhalation, and dermal contact, as well as environmental exposure to contaminants. Reconstruction of the Upland Recharge/Meadow Marsh Area wetlands was successfully implemented and has minimized uptake of contaminants in the soil/sediment by ecological receptors, including the eastern tiger salamander. Reconstruction activities included the planting of aquatic vegetation plants within the pond, planting of native grasses adjacent to the pond, and the addition of rip-rap on the pond slopes to prevent erosion. Reconstruction of the former HWMF wetlands was performed in mid-2005. For the soil excavation remedies completed, such as the former HWMF, Building 811, and the former residual surface soils at the Chemical Holes, the work was performed in accordance with the ROD, applicable design documents, and Remedial Action Work Plans. The third and final phase of cleanup for the radiological soil contamination within the former HWMF Perimeter Area (AOC 1J) was completed in 2014. The soil cleanup levels defined in the ROD have been met for these areas. Buildings 810 and 811 were demolished in 2015 following their decommissioning from active use. The removal of contaminated soils associated with these buildings was initiated in 2015 and work is nearing completion. A final status survey will be performed following the completion of soil remediation and an independent verification will be conducted by ORISE. An additional area of shallow radiological soil has been identified along the northern fence line separating this area from the Collider Accelerator Department storage yard. This area will be placed under institutional controls until remediation is completed.

- The landfill areas were capped in accordance with the ROD and the NYS Part 360 requirements. The buried waste is contained and groundwater monitoring results indicate that the caps have achieved the objective to minimize the further leaching of contaminants from the soil into the groundwater. Although groundwater monitoring results for the Current Landfill indicate that several VOCs (e.g., chloroethane and benzene) and metals (e.g., iron and sodium) continue to be detected at concentrations above MCLs in several downgradient wells, there has been an overall reduction in VOC concentrations since the landfill was capped in 1995. Elevated levels of VOCs continue to emanate from a location on the northeast side of the landfill. Characterization work to assess the downgradient migration of these VOCs is being performed in 2016. The monitoring network will be supplemented with several new wells to allow for more precise monitoring of these VOCs. Previous downgradient monitoring of VOCs from this location indicates that concentrations attenuate to below the DWS before they arrive at the southern site boundary. The groundwater model will be updated following the completion of the latest characterization effort and the attenuation of VOCs from this area will be simulated. Furthermore, although low levels of tritium and Sr-90 continue to be detected in the Current Landfill monitoring wells, all concentrations have been below MCLs since 1998. At the Former Landfill, there has been an overall reduction in contaminant concentrations since it was capped in 1996. Currently all VOC and radionuclide (e.g., tritium and Sr-90) concentrations are below MCLs. Iron concentrations continue to exceed MCLs in one downgradient well. The soil cover placed on the ash pit prevents direct contact with the metals in surface soils and prevents the potential migration of the metals by wind.
- The OU I groundwater pump and treat system has been in operation since 1997, and is effectively remediating groundwater contamination originating from the former HWMF and the Current Landfill. The OU I groundwater treatment system was placed in standby mode in July 2013 following regulatory approval of the *Petition for Shutdown* (BNL 2013b). TVOC concentrations have remained below the capture goal of 50 µg/L in both the monitoring and extraction wells associated with this plume. There has been no evidence of VOC concentration rebound since the system was shut down.

OU I System Operations/O&M

- BNL performs monthly surveillance of the caps and associated drainage structures at the Current and Former Landfill areas. Although evidence of burrowing by small animals is common at the Current Landfill, the burrows do not penetrate beyond the outer soil layer, and therefore do not affect the protectiveness of the cap. As they are found, the burrows are filled in and repaired. Grass areas are periodically mowed, and small pine seedlings are removed before their roots can damage the caps. Monthly inspections will continue to ensure that the caps are properly maintained and repaired.
- The OU I treatment system operated without any significant down time or maintenance issues since 1997 and the system effluent has consistently met the discharge requirements. The system has

remained in an operationally ready mode since it was shut down and placed in standby in 2013. The O&M manual identifies required preventative maintenance tasks, and there do not appear to be any issues that would impact future operations or the effectiveness of the remedy.

OU I Costs of System Operations/O&M

Since the OU I treatment system was shut down in 2013, the average annual O&M cost is approximately $59K. This does not include project engineering, project management, or groundwater monitoring well sampling and analysis costs.

OU I Implementation of Institutional Controls and Other Measures

The land use and institutional controls that are in place and maintained for OU I include:

- Postings to communicate potential hazards and aid in controlling access at areas such as Building 650 Sump Outfall, Upland Recharge/Meadow Marsh pond, and former HWMF.
- No activities shall be permitted in the Landfills and Ash Pit areas that could compromise the integrity of the caps.
- Institutional controls for all three phases of the former HWMF Perimeter Areas are being implemented. The Phase II area was granted to the Long Island Solar Farm in 2010 via an easement from DOE. The cleanup of Phase II allowed for industrial reuse as the solar farm, but prohibits soil removal from this area.
- Fencing around cleanup areas such as the Current Landfill and former HWMF to aid in controlling physical access.
- Maintenance of landfill engineered caps to prevent continued groundwater contamination and covers over residual soil contamination to aid in preventing the direct exposure of such contamination to site workers, visitors, and wildlife.
- Several wetland areas that may contain protected habitats are adjacent to the former HWMF. NYSDEC regulates all work within 100 feet of wetlands with confirmed protected species habitats. Any work activities within 100 feet of a wetland requires DOE and NYSDEC notification and approval.
- BNL limits activities within 850 feet of wetlands with confirmed protected species habitats.
- Restrictions/controls on the pumping and recharge of groundwater on the BNL site until cleanup levels are achieved. This will help maintain consistent groundwater flow directions.
- Groundwater monitoring to track contaminant plumes as well as reporting in the Annual Groundwater Status Report.

No activities were observed at OU I that would have violated these institutional controls.

OU I Monitoring Activities

- The monitoring data obtained from the groundwater monitoring wells and the treatment system provide the basis to evaluate system performance and effectiveness. The monitoring wells for the OU I plume and treatment system are categorized as background, core, perimeter, or bypass wells. The landfill areas are monitored by upgradient and downgradient wells. Descriptions of the wells that are sampled and their monitoring frequencies are presented in the annual *BNL Environmental Monitoring Plan* (BNL 2016b). The monitoring data are reported in the annual *BNL Groundwater Status Report* (BNL 2016a) and the *BNL Environmental Monitoring Report – Current and Former Landfill Areas* (BNL 2016c).
- The Sr-90 source area in the former HWMF was characterized in 2015 and 2016 utilizing temporary wells in response to a *2014 Groundwater Status Report* (BNL 2015d) recommendation. An area of elevated Sr-90 concentrations ranging up to 302 pCi/L was observed from the central portion of the former facility extending approximately 2,200 feet to the south.

OU I Early Indicators of Potential Issues

- In 2015 and 2016, groundwater characterization identified Sr-90 in groundwater at the former HWMF at higher concentrations than were previously observed (See **Section 6.4**). The groundwater model was updated in March/April 2016 with the recent characterization data and the attenuation of Sr-90 from the former HWMF was simulated. The model predicts that a small area of Sr-90 at or just above the DWS of 8 pCi/L will arrive at the site boundary in approximately 42 years (by 2058). The groundwater model update is provided in Appendix I of the *2015 Groundwater Status Report* https://www.bnl.gov/gpg/gw-reports.php. The OU I ROD selected the 1996 interim remedy of natural attenuation, monitoring, and institutional controls as the final remedy for this area. The 1996 Action Memo (BNL 1996b) presents further details on the remedy.
- There do not appear to be any problems or issues at this time that could place protectiveness of the remedies at risk.

OU I Opportunities for Optimization

- The recent characterization of an area of Sr-90 contamination in groundwater migrating from the center of the former HWMF yard requires additional and continued monitoring. The monitoring can be achieved with new monitoring wells, the periodic installation of temporary wells using the Geoprobe®, or a combination of the two. The next Five-Year Review Report will evaluate the model-predicted Sr-90 attenuation by comparing monitoring data with the model projections.

OU I Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

OU I Changes in Standards and items To Be Considered (TBCs)

- As identified in **Attachment 5**, the standards or TBCs in the OU I ROD have not changed, nor do they call into question the protectiveness of the remedy. Except for the lowering of the arsenic standard in 2001, radiological soil cleanup levels and the MCLs for drinking water are unchanged since the signing of the ROD in 1999. EPA's third Six-Year Review of the drinking water standards is expected to be completed in 2016. The last review was completed in 2010. **Attachment 6** provides the cleanup levels for the OU I primary contaminants of concern.

OU I Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU I or in the use of the site that would reduce the protectiveness of the remedies or require updates to the risk assessment. The exposure assumptions used in the original risk assessment are consistent with current land use.
- In 2006, a preliminary screening of the OU I groundwater VOC plume was performed to evaluate the potential for soil vapor intrusion. The Current Landfill is the only OU I area of VOC contamination that is close to an inhabited building. Although groundwater contamination immediately beneath the Current Landfill is shallow and the levels of several VOCs exceed MCLs, the closest office building is approximately 1,000 feet upgradient of the landfill. Therefore, the subsurface vapor to indoor air pathway is incomplete, and no further evaluation is needed. The downgradient portion of the plume is deeper and has a clean layer of groundwater above. Therefore the contaminants are not present in the uppermost portion of the groundwater (i.e., water table) to present a soil-gas concern. The previous Five-Year Review presented the soil vapor intrusion screening for the plume.
- In the event that further construction is planned at BNL within the area of the OU I VOC groundwater plume, landfills, or former HWMF, BSA will reevaluate any potential issues and, if necessary, undertake appropriate measures to address them. Any construction projects to be undertaken at the Lab are reviewed for environmental, security, and safety and health concerns in the conceptual design or early planning phase. BSA procedure *EP-ES&H-500, Project*

Environmental, Security, Safety and Health Review, includes an *ES&H 500A Evaluation Form* that requires any potential issues, such as potential soil vapor gas intrusion, be identified, documented, and mitigated, if necessary. In addition, the LUCMP and the groundwater plumes factsheet will be revised to reflect the potential for soil vapor intrusion should new buildings be proposed.

- As discussed in **Section 6.4.1** above, additional soil-gas samples were obtained in 2016 southeast of the Current Landfill. There were no detections of soil gas in any of the samples. However, another round will be collected during a dry period to confirm the readings.

OU I Expected Progress in Meeting Remedial Action Objectives

- Projects completed to date within OU I continue to meet the remedial action objectives identified in the OU I ROD, based on post-excavation confirmatory soil sampling results, continued monitoring of the surface waters and sediment, groundwater monitoring downgradient of potential source areas, and visual inspections of remediated areas. Institutional controls continue to remain effective.
- The OU I groundwater restoration project is on schedule for meeting the ROD cleanup goal of reaching MCLs for VOCs in the Upper Glacial aquifer within 30 years (by 2030). As long as no significant rebound in VOCs are observed, the system will remain in standby mode for two more years, then a *Petition for Closure* of the system will be submitted to the regulators for review and approval. This period of monitored natural attenuation will reduce any remaining low-level VOCs in the plume to below MCLs.
- Based on the groundwater model update, the Sr-90 from the former HWMF is projected to be at or near the DWS when it reaches the site boundary by approximately 2058. Monitoring of the plume will continue and comparison of the data with the model projected concentrations will be performed.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no additional information that calls into question the protectiveness of the remedies at OU I.

7.2 Operable Unit II

The AOCs in this OU are documented in the OU I and OU III RODs, except for BLIP, which was documented in the g-2/BLIP/UST ROD. The following questions relate to remedial actions taken at the BLIP facility.

OU II Question A: Is the remedy functioning as intended by the decision documents?

- Silica grout was injected into the activated soil at the BLIP facility in 2000. This Removal Action was an additional protective measure to further reduce the permeability of the activated soil. Moreover, it would reduce the potential impact of rainwater leaching radionuclides into the groundwater should the primary stormwater controls fail. The g-2/BLIP/USTs ROD included requirements for maintenance of the building roof drains and surrounding cap (including paved areas and gunite cap), and continued groundwater monitoring. No further monitoring of the silica grout injection is required.
- As reported in the *BLIP Closeout Report Removal Action AOC 16K* (BNL 2001d), the injection of the silica grout at BLIP can be characterized as successful; however, its deployment was not. Although the objectives of minimizing threats to human health, migration of contaminants to the groundwater, and migration from operations of the facility in the future appear to have been met, the displacement of contaminated soil-pore water during the grout injection process caused a short-term impact to groundwater quality. As a result, the goal of improving the control of the activation

area "without harm to the environment" was not achieved. As discussed in **Section 6.4** above, the concentrations of tritium in the groundwater have remained less than the 20,000 pCi/L MCL since early 2006.

- The cap inspection and repair are included under BNL's Preventative Maintenance Program. The gunite cap, paved areas, and roof drains at BLIP are in good condition and are effectively controlling stormwater infiltration. Although direct inspection or maintenance 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.
- Semiannual groundwater monitoring in the immediate vicinity of BLIP continues per the *BNL Environmental Monitoring Plan* (BNL 2016b), and the monitoring results are summarized in the annual *Groundwater Status Report*.

The final remedy for the BLIP facility was documented in the g-2/BLIP/USTs ROD which was signed in 2007.

OU II Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

- The Remedial Action Objective to prevent further migration of radionuclides from the activated soil to the groundwater is still valid. There have been no changes to the exposure assumptions or the MCLs.
- There have been no physical changes to the BLIP area except as an added measure of protection, a new protective concrete cap over the Linac-to-BLIP spur was constructed in late 2004, and the spur cap was further extended in several areas in 2015. The spur is where the beam line from the Linac is kicked into the Linac-to-BLIP beam line, and is an area where beam losses have the potential to activate the surrounding soil shielding.

OU II Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no additional information that calls into question the protectiveness of the remedy at BLIP.

7.3 Operable Unit III

OU III Question A: Is the remedy functioning as intended by the decision documents?

OU III Remedial Action Performance

- The OU III groundwater plumes are tracked and monitored via a comprehensive network of temporary and permanent monitoring wells on and off of the BNL property. Plume and system monitoring data and system performance and recommendations for optimization are described in the annual *BNL Groundwater Status Reports.*
- The groundwater remediation program remains on track to reach the overall groundwater cleanup objectives as defined by the OU III ROD and modified by the OU III ESDs. These objectives are:
    - Meet MCLs for VOCs and tritium in the Upper Glacial aquifer by 2030.
    - Meet MCLs for Sr-90 at the former Chemical Holes plume and the BGRR/WCF plumes by 2040 and 2070, respectively.
    - Meet MCLs for VOCs in the Magothy aquifer by 2065.
- Remediation of the OU III plumes began in 1997. Fourteen of BNL's 17 groundwater treatment systems are included under OU III. Nine of these systems are currently in active operation. Two systems met the cleanup goals and were dismantled (Carbon Tetrachloride and Industrial Park East) and three systems (North Street East, HFBR Tritium Pump and Recharge, and Building 452 Freon-

11) are in standby mode and will be restarted if needed.

- The operational timeframe of several treatment systems have recently been extended to ensure capture of upgradient contamination, and two of the systems approved for shutdown were restarted due to rebound of contaminants. However, these systems are still on track to meet the cleanup objectives in the ROD.
- A detailed discussion of the progress of the OU III groundwater remediation is available in the *2015 BNL Groundwater Status Report* (BNL 2016a) (see **Attachment 2** for the CD or https://www.bnl.gov/gpg/gw-reports.php).
- DOE continues to offer free annual water testing to three homeowners known to be using a private well for drinking water purposes in the OU III public water hookup area. The last time the homeowners accepted the annual test was in 2015. The test results indicate that the water quality complies with NYS drinking water standards, except for iron, which can cause taste, stain, and odor problems. In addition to iron, one residential well detected manganese and nitrates above drinking water standards. For that well, Suffolk County recommended that the homeowner not use their well water supply for consumptive purposes, and to either connect to a public water supply or use NYSDOH-certified bottled water.
- The additional extraction wells installed between 2012 and late 2014 at the Middle Road, South Boundary, and Industrial Park systems are addressing the VOC contamination that is deeper than the extraction recirculation wells originally installed in these areas. These wells are addressing contamination in the deep Upper Glacial/Magothy aquifer interface.

OU III System Operations/O&M

The operation of each of the treatment systems is evaluated in a number of ways: weekly during project status meetings, monthly during preparation of the NYSDEC SPDES discharge monitoring reports, during preparation of the quarterly operation reports, and annually in the *Groundwater Status Report.* These evaluations include review of the extraction well and system influent data, treatment system midpoint data, if appropriate, and the effluent data. The systems' O&M manuals identify required preventative maintenance tasks (BNL 2002-2012). The systems are routinely inspected and can also be monitored remotely via a system which allows for the control panel information to be viewed from the Groundwater Protection Group office. There do not appear to be any issues that would impact continued operations or the effectiveness of the remedy. The BNL Preventive Maintenance Program helps to eliminate unnecessary system shutdowns due to routine wear and tear on equipment. Maintenance of remediation system recharge basins, such as periodic scraping to remove sediment buildup, is performed in accordance with the *Natural Resource Management Plan for Brookhaven National Laboratory* (BNL 2011f) to ensure protection of potential eastern tiger salamander habitats.

The VOC treatment systems experienced mostly minor downtime or other operational issues over the past five years, and treatment system discharges have consistently met the NYSDEC SPDES discharge equivalency permit requirements. However, there have been three instances where a treatment system was not sampled due to a scheduling error. A sample tracking tool is used to help ensure that samples are collected monthly while the systems are operating. There was one instance of an exceedance of total xylenes in the BGRR system effluent just above the discharge limit. Xylene has never been detected in the system influent, and it is believed that this detection was due to sample contamination or from maintenance work performed on the treatment system that may have inadvertently introduced the contaminant. These excursions are documented in NYSDEC Noncompliance Reports. A summary of issues, successes, and lessons learned from the operation of the various treatment systems follows.

- The Middle Road and South Boundary treated effluent is distributed between the OU III basin and the RA V basin. This is accomplished through the use of a wet well adjacent to the air strippers and allows for the management of the amount of water that is discharged to each basin. This balancing of discharges, in combination with carefully coordinating water withdrawals from BNL's potable water supply wells, has been very successful in allowing for the maintenance of relatively steady groundwater flow directions on the BNL site and minimizing the potential shifting of plumes. Due to repairs needed on BNL's potable water supply wells or Water Treatment Plant, there were two instances over the last five years where the eastern supply wells were used to provide the majority of the Laboratory's water supply for several months. This resulted in a noticeable change in groundwater flow directions in several areas, including a slight eastward shift in the movement of the g-2 tritium plume near the source area.

- Resin usage for the Sr-90 treatment systems remain lower than originally estimated, resulting in lower operational costs. To increase their reliability, minor modifications were made to the systems' design; at the Chemical Holes treatment system the post-treatment bag filters were removed, and at the BGRR system the post-treatment bag filters were relocated to the pretreatment process stream. These helped to reduce maintenance costs.
- In 2015, a change was made to the method of disposal of the spent Sr-90 resin from the treatment systems which resulted in cost savings and waste minimization. Instead of disposing of the entire vessel that contains the spent resin as low-level radioactive waste, the resin is now vacuumed from the vessels and disposed of in 55-gallon drums. The vessels are then reused.
- The recirculation wells in the Industrial Park require more maintenance to keep them operational than conventional extraction wells and injection wells. This is due to the increased amount of equipment associated with them and the difficulties in cleaning the double screen design. The injection screens on the seven recirculation wells are cleaned on an annual basis to remove iron deposition that causes clogging.
- In 2013 there was a water leak at the pitless adaptor at one of the Chemical Holes Sr-90 system extraction wells, resulting in the discharge of untreated water to the nearby ground surface. DOE and the regulators were immediately notified. Monitoring data indicated that all Sr-90 concentrations in the untreated water from that well had been below the 8 pCi/L MCL during the year prior to the leak. The well piping/connection was quickly repaired. As a preventative measure, a portion of the steel piping that was connected to the second extraction well was also replaced. This was not an issue with the original extraction well at the Chemical Holes system since it was installed in a vault.
- In 2015, a hole was found in the submersible pump drop pipe on one of the extraction wells at the Middle Road system which caused water to shoot up out of the top of the pitless adaptor of the well. The regulators were informed of the untreated water discharge, and the drop pipe and well screen were subsequently repaired. A NYSDEC Noncompliance Report was issued. The remaining extraction wells at this system were also evaluated to ensure the same issue did not occur.
- Lightning strikes in the vicinity of the treatment systems have caused numerous problems with the control systems. Systems are periodically disabled due to this issue. The programs for each system are backed up and spares of parts frequently impacted are stocked in order to mitigate system downtime. This is also a sitewide problem for other BNL utilities.
- Flow meter failures have been a common problem. Both mechanical and digital meters have been used and there have been durability issues with each type. Changing some of the meters to a different manufacturer has increased durability.
- Due to prolonged repairs to BNL's meteorological tower, which houses the antennae used to communicate with the off-site groundwater treatment systems, the LIPA Magothy extraction well had several weeks of downtime over the last year. Fortunately, VOC concentrations were significantly below the system capture goal during 2015. The tower repairs were completed in March 2016.

OU III Costs of System Operations/O&M

- The O&M costs over the past five years for the OU III treatment systems are presented in **Table 4-1** in **Section 4.3**. The largest overall cost drivers for the systems are electricity and disposal or reuse of spent carbon and resins. It should be noted that the O&M costs in this document do not include costs for Field Engineering and Project Management or costs associated with sampling and analysis of the monitoring wells associated with each project.

- BNL continues to successfully minimize costs for many of the systems by shutting off extraction wells when influent concentration data and groundwater contamination levels at a given location are very low and meet the shutdown criteria. The extraction wells remain in standby mode and continue to be monitored. A few of the extraction wells were restarted due to rebound in VOC concentrations. A depiction of the current status of the individual extraction wells is provided on **Figure 4-3**.
- Due to the extensive use of activated carbon for the treatment of VOCs, a large-scale carbon services contract was awarded based on competitive bidding. The contractor performing this work regenerates the carbon in batches and returns the cleaned carbon back to that specific project the next time a carbon replacement is needed.
- Access agreements were negotiated with private property owners to allow the operation of treatment systems on their property. In consideration for access for the North Street East system, payments of $85K per year will be made to the property owners for as long as the treatment system is on their property. Although access agreements are also in place for the other off-site treatment systems (Industrial Park, North Street, Airport and LIPA), no lease fees are required because they are either constructed on publicly owned property, along public right-of-ways, or the property owner did not request compensation for the use of the property.

OU III Implementation of Institutional Controls and Other Measures

Institutional controls are in place at BNL to ensure the effectiveness of all groundwater remedies. The OU III groundwater LUICs continue to be maintained and are effective in protecting human health and the environment. During the past five years, there have been no activities at any of the OU III areas that would have violated these institutional controls.

The LUICs that are in place and maintained for OU III include:

- Groundwater quality is monitored in the vicinity of each treatment system to evaluate the system's performance and to detect any change in conditions that might result in the system not meeting its stated objective or threatening a water supply source. The details of this monitoring program are described in the *BNL Environmental Monitoring Plan* (BNL 2016b).
- Extensive groundwater monitoring program to track contaminant plumes and reporting of the data.
- Monitoring of BNL potable supply system and SCDHS monitoring of Suffolk County Water Authority (SCWA) well fields closest to BNL.
- Remediation progress is continually assessed by project managers and reported annually in the *Groundwater Status Report*.
- In accordance with CERCLA, five-year reviews are performed until cleanup goals are met and to help determine the effectiveness of the groundwater remediation program.
- Controls are placed on the installation of new supply wells and recharge basins on BNL property.
- Public water service has been offered in plume areas south of BNL.
- BNL maintains an internal Water and Sanitary Planning Team to coordinate operational activities on the BNL site that may impact groundwater flow directions and possible plume migration pathways. The committee also tracks and evaluates changes in groundwater management activities off of the BNL site (i.e. water withdrawals and recharge operations) to determine if they could affect BNL groundwater remedies.
- Property access agreements for treatment systems off of BNL property are in place and the requirements are being met.
- The treatment systems installed off of the BNL site are fenced, and have locked and alarmed buildings. No significant security violations have been identified.

OU III Monitoring Activities

- Monitoring data for the treatment systems and associated groundwater monitoring wells are used to evaluate the performance and effectiveness of the remediation activities. These data are reported in the annual *BNL Groundwater Status Report.*
- Proposed changes to the groundwater monitoring program are presented each year in the annual *BNL Groundwater Status Report* and are implemented following regulatory approval. Changes to several of the OU III plume monitoring networks were recommended in the *2015 BNL Groundwater Status Report* (BNL 2016a). Typically, these modifications include the installation of additional permanent and temporary monitoring wells, changes in sampling frequency for wells, changes in analytical procedures, or the decommissioning of monitoring wells no longer needed. Proposed changes are designed to improve contaminant plume tracking and obtain the information required to assess remediation progress. **Tables 6-3 and 6-4** summarize the permanent monitoring wells installed and those decommissioned by well identification number over the last five years.

OU III Early Indicators of Potential Issues

- In 2010, groundwater modeling results suggested that following the removal of the PCE-contaminated soil from the Building 96 source area, the treatment system should achieve the capture goal of 50 µg/L TVOCs by 2016. The most likely cause for increased remedial pumping duration is the presence of residual amounts of PCE beneath the excavation being mobilized to groundwater. Another potential issue is whether there are any additional sources of PCE that have not been identified. Additional sources appear unlikely due to results of extensive soil-gas surveys and soil sampling conducted in the area in 2008 and 2015. Groundwater monitoring results near the former source area indicate that PCE concentrations have been significantly decreasing over the last three years. The system is currently projected to continue operating until 2018.
- Several of the Sr-90 plumes on the site have similar issues that are being addressed:
    - Since 2011, when high concentrations of Sr-90 were observed in BGRR extraction well SR-3 (located immediately downgradient of the below ground ducts), the levels have significantly dropped off. However, Sr-90 concentrations in the two source area monitoring wells upgradient of this extraction well have shown significant increases and decreases from 2011 through 2015. There appears to be a correlation between the water-table elevation fluctuations and the release of residual Sr-90 in the deep vadose zone. The fluctuations are not controlled or caused by on-site activities; rather, they are the result of natural fluctuations in the elevation of the water table as a result of long- and short-term groundwater recharge variations. The persistence of this residual Sr-90 source, which was not accounted for in the groundwater modeling projections, will require the treatment system to operate longer than originally planned.
    - Periodic increases in Sr-90 concentrations at the former WCF present a similar issue to that discussed above for the BGRR. These extraction wells are also operating longer than originally planned. To help optimize the groundwater cleanup at this area, in 2015 and 2016 WCF Buildings 810 and 811 were removed along with contaminated soil, thereby reducing any residual Sr-90 source(s) that may have been present.
    - Elevated concentrations of Sr-90 continue to be detected in the former Chemical Holes source area and monitoring wells upgradient of extraction well EW-1. Characterization efforts since 2012, which included a comprehensive soil investigation in 2015, failed to identify a continuing source area. The rise and fall of the water table appears to be flushing the residual Sr-90 from the deep vadose zone. Groundwater modeling performed in 2015 identified the need to extend the operational period of the groundwater treatment system in order to meet the drinking water standard before 2040.
- 2016 characterization of groundwater in the upgradient portion of the Western South Boundary plume identified elevated VOCs deeper than expected. Freon-12 was not identified above the standard, however significant concentrations of other VOCs were. Further monitoring and

groundwater modeling will be needed to evaluate the nature and extent of this deeper contamination.

- Additional elevated detections of EDB in the North Street East plume over the next couple of years could result in the restart of extraction well NSE-1. This could delay the planned closure/decommissioning of this system, however, it is not expected to impact meeting the overall cleanup objective.
- Although the operational period of several of the treatment systems has been extended compared to the original designs, it is expected that the overall groundwater cleanup objectives will be met.
- There do not appear to be any problems or issues at this time that could place protectiveness of the remaining remedies at risk.

OU III Opportunities for Optimization

Optimization of several of the OU III groundwater treatment systems was recommended as part of the *2013 BNL Groundwater Status Report*. Several other optimization recommendations are planned for the 2015 Report. The status of each of the groundwater treatment systems is shown on **Figure 4-2** and the operational status of the extraction wells is provided on **Figure 4-3**. These changes are based on an evaluation of treatment system and monitoring well contaminant concentration trends. A summary of optimization activities and opportunities include:

- Additional groundwater extraction wells were installed from 2012 through 2014 to address the deep VOC contamination identified at the Middle Road, South Boundary, and Industrial Park areas. These modifications will help ensure that the cleanup objectives for the Upper Glacial and Magothy aquifers will be met.
- As noted in **Section 6.4.3**, many of the treatment system extraction wells have been in pulsed pumping mode (e.g., on one month, off the next) due to a reduction in contaminant concentrations, or have been shut down. In several cases, entire systems have been shut down following regulatory approval. The systems and monitoring wells continue to be monitored during this time to evaluate if any rebound in contamination is identified. In some cases, systems have been turned back on temporarily to address this situation. **Table 6-1** provides the operational status of each treatment system.
- The existing BGRR/WCF and Chemical Holes treatment systems are successfully capturing the Sr-90 plumes; however, the cleanup period is longer than originally anticipated. This is primarily due to the continued release of Sr-90 from the vadose zone to the aquifer, which was not accounted for in the original design modeling. Efforts to locate a continuing source in the vadose zone and/or reduce infiltration through capping, if successful, would reduce the time required for active pumping to remove the Sr-90. A 2015 review of other DOE sites (**Attachment 5)** identified a trend over the last five years towards installing permeable reactive barriers that would allow for decay of the Sr-90 *in-situ*. However, use of a permeable reactive barrier at BNL is probably not feasible due to the absence of a competent geologic layer to key into and the high initial cost of barrier installation. Options will continue to be reviewed if the duration of the strontium plume cleanup remains a concern.
    - To reduce the time for active pump and treat of the Sr-90 plumes requires either: a) removal of the vadose zone source term or b) capping at the surface to reduce or eliminate surface recharge (from precipitation and/or runoff) and thereby the flux of water and Sr-90 through the unsaturated zone and into the aquifer. However, finding the exact location of the source would be extremely difficult (particularly beneath the BGRR). Even with a cap, a rising water table will continue to add strontium from the vadose zone until the soil in the zone of water-table fluctuation is depleted of Sr-90. To help optimize the groundwater cleanup, in 2015 and 2016 WCF Buildings 810 and 811 were removed along with residual contaminated soil. As noted above, an extensive soil characterization effort was conducted in 2015 in the former source area upgradient of the Chemical Holes extraction wells, but failed to identify a continuing source in the vadose zone.

- Optimization of the groundwater monitoring program is performed on an annual basis. Adjustments to sampling frequencies are performed based on a review of the plume data and the data quality objectives. For example, the HFBR tritium plume monitoring program has seen a reduction in the number of permanent wells needed to monitor the plume, from 103 wells in 2011 to 25 wells in 2016.

OU III Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU III Changes in Standards and TBCs

The standards or TBCs identified in the OU III ROD have not changed, nor do they call into question the protectiveness of the remedy. There have been no substantial changes to the regulations since 2010. Groundwater MCL values were last updated in 2008 (NYS) and 2009 (EPA). Guidance for radioactively contaminated soils has been issued in 2013 (NYS) but the dose limit of 10 mRem/year above background that was used to set BNL cleanup levels has not changed. **Attachment 5** provides a review of any changes to the soil cleanup and drinking water standards and **Attachment 6** provides the cleanup levels for the OU III primary contaminants of concern. The PCB soil cleanup levels and MCLs for groundwater have remained the same since 1999.

OU III Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU III or in the use of the site that would reduce the protectiveness of the remedies or render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2000.
- The number of homes that continue to use their private well as their sole source of drinking water remains at three within the OU III area. DOE continues to offer free annual water testing to these homeowners.
- In 2011, a new source of groundwater contamination was identified within OU III which required the construction of the Building 452 Freon-11 treatment system. This plume did not impact the operation of any potable supply wells. From 2012 through 2016, the treatment system removed approximately 100 pounds of Freon-11 from the aquifer and successfully reduced the Freon-11 concentrations to below the 50 µg/L cleanup goal. The system was placed in standby mode in March 2016.
- The drop in hexavalent chromium concentrations in the Building 96 plume over the last few years indicates that it has converted back to the trivalent form, which is less toxic. As a result, further sampling was eliminated in 2015.
- A preliminary initial soil vapor screening of the OU III VOC groundwater plumes and the potential impact to existing and planned buildings was documented in the *2011 Five-Year Review Report* (2011a). Since a clean layer of groundwater exists above these plumes, the subsurface to indoor air pathway is incomplete and no further evaluation was needed at that time. Since 2011, no additional buildings were constructed at BNL that weren't previously evaluated.
- An upcoming construction project that BNL has been envisioning for the last few years is a Federal land-use project to create a science and technology gateway zone. This *Discovery Park* would be located outside the main security area to foster complimentary community and economic impact. The proposed site, the previously developed 40-acre apartment area, is contiguous to the research core of BNL and adjacent to the main entrance and William Floyd Parkway. The project would include offices, housing, and technical space. Planning studies will begin in 2016, with a goal for the start of the first phase of construction in 2018. A soil vapor screening for this area will be performed as plans are further developed.

- In the event that further construction is planned at BNL within the area of the OU III VOC groundwater plumes, BNL will reevaluate any potential exposure issues and, if necessary, undertake appropriate measures to address them. Any construction projects to be undertaken at BNL are reviewed for environmental, security, and safety and health concerns in the conceptual design or early planning phase. BNL procedure *EP-ES&H-500, Project Environmental, Security, Safety and Health Review,* includes an *ES&H 500A Evaluation Form* that requires any potential issues, such as potential soil vapor gas intrusion, be identified, documented, and mitigated, if necessary. In addition, the *BNL Land Use Controls Management Plan* and the LUIC groundwater plume factsheets will be revised to reflect the potential for soil vapor intrusion should new buildings be proposed.

OU III Expected Progress in Meeting RAOs

- There are currently nine groundwater remediation systems in operation under OU III. All the systems are on track for meeting the ROD and ESDs cleanup goal of reaching MCLs in the aquifer and preventing or minimizing plume growth. The *2015 BNL Groundwater Status Report* (BNL 2016a) evaluates each system's performance based on decision rules identified from the BNL groundwater Data Quality Objective (DQO) process (see *BNL Environmental Monitoring Plan* [BNL 2016b] for discussions of the DQO process).
- **Figure 7-1** provides a graphical representation of the status of the planned operational timeline of each treatment system. As noted previously, the original planned operational period of several systems has been extended; however, they are still on track to meet their overall groundwater cleanup goals. Of the 14 treatment systems in OU III, two have met their goals and were decommissioned, and three were shut down and placed in standby mode.
- Within the last four years, the Building 452 Freon-11 groundwater treatment system has successfully decreased the high Freon-11 concentrations levels to below the capture goal. This is consistent with the original projections identified in the 2012 ESD.
- With the addition of the four new extraction wells to capture the deep OU III VOC plume from Middle Road to the Industrial Park, BNL will be on track to meet the objectives of reducing VOCs in the Upper Glacial and Magothy aquifers to below MCLs by 2030 and 2065, respectively.
- BNL will remain alert to any new Sr-90 remediation techniques and technologies, as well as any operational efficiency that might accomplish cleanup sooner.
- The property access agreements for the groundwater treatment systems off of BNL property need to be recorded with the County Clerk.
- There are no known issues with any of the institutional controls that could jeopardize their future operation.

OU III Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has come to light that calls into question the protectiveness of the OU III remedies. No newly identified ecological risks or impacts from natural disasters have been found within OU III.

7.4 Operable Unit IV

OU IV Question A: Is the remedy functioning as intended by the decision documents?

Although the OU IV ROD states that a Five-Year Review of this remedial action is not necessary, the following items are provided as a summary.

- The OU IV remedial action objectives have been satisfied. The soil/groundwater treatment AS/SVE system met its cleanup objectives and the regulators approved its dismantlement in 2003. A fence was installed as an interim measure around the Building 650 Sump Outfall in 1995 prior to excavation of the soil. The excavation of the radiologically contaminated soil in the Building 650 Sump, along with the discharge pipe and Sump Outfall, was included under the OU I ROD and was completed in 2002.

- The remediation has achieved the objectives of preventing or minimizing the leaching of contaminants from the soil into the groundwater, human exposure (including ingestion, inhalation, and dermal contact), and the uptake of contaminants present in the soil and groundwater by plants and animals.
- BNL continues to monitor for VOCs in groundwater at select wells downgradient of the former AS/SVE system, as well as monitoring for Sr-90 at the Building 650 Sump and Sump Outfall per the *BNL Environmental Monitoring Plan* (BNL 2016b). Sr-90 continues to attenuate as predicted as it migrates slowly to the south. Characterization work in 2015 identified the leading edge of an area of Sr-90 above DWS located just to the north of Brookhaven Avenue. The results are reported in the 2015 *BNL Groundwater Status Report* (BNL 2016a).
- The AS/SVE-remediated area is classified for unrestricted industrial use.

OU IV Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

- The standards or TBCs identified in the OU IV ROD have not changed, nor do they call into question the protectiveness of the remedy. The radiological soil cleanup levels and the MCLs for drinking water have remained the same since 1999. **Attachment 6** provides the cleanup levels for the OU IV primary contaminants of concern.
- The remedial action objectives have been met and have not changed.
- The groundwater within OU IV is not contaminated with VOCs above MCLs; therefore, subsurface vapor intrusion is not an issue.

OU IV Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information calls into question the protectiveness of the remedy at OU IV.

7.5 Operable Unit V

OU V Question A: Is the remedy functioning as intended by the decision documents?

OU V Remedial Action Performance

- VOC concentrations were below MCLs as of 2013 and tritium concentrations remain less than the 20,000 pCi/L MCL. As a result, all groundwater monitoring requirements for OU V have been met. In January 2011, supplemental remediation of PR-WC-06 and PR-SS-15, as well as removal of the Sediment Trap was completed. The Completion Report (BNL 2012h) was issued in 2012 and the regulators provided their approval.
- The Peconic River remedy performed as intended:
    - The 2004/2005 Peconic River cleanup of mercury in the sediment has led to substantially reduced mercury concentrations in fish. Although there was a rise in concentrations from 2011 through 2015, the average mercury levels in fish for 2011 and 2015 remain lower than the pre-2004/2005 cleanup values. Reduced mercury concentrations mitigate potential health impacts for human and wildlife consumers of fish.
    - Routine sediment monitoring has functioned as intended by identifying one small on-site area with elevated mercury concentrations in the sediment that merits removal. The plan for cleanup of this area is being reviewed with the regulators.

- In addition to the ROD-related environmental cleanups of the BNL STP soils and the Peconic River on-site and off-site sediment, remediation of the STP digester sludge and sand filter beds were completed in 2009. Mercury concentrations in the STP effluent have been substantially lower since completion of the removal and shipment of the sand filter waste. The average of the two 2014 STP effluent Peconic River water-column monitoring program samples (31 ng/L) was substantially lower than the average mercury concentration for the six 2006 – 2009 samples (106 ng/L).
- To help further improve Peconic River water quality, beginning in September 2014 the treated STP effluent is now recharged directly to groundwater rather than continuing to discharge into the Peconic River. This change, together with the completed sludge digester/sand filter bed remediation and the completed Peconic River sediment removal, are anticipated to even further reduce mercury concentrations in the Peconic River.

OU V System Operations/O&M

As required by the OU V Peconic River ROD, a long-term monitoring program was implemented to ensure protection of human health and the environment. This monitoring program, conducted from 2006 through 2010, included: mercury, PCBs and cesium-137 in sediment; total mercury and methyl mercury in the water column; and mercury, PCBs and cesium-137 in fish on and off of BNL property, as appropriate. The sediment, surface-water and fish monitoring results for each year since completion of the 2004/2005 cleanup (i.e., 2006-2011) are available in the annual *Peconic River Monitoring Reports* (BNL 2007f, 2008a, 2009e, 2010f, 2011h and 2012g). As noted in **Section 6.4.5** above, based on the previous five years of data, the monitoring program was reduced starting in 2011. The 2011 through 2015 monitoring requirements are identified in the *Soil and Peconic River Surveillance and Maintenance Plan* (BNL 2013f).

OU V Costs of System Operations/O&M (Not applicable for this project.)

OU V Implementation of Institutional Controls and Other Measures

Institutional controls are in place at BNL to ensure the effectiveness of all remedies. The OU V land use and institutional controls continue to be maintained and effective in protecting human health and the environment. During the past five years, there have been no activities at any of the OU V areas that would have violated these institutional controls.

The land use and institutional controls that are in place and maintained for OU V include:

- The New York State general advisory on the consumption of freshwater fish caught from New York freshwaters applies to the Peconic River. The advisory is to eat no more than one meal (1/2 pound) of fish per week.
- The DOE does not envision any sale or transfer of property in the Peconic River area. If it were to occur, the sale or transfer would meet the requirements of Section 120 (h) of CERCLA to ensure that future users are not exposed to unacceptable levels of contamination.
- In accordance with CERCLA, five-year reviews will be performed until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program and sediment remediation.
- Controls have been placed on the installation of new supply wells and recharge basins on BNL property.
- NYSDEC regulations regulate all work within 100 feet of wetlands with confirmed protected species habitats. Any work activities within 100 feet of a wetland requires DOE and NYSDEC notification and approval.
- BNL limits activities within 850 feet of wetlands with confirmed protected species habitats.

OU V Monitoring Activities

- From 2011 to 2015, Peconic River post-cleanup monitoring included collection of: sediment samples at three locations per year; surface-water samples at 15 locations two times per year; fish samples every other year; and wetland monitoring to ensure vegetation success. This work is performed in accordance with the *Soil and Peconic River Surveillance and Maintenance Plan* (BNL 2013f). Beginning in 2012, the annual monitoring results are summarized in the annual *BNL Site Environmental Report* which can be found at https://www.bnl.gov/esh/env/ser/.

- Detailed sediment sampling in 2014 and 2015 identified the need to perform supplemental remediation of one remaining area in the Peconic River, PR-WC-06.
- Due to the reduced water levels in the river, the number of surface-water samples has drastically dropped since 2011. The mercury concentrations in the STP discharge through 2014, as well as values in the river, have been significantly reduced since the 2006 to 2010 timeframe.
- Mercury concentrations in fish during the 2011, 2013, and 2015 collections have varied and were somewhat higher than the 2006 to 2010 average values. However, the 2011 and 2015 average values are still less than the 2004/2005 pre-cleanup average mercury levels.
- In 2013, NYSDEC concurred that the wetland monitoring and maintenance performed by BNL from 2011 through 2012 satisfied the conditions in the equivalency permit, and no further monitoring was needed. In 2014, BNL also satisfied the federal duration requirements for monitoring and control of invasive species in the three supplemental remediated areas. The details of the monitoring efforts are presented in the *2012 Wetland Monitoring Status Report* (Roux 2013a) and the *2013* and *2014 Invasive Species Monitoring and Control Letter Reports* (Roux 2013b and 2014).
- All groundwater monitoring requirements were met in 2013, and no further sampling is needed. See the *2013 Groundwater Status Report* (BNL 2014a) for more information.

OU V Early Indicators of Potential Issues

- Disposal of the excavated sediment from the supplemental cleanup of Area PR-WC-06 is planned at a Subtitle D facility. The previous sediment cleanups in 2004/2005 and 2011 disposed of the waste in this manner. However, a justification for release of the waste to this facility needs to be prepared and approved by DOE, with concurrence from NYSDEC and NYSDOH. If the concentrations of radionuclides (such as Cs-137) in the sediment do not meet the release limit criteria, then the waste would need to be disposed of as low-level radioactive waste. This will not have an impact on the protectiveness of the remedy, but will significantly impact the cost for disposal.
- The planned excavation of Area PR-WC-06 is expected to be performed during a dry period, typically in the summer/early fall. Should the river and groundwater levels significantly increase during this time, implementation of the excavation would be complicated and require the use of river diversion/bypass and significant groundwater dewatering. Although the cleanup is still technically feasible, it will require a more significant effort and subsequent cost implications.

OU V Opportunities for Monitoring Optimization

- As discussed in **Section 6.4.5** above, VOC concentrations have remained below MCLs and perchlorate was below the NYSDOH Action Level and EPA Interim Lifetime Drinking Water Health Advisory level. As a result, the groundwater sampling requirements for OU V have been met and no further monitoring is required.
- Concurrent with the preparation of the 2016 Five-Year Review Report, DOE proposed, and the regulators agreed, to optimize the Peconic River remedy and perform a supplemental sediment removal in one remaining area (PR-WC-06). The supplemental sediment removal is expected to begin in summer/fall of 2018. Residual mercury concentrations in the Peconic River sediment and the proposed sediment cleanup area are shown in **Figure 7-2**.
- The Peconic River ROD states that after the first five years of monitoring are completed (2006 - 2010) and the data are reviewed by EPA, NYSDEC and SCDHS, appropriate modifications will be

made as necessary for subsequent sampling.[3] These modifications were identified in the 2011 Five-Year Review Report (BNL 2011a) and summarized in **Section 6.4.5** above.

- As a result of the continued long-term monitoring performed from 2006 through 2015, additional modifications to the Peconic River monitoring program are recommended. These modifications are supported by the following analytical data:
  - Approximately 2,380 confirmation sediment samples collected during the 2004 to 2005 20-acre excavation to ensure that the cleanup goals from the ROD were met;
  - Approximately 1,700 post-cleanup sediment, surface-water, and fish monitoring samples collected between 2006 and 2010;
  - 37 confirmation sediment samples collected in December 2010 and January 2011 at the supplemental excavation of PR-WC-06, Sediment Trap, and PR-SS-15 areas to ensure that the sediment cleanup goals from the ROD were met;
  - Annual samples collected from 2011 through 2015 at the supplemental cleanup areas PR-WC-06, former Sediment Trap, and PR-SS-15;
  - 140 sediment samples collected in 2014 and 2015 to characterize area PR-WC-06;
  - 80 surface-water samples collected between 2011 and 2015;
  - 219 fish samples collected in 2011, 2013, and 2015;
  - Approximately 43,000 native transplants were planted in the remediated areas of the river during the 2004/2005 cleanup, and additional revegetation performed during the 2010/2011 supplemental cleanup;
  - Removal of invasive species following the 2004/2005 and 2011 cleanups; and
  - Monitoring and maintenance of wetland vegetation following the 2004/2005 and 2011 sediment cleanups in accordance with the equivalency permits.

- All long-term monitoring data collected during the last 10 years have been reviewed by and with the DOE, EPA, NYSDEC, NYSDOH, and the SCDHS. Modifications to sediment, water column and fish monitoring are discussed below.

Table 7-1: Recommendations for Peconic River Optimization

	2011 - 2015 Requirements	2016	Comments
Surface Water	15 samples 2x/yr - Hg, MeHg, TSS	Discontinue	
Sediment	1 sample annually (SS-15 and former Sediment Trap)	Discontinue	All values were below 2.0 mg/kg of mercury
	1 sample annually (PR-WC-06)	Perform supplemental sediment cleanup	Obtain confirmatory sediment samples every 100 square feet following the excavation.
Fish	4 locations every other year (2011, 2013, 2015)	Discontinue	
	Age determination on all fish	Discontinue	
Vegetation	NYSDEC - Monitor for 2 full growing seasons for plant survival and invasive species control (4/2011 - 9/2012) EPA - 3 to 5 years for invasive species control	TBD based on discussion w/regulators	Allow river to naturally recover following the planned excavation at Area PR-WC-06 in 2018.

[3] *Final Operable Unit V Record of Decision for Area of Concern 30 (Peconic River)*, page 38, paragraph 2.

Sediment Monitoring Modifications

- The 2011 through 2015 long-term sediment monitoring results presented in **Section 6.4.5** for Areas PR-SS-15 and the former Sediment Trap indicate that all samples are below the ROD cleanup goal that all mercury samples in the remediated areas would be less than 2.0 mg/kg[4]. **BNL recommends that sediment monitoring at these two stations be discontinued in 2016. Data indicate that monitoring is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy**.
- In accordance with the *Draft Plan for Optimization of the Peconic River Remedy PR-WC-06 Area,* (BNL 2016d), **BNL recommends that excavation and offsite disposal of sediment containing elevated mercury greater than 2.0 mg/kg be performed at Area PR-WC-06**. The excavation will extend approximately five feet beyond downstream sample point PR-WC-06-D1-L50-145. Following the excavation, confirmatory sediment samples will be collected at a density of 100 square feet to ensure that the sediment cleanup goals from the ROD are met (average mercury concentration of less than 1.0 mg/kg and all individual samples are less than 2.0 mg/kg). **BNL recommends that following the supplemental remediation at Area PR-WC-06 and successful confirmatory sampling, long-term sampling of this area be discontinued. Data indicate that sampling is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy.** The data from the post-cleanup confirmation samples will be reported in a completion report.

Surface-Water Monitoring Optimization

- As shown on **Figure 6-17**, the 2011-2015 Peconic River water column mercury concentrations are higher between station STP-EFF-UVG and PR-WC-02 than at the stations located upstream and downstream of this section of the river. However, the mercury concentrations in the STP discharge through 2014, as well as the values in the river, have been significantly reduced since the 2006 to 2010 timeframe. As noted previously, as of September 2014, the STP no longer discharges into the Peconic River.
- As discussed in **Section 6.4.5** above, methyl mercury concentrations from 2011 through 2015 are higher at stations PR-WC-12-D7 (located upstream of the former STP) and PR-WC-06. However, the methyl mercury concentrations are significantly lower than the data from 2006 to 2010.
- Sufficient water quality data have been collected over the past 10 years to support **BNL's recommendation that routine water-column monitoring for total mercury, methyl mercury and Total Suspended Solids (TSS) at the 15 stations between PR-WC-15 (upstream of STP-EFF-UVG) and PR-WC-02 be discontinued in 2016. Data indicate that is monitoring is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy.**

Fish Monitoring Optimization

Fish tissue mercury concentrations have varied during the 2011, 2013, and 2015 collections. The annual average fish tissue mercury concentrations for the three sampling events were; 0.31 mg/kg in 2011, 0.69 mg/kg in 2013, and 0.40 mg/kg in 2015. These are higher than the 2006 through 2010 average of 0.28 mg/kg, but the 2011 and 2015 values are still lower than the 1997 and 2001 pre-cleanup concentration (0.58 mg/kg). Since there is no action or cleanup level for mercury in fish identified in the ROD, the EPA mercury criterion for fish of 0.3 mg/kg has been used for reference purposes. Factors that may have contributed to the increased mercury levels in fish over the last five years include reduced sample size, fish age, fish size, food consumed, and limited open water areas.

- Based on the data collected over the past 10 years following the 2004/2005 cleanup, there does not appear to be any significant increasing or declining trends in mercury concentrations in fish.

[4] *Final Operable Unit V Record of Decision for Area of Concern 30 (Peconic River),* page 28, paragraph 4.

Flow in the on-site portion of the river has become increasingly intermittent over the last couple of years since there is no continuing discharge to the river. These seasonal variations are also not favorable for the survival of fish populations. **BNL recommends that fish monitoring, including age determination, be discontinued in 2016. Data indicate that monitoring is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy.**

- As a best management practice, BNL will continue to periodically monitor fish under the environmental surveillance monitoring program every other year (even years) provided sufficient river water levels are present to support fish populations. These monitoring requirements are identified in the *Environmental Monitoring Plan* (BNL 2016b) and are subject to change annually.

OU V Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU V Changes in Standards and TBCs

The standards or TBCs identified in the OU V ROD have not changed, nor do they call into question the protectiveness of the remedy. The mercury sediment cleanup level and the MCLs for drinking water have remained the same since 1999. An Interim Lifetime Drinking Water Health Advisory for perchlorate of 15 µg/L was established by EPA in 2012. This is lower than the NYSDOH Action Level for perchlorate of 18 µg/L in drinking water supply wells. **Attachment 5** provides a review of the applicable standards and **Attachment 6** provides the cleanup levels for the OU V primary contaminants of concern.

OU V Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU V or in the use of the STP, the Peconic River, or the groundwater that would reduce the protectiveness of the remedies or render the initial risk analysis invalid. The exposure assumptions used in the original risk assessment are consistent with current land use.
- The diversion of the STP effluent from the Peconic River to a nearby groundwater recharge basin in September 2014 has resulted in a significant change in the extent of wet stream-bed and open water in the on-site portions of the Peconic River. This in turn affects the potential availability of fish and surface-water sampling on site. This change also eliminated continued discharges of low levels of metals (such as mercury) to the river.
- DOE continues to offer free annual water testing to the one homeowner known to be using a private well for drinking water purposes in the OU V public water hookup area. The last time the homeowner accepted the annual test was in 2013. To date, all test results indicate that the water quality complies with NYS drinking water standards.
- No new contaminants or sources of contamination have been identified within OU V, and no unanticipated toxic byproducts have been detected.

OU V Expected Progress in Meeting RAOs

- Excavation of the radiologically and metal-contaminated sediment at the STP and in the Peconic River on and off of BNL property met the appropriate cleanup levels and remedial action objectives specified in the OU V STP and Peconic River RODs. A monitoring program was implemented to demonstrate the effectiveness of the Peconic River cleanup to mitigate potential ecological effects.
- Based on 10 years of post-cleanup, long-term monitoring, the Peconic River remedy remains protective of human health and the environment. Supplemental remediation, followed by post-

excavation confirmatory sampling in one small area will be completed. It is recommended that further monitoring of the Peconic River be discontinued.
- Groundwater monitoring in OU V has demonstrated that MCLs have been met in 2013 and no further monitoring was needed.

OU V Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified ecological risks or impacts from natural disasters have been found within OU V. No additional information has come to light that calls into question the protectiveness of the OU V remedies.

7.6 Operable Unit VI

OU VI Question A: Is the remedy functioning as intended by the decision documents?

OU VI Remedial Action Performance
- The OU VI EDB groundwater plume has been defined and continues to be monitored via a network of monitoring wells on and off of BNL property. The plume is currently positioned entirely south of the BNL site.
- The EDB groundwater treatment system was installed in accordance with the OU VI ROD, and began operating in August 2004. EDB is being captured by the extraction wells and the hydraulic capture performance of the system is being met as described in the *2015 BNL GroundwaterStatus* Report (BNL 2016a). The system is currently on schedule to meet the cleanup goal of reaching the MCL by 2030.
- DOE continues to offer free annual water testing to the two remaining known homeowners still using private wells for drinking water purposes in the OU VI public water hookup area. The results for all samples have showed compliance with the NYS drinking water standards.

OU VI System Operations/O&M
- The system O&M manual identifies required preventative maintenance tasks. There do not appear to be any issues that would impact continued operations or the effectiveness of the remedy. The BNL Preventive Maintenance Program helps to eliminate unnecessary system shutdowns due to routine wear and tear on equipment.
- The treatment system operation is evaluated monthly during preparation of the discharge monitoring reports, quarterly during preparation of the quarterly operation reports, and annually in the *BNL Groundwater Status Report.* These evaluations include review of the extraction well and system influent data, treatment system midpoint data, and the effluent data.

OU VI Costs of System Operations/O&M
- The system has been operational for 11 years and the average annual O&M cost is approximately $225K. The largest overall cost drivers for the system are annual property access payments, carbon change-outs, and electricity.
- Since the OU VI ROD was signed in 2001, two access agreements were negotiated with private property owners to allow for treatment system operations on their property. In consideration for the agreements, total payments of $85K per year are made to the property owners as long as the treatment system is on their property. These costs are in addition to the payments required for the OU III systems discussed above.

OU VI Implementation of Institutional Controls and Other Measures

The OU VI groundwater land use and institutional controls continue to be maintained and effective in protecting human health and the environment. Based on inspections, no activities were observed at OU VI that would have violated these institutional controls.

OU VI Monitoring Activities

- The monitoring data obtained from the EDB treatment system and the plume monitoring wells provide the basis to evaluate the remediation system's performance and effectiveness.
- Changes to the OU VI plume monitoring network are recommended in the annual *BNL Groundwater Status Report*. These modifications, such as additional monitoring wells and temporary wells, would increase BNL's confidence in the plume's distribution and remediation progress.

OU VI Opportunities for Optimization

The existing treatment system is successfully capturing the EDB plume, however at a slower rate than originally anticipated. Two treatment options, enhanced *in-situ* biodegradation or adding new treatment wells, could reduce the time required to meet the drinking water standard of 0.05 µg/L EDB in the aquifer. However, considering the cost of implementing these options, it appears that continued operation of the existing two extraction wells is the most cost-effective solution to meet the cleanup goal at this time.

OU VI Early Indicators of Potential Issues

There do not appear to be any problems or issues at this time that could place protectiveness of the remedy at risk. Although the system was planned to be shut down in 2015, the data and updated groundwater modeling indicate the system will need to operate until 2019. This increased duration will not impact the ROD cleanup goal of reaching MCL by 2030.

OU VI Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

OU VI Changes in Standards and TBCs

- The regulatory standards or TBCs identified in the OU VI ROD have not changed, nor do they call into question the protectiveness of the remedy. The EDB standard and the MCL of 0.05 µg/L for drinking water have remained the same since 1999. **Attachment 6** provides the cleanup level for the OU VI primary contaminant of concern.
- There have been no detections of EDB in the system effluent above SPDES equivalency permit levels since the system began operations in 2004. In 2009, the NYSDEC changed the SPDES equivalency permit discharge level for EDB from 0.05 µg/L to 0.03 µg/L. There have been no detections of EDB in the system effluent above this more stringent discharge level.

OU VI Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within OU VI or in the use of the site that would reduce the protectiveness of the remedies or render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2001.
- DOE continues to offer free annual water testing to the two homeowners in the OU VI plume area who are still using their private wells for drinking purposes. The results for all samples were below the NYS drinking water standards.
- A preliminary initial screening of the OU VI groundwater VOC plume was performed during the 2011 Five-Year Review to evaluate the potential for soil vapor intrusion. The portion of the plume that exceeds the MCL is located off of the BNL property, is deeper, and has a clean layer of groundwater above. Therefore the contaminants are not present in the uppermost portion of the groundwater to complete an exposure pathway and present a soil-gas concern.

OU VI Expected Progress in Meeting RAOs

- The annual *BNL Groundwater Status Report* evaluates the system's performance based on decisions identified from the BNL groundwater DQO process (See *BNL Environmental Monitoring Plan* [BNL 2016b] for the DQO process). As described in the *2015 BNL Groundwater Status Report* (BNL 2016a), EDB concentrations are expected to be below the 0.05 µg/L MCL by 2030, as required by the OU VI ROD.
- The two property access agreements for the groundwater treatment system need to be recorded with the County Clerk.

OU VI Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified ecological risks or impacts from natural disasters have been found within OU VI. No additional information has come to light that calls into question the protectiveness of the OU VI remedy.

7.7 BGRR

BGRR Question A: Is the remedy functioning as intended by the decision documents?

BGRR Remedial Action Performance

- As described in the completion and closeout reports to date, site inspections, and regulatory interviews, the interim cleanup measures were implemented in accordance with the Action Memoranda and NEPA categorical exclusions, and are consistent with the BGRR ROD. This has achieved the remedial action objectives of protecting human health from the hazards posed by the radiological inventory at the BGRR using the ALARA principle (i.e., limiting worker exposure) and implementing monitoring, maintenance, and institutional controls to manage remaining hazards. Specific activities completed to help reduce the radiological inventory, to reduce the potential for exposure, and to prevent the future migration of radiological contamination into surrounding soil and groundwater include:
    - Removal of primary air cooling fans – Removed and properly disposed of contaminated equipment in the fan rooms and decontaminated or fixed surface contamination (Note: Fanhouse buildings and soil were removed under the HFBR ROD).
    - Removal of the Pile Fan Sump, pipes, and contaminated soil
    - Removal of above-ground ducts, pipes, and contaminated soil – Prevented low-level radioisotopes from being released to soil and potential migration into groundwater
    - Removal of canal and water treatment house, piping, and accessible contaminated soils – Reduced the amount of contamination in the concrete structures of the canal and removed contaminated surface soil
    - Removal of the exhaust cooling coils and filters
    - Removal of BGD primary liner
    - Sealing of the BGDs
- The April 2005 completion of the removal of the canal structure and subsurface contaminated soil located outside the footprint of the reactor building was performed in accordance with the Action Memorandum (BNL 2005g) and is consistent with the selected remedy in the BGRR ROD. A completion report was prepared and issued to the regulators in 2005.
- In 2005, a temporary asphalt cap was installed over the soil areas to minimize water infiltration prior to the final cap installation.
- In May 2010, Graphite Pile removal was completed in accordance with the ROD. A final closeout report was issued to the regulators in October 2010.

- In May 2012, the biological shield removal and the final engineered cap installation to prevent water infiltration were completed.

BGRR System Operations/O&M

As required by the BGRR ROD, long-term surveillance and maintenance activities are conducted to ensure effectiveness of the remedy. Specific measures are being implemented for the BGRR project. They include the following:

- Routine environmental health and safety monitoring
- Radiation detection monitoring
- Secure access via locked doors
- Periodic structural inspections of Building 701
- Water intrusion monitoring
- Preventive maintenance of Building 701 and the infiltration management system
- Groundwater monitoring required as part of the OU III ROD and the ESD
- Periodic inspections of the below-ground ducts
- Periodic maintenance and repairs as identified during the inspections, such as the window replacements in the former offices on the second and third floor and roof repairs performed in 2014 and 2015.

BGRR Costs of System Operations/O&M

The estimated cost of long-term surveillance and maintenance activities is approximately $200K annually (in FY15 dollars) for routine surveillance and groundwater monitoring. Additionally, surveillance and maintenance costs for the BGRR include upkeep every 10 years for the infiltration barrier and $760K every 20 years to refurbish the Building 701 exterior facade and roof system. The surveillance and maintenance activities include radiation and environmental monitoring, the testing, inspection, and maintenance/repair of essential equipment and components, and verification of conditions throughout the facilities including the below-ground ducts. Activities also include preventative and corrective maintenance on the temporary asphalt cap to ensure its integrity.

BGRR Implementation of Land Use and Institutional Controls and Other Measures

In addition to the administrative controls placed on the future land use at BNL, the following specific institutional controls are being implemented:

- Control measures for future excavation of residual subsurface contamination. No digging, drilling, ground-disturbing activities, or groundwater shall be extracted within the area designated on Figure 10-1 of the BGRR ROD (https://www.bnl.gov/bgrr/docs/BGRRRecordofDecision.pdf) unless the activity has undergone a BNL review process, which includes, but is not limited to, the restrictions in BNL's LUCMP and the BNL digging permit review for any excavations. Any activity that occurs deeper than 15 feet will require EPA concurrence.
- Specific land use restrictions are established within the BNL LUCMP limiting future use and development of the BGRR complex to commercial or industrial uses only. Additionally, any future plans for excavation of the inaccessible contaminated soils will include the assessment of risk to human health and the environment based on the actual distribution, depth, and concentrations of the residual radioactive material encountered.
- Annual certification is provided to the regulators verifying that the institutional controls and engineering controls put in place are unchanged from the previous certification, and that nothing has occurred that would impair the ability of the control to protect public health or the environment. The annual certification is prepared and submitted by a professional engineer or environmental professional accepted by NYSDEC.
- Land-use restrictions and reporting requirements will be passed on to any/all future landowners through an environmental easement on the deed to the property. In light of the fact that a deed does not exist for property owned by a federal entity, DOE will be responsible for implementing,

enforcing, maintaining, and reporting on these controls. Although DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the DOE or its successor agency shall retain ultimate responsibility for remedy integrity. Upon transfer of the property to a nonfederal entity by the U.S. government, a deed will be established and an environmental easement will be added to the deed at that time.

BGRR Monitoring Activities

- Monitoring environmental health and safety, such as radiological dose monitoring, is an important component of the surveillance and maintenance work. Work is planned to limit worker exposure throughout all phases of the surveillance and maintenance effort.
- Groundwater monitoring in the vicinity of the BGRR complex will continue throughout the institutional control period. Results of the OU III BGRR/WCF monitoring program will be used to help verify the effectiveness of the BGRR remedy.
- Water intrusion monitoring is routinely performed in accordance with the surveillance and maintenance manual for the BGRR to ensure that water does not infiltrate into contaminated areas of the BGRR complex, which could potentially cause the migration of radiological contamination into surrounding soils and groundwater.

BGRR Opportunities for Optimization

- There are no opportunities for optimization of the remedial or surveillance and maintenance activities at this time.

BGRR Early Indicators of Potential Issues

- A potential continuing source of Sr-90 contamination beneath the BGRR below-ground ducts is a concern for the groundwater remediation system. See **Section 7.3** for additional discussion.
- Water intrusion from the roof and walls, although minor at this time, is accelerating the degradation of the brick work on the south wall and may be an issue for the long-term maintenance of Building 701. The quantity of water has not been enough to cause any accumulation of water in the building.

BGRR Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

BGRR Changes in Standards and TBCs

The standards or TBCs, including DOE Orders, identified in the BGRR ROD have not changed, nor do they call into question the protectiveness of the remedy. See **Attachment 5** for a review of the standards and TBCs.

BGRR Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within the BGRR complex or in the use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2005.
- No new contaminants or sources of contamination have been identified within the BGRR, and no unanticipated toxic byproducts have been detected.

BGRR Expected Progress in Meeting RAOs

- A significant effort has already been completed with the removal and disposal of contaminated components, structures, water, and soil at the BGRR complex. Based on sampling results, continued monitoring and surveillance of the facility, groundwater monitoring downgradient of potential source areas, and visual inspections of remediated areas, those projects completed to date continue to meet the remedial action objectives identified in the ROD.

  - A portion of the radiological inventory at the BGRR has been either removed or stabilized as a result of the cleanup actions.
  - The implementation of long-term monitoring, maintenance, and institutional controls continues for the BGRR.
  - The overall remedy removed over 99 percent of the radioactive material inventory at the BGRR complex.
  - The Building 701 structure and engineered cap protect the contaminated soil and components that will remain under the building footprint. It will form a significant barrier to future excavation and direct exposure, and serve as an effective barrier to prevent the migration of the remaining contaminants to groundwater.
  - Water infiltration management and institutional controls are effective in protecting human health and the environment.
- As noted in **Section 7.3** above, BNL will carefully evaluate the performance and efficiency of the Sr-90 ion exchange treatment system implemented for remediation of the BGRR/WCF plumes to ensure that they are on track to meet the objective as stated in the OU III ROD and ESD of meeting the MCL in the aquifer within 70 years. BNL will also remain alert to any new Sr-90 remediation techniques and technologies as well as any operational efficiencies that might accomplish cleanup sooner with less remediation waste. Continued evaluation of the potential continuing source of Sr-90 contamination from the BGRR below-ground ducts will be performed.

BGRR Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified risks, impacts from natural disasters, or land use changes have been found within the BGRR complex. No additional information has come to light that calls into question the protectiveness of the BGRR remedy.

7.8 g-2/BLIP/USTs

g-2/BLIP/USTs Question A: Is the remedy functioning as intended by the decision documents?

g-2/BLIP/USTs Remedial Action Performance

- Groundwater monitoring at the BLIP source area has shown that the stormwater controls have been effective in preventing additional leaching of radionuclides from the activated soil shielding. All tritium concentrations have been below the 20,000 pCi/L MCL since early 2006. During 2015, the maximum tritium concentration in the BLIP monitoring wells was 2,690 pCi/L. The stormwater controls (e.g., gunite cap, paved area, and drainage system for the building) are routinely inspected and maintained. Furthermore, the silica grout injected into the activated soil at the BLIP facility during the 2000 Removal Action provides an additional protective measure by reducing the permeability of the activated soil and the ability of rainwater to leach out contaminants should the primary stormwater controls fail. Although direct inspection or maintenance of the silica grout is not possible, it is expected to be in good condition.
- The cap at the g-2 source area is routinely inspected and maintained. Although the cap is effectively preventing rainwater infiltration into the remaining activated soil shielding, tritium concentrations in source area monitoring wells continue to periodically exceed the 20,000 pCi/L MCL. During 2015, the maximum tritium concentration in the source area wells was 55,000 pCi/L. As in past years, periodic, short-term increases in tritium concentrations appear to be related to water-table fluctuations and the flushing of residual tritium from the deep portion of the vadose (unsaturated) zone below the source area. The overall reductions in tritium concentrations observed in source area wells suggest that the amount of residual tritium that is available to be flushed out of

the deep vadose zone is decreasing. Continued monitoring is required to verify the long-term effectiveness of the engineered controls.

- Tritium concentrations in the downgradient g-2 plume segment have attenuated (via radioactive decay and dispersion) to concentrations less than the 20,000 pCi/L MCL. The reductions in tritium concentrations are consistent with model predictions of decay and dispersion effects on the plume segments with distance from the source area. No additional remedial actions or continued monitoring for this plume segment is required.
- No groundwater monitoring is required for the former UST areas.

g-2/BLIP/USTs System Operations/O&M

As required by the 2007 ROD, long-term cap maintenance activities are conducted to ensure effectiveness of the remedy. The BNL LUCMP contains sitewide control measures and land-use restrictions to prevent exposure to environmental contamination and to protect the integrity of remedies specified within the g-2/BLIP/USTs ROD and other approved RODs. To accomplish this objective, specific measures are being implemented for the g-2/BLIP project. They include the following.

- Routine inspections and maintenance of the caps and other stormwater controls at the g-2 source area and BLIP facility
- Groundwater monitoring required to verify that the source controls remain effective
- There are no actions associated with the former UST areas.

g-2/BLIP/USTs Costs of System Operations/O&M

The estimated annual costs for routine cap inspections and groundwater monitoring are:

- Approximately $10,000 for routine inspections and minor maintenance of the caps and other stormwater controls at the g-2 source area and BLIP facility.
- Approximately $10,000 for groundwater monitoring at the g-2 source area and approximately $4,000 for monitoring groundwater at the BLIP facility.
- There are no costs associated with the former UST areas.

g-2/BLIP/USTs Implementation of Land Use and Institutional Controls and Other Measures

- The *BNL Land Use Controls Management Plan* (BNL 2013a) provides an overview of land use and other controls that are deployed at BNL to prevent exposure to residual environmental contamination. The web-based *Land Use and Institutional Controls Mapping* tool contains map locations and fact sheets for the g-2 and BLIP facilities. The LUCMP is a living document and is periodically updated to stay current with evolving management techniques.
- There are no LUCMP issues associated with the former USTs.

g-2/BLIP/USTs Monitoring Activities

- Groundwater monitoring at the g-2 and BLIP source areas will continue throughout the institutional control period. Results of the g-2 and BLIP monitoring programs will be used to help verify the effectiveness of the remedy.
- No groundwater monitoring is required for the former UST areas.

g-2/BLIP/USTs Opportunities for Optimization

- During 2015, the Linac Y cap, which adjoins the BLIP cap to the north, was extended in several areas to provide protection of soil shielding that are expected to become activated following planned changes in beam line operations. Monitoring data indicate that the source area controls are effective.

g-2/BLIP/USTs Early Indicators of Potential Issues

- There have been no changes in the physical conditions at the g-2 or BLIP facilities or in the use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2007.
- Groundwater monitoring data from both facilities suggest that the caps and other stormwater controls are effective.
- Because the g-2 facility has not operated since the completion of the project in April 2001, no additional buildup of radioactivity has occurred. Therefore, with natural radioactive decay, radionuclide levels in the soil shielding at the g-2 source area are less than when they were evaluated at the time of the 2007 ROD. Because BLIP is an active facility, additional buildup of radioactivity is occurring in a zone of soil shielding. In addition to the surface controls to prevent rainwater infiltration, the colloidal silica grout that was injected into the zone of activated soil shielding in 2002 offers additional protection from potential stormwater infiltration.

g-2/BLIP/USTs Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

g-2/BLIP/USTs Changes in Standards and TBCs

The standards or TBCs identified in the ROD have not changed, nor do they call into question the protectiveness of the remedy. See **Attachment 5**.

g-2/BLIP/USTs Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

There have been no changes in the physical conditions within the g-2 or BLIP facilities or use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was signed in 2007. There are no risks associated with the former UST areas.

g-2/BLIP/USTs Expected Progress in Meeting RAOs

- Groundwater monitoring at the g-2 and BLIP source areas has shown that the stormwater controls have been effective in preventing additional leaching of radionuclides from the activated soil shielding. At the BLIP facility, all tritium concentrations in groundwater have been less than the 20,000 pCi/L MCL since early 2006. However, tritium concentrations continue to periodically exceed 20,000 pCi/L in the g-2 source area groundwater monitoring wells. The continued detection of tritium appears to be related to water-table fluctuations and the flushing of residual tritium from the deep portion of the vadose (unsaturated) zone below the source area. The overall reductions in tritium concentrations observed in the g-2 source area wells since 2003 suggest that the amount of residual tritium that is available to be flushed out of the deep vadose zone is decreasing by means of this flushing mechanism and natural radioactive decay.
- The downgradient segment of the g-2 tritium plume had been tracked to the vicinity of the National Synchrotron Light Source II facility. Monitoring conducted in 2015 confirmed that natural attenuation (dispersion and radioactive decay) reduced tritium concentrations to less than the 20,000 pCi/L MCL. As a result, groundwater monitoring in the area south of Brookhaven Avenue will be discontinued.
- There are no continued environmental concerns associated with the former UST areas.

g-2/BLIP/USTs Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified risks or any changes in land use have been found at the g-2 or BLIP facilities. There are no continued environmental concerns associated with the former UST areas. No additional information has come to light that calls into question the protectiveness of the remedy defined in the ROD.

7.9 HFBR

HFBR Question A: Is the remedy functioning as intended by the decision documents?

HFBR Remedial Action Performance

As described in the completion and closeout reports to date, site inspections, and regulatory interviews, the interim cleanup measures were implemented in accordance with the Action Memoranda (BNL 2007d and 2008b) and *National Environmental Policy Act* (NEPA) categorical exclusions, and are consistent with the HFBR ROD. This has achieved the remedial action objectives of: protecting human health from the hazards posed by the radiological inventory at the HFBR using the ALARA principle, and implementing monitoring, maintenance, and institutional controls to manage potential hazards. Specific activities completed to help reduce the radiological inventory, to reduce the potential for exposure, and to prevent the future migration of radiological contamination into surrounding soil and groundwater include:

- The fuel was removed and sent to an off-site facility
- The primary coolant was drained and sent to an off-site facility
- The cooling tower superstructure was dismantled
- The spent fuel canal was modified to meet Suffolk County Article 12 requirements
- The Stack Monitoring Facility (Building 715) was dismantled
- The Water Treatment House (Building 707B) was dismantled
- The Cold Neutron Facility (Building 751) contaminated systems were removed
- The Guard house (Building 753) was dismantled
- Control rod blades and beam plugs were removed
- Removal of ancillary buildings and associated soils
- Removal of fan houses
- Removal of contaminated underground pipes and utilities
- Soil excavation and disposal of the former HWMF WLA
- Removal of Bldgs. 801-811 underground waste transfer lines and associated soil

HFBR System Operations/O&M

Long-term surveillance and maintenance activities are being conducted in accordance with the *Long-Term Surveillance and Maintenance Plan for the HFBR* (BNL 2011g) to ensure effectiveness of the remedy. The BNL LUCMP contains sitewide control measures and land-use restrictions to prevent exposure to environmental contamination and to protect the integrity of remedies specified within the HFBR ROD and other approved RODs. To accomplish this objective, specific measures are being implemented for the HFBR project. They include the following:

- Routine environmental health and safety monitoring including radiological surveys.
- Secure access via locked doors.
- Periodic structural inspections of Building 750.
- Periodic inspections of the stack and grounds.
- Water intrusion monitoring.
- Preventive maintenance of Building 750 and the infiltration management system.
- Management and disposal of water generated from precipitation through the stack.
- Groundwater monitoring required as part of the OU III ROD.

HFBR Costs of System Operations/O&M

The estimated cost of surveillance and maintenance activities required to ensure that Building 750 (HFBR) remains in a safe and stable condition during the safe storage phase is approximately $180K annually (in FY15 dollars). The surveillance and maintenance activities include radiation and environmental monitoring, management and disposal of stack drain water, the testing, inspection, and maintenance/repair of essential equipment, and verification of conditions throughout the facilities.

HFBR Implementation of Land Use and Institutional Controls and Other Measures

The HFBR remedy includes the continued implementation of LUICs in accordance with the LUCMP. These include:

- Measures for controlling future excavation and other actions that could otherwise disturb residual subsurface contamination.
- Land use restrictions and an acceptable method for evaluating potential impact that the remaining contaminants have on future development.
- Periodic certification to EPA and NYSDEC stating that the institutional and engineering controls put in place are unchanged from the previous certification, and that nothing has occurred that would impair the ability of the control to protect public health or the environment or constitute a violation or failure to comply with the site management plan. This annual certification is prepared and submitted to NYSDEC on an annual basis as part of the LUIC letter report.

DOE is currently responsible for implementing the land-use controls with regard to the property that is the subject of the HFBR ROD. If the property is transferred out of federal ownership, it is DOE's intention that all continuing land-use restrictions, reporting requirements, and any other obligations relating to the property of DOE (or any other successor federal entity on behalf of the United States) will be satisfied through the United States' conveyance of a deed restriction/ environmental easement prior to any such transfer of any deed(s) to the property.

While it is DOE's intention that any such deed restriction/environmental easement would require that the transferee (and subsequent transferees) would be required to satisfy all of DOE's obligations relating to the property, DOE acknowledges that, notwithstanding this intention, it (or any other successor federal entity on behalf of the United States) remains ultimately responsible for satisfying DOE's remedial obligations set forth in this ROD relating to the property if any subsequent transferee fails to satisfy the remedial obligations in this regard.

DOE will address any activity that is inconsistent with the land-use restrictions or actions that may interfere with the effectiveness of the institutional controls established for the HFBR complex with EPA and NYSDEC, as outlined in the BNL LUCMP. LUICs will be maintained until the hazardous substances reach levels that allow unlimited use and unrestricted exposure.

HFBR Monitoring Activities

The *Long-Term Surveillance and Maintenance Plan for the HFBR* was developed to manage the inventory of radioisotopes that will remain in the HFBR Confinement Building during the safe storage (decay) period and subsequent decontamination and dismantlement. The details of the surveillance and maintenance processes are contained in a supporting document – the *Long-Term Surveillance and Maintenance Manual*. The Surveillance and Maintenance Plan and Manual are implemented to ensure that the inventory of stored radioisotopes and all residual contamination is maintained in a safe condition, and to preclude future human exposure pathways or migration from their locations within the HFBR. Inspections of the HFBR have been ongoing since the facility was placed in a long-term safe storage mode in 2012. The building is structurally sound and little deterioration has been observed to date. There have been no water intrusion alarms sounded in the facility. Minor maintenance and repair work have been performed on the facility including the replacement of light bulbs, roof repairs over the former machine shop area located outside of the confinement dome, and re-caulking of a vent on the outside of the dome outside the generator room. Radiation measurements of the V-14 port (located at the top of the reactor vessel) were conducted in 2010 and 2015 as a means to confirm that radioactive decay in the vessel is occurring at the modeled rate. The measurements to date suggest that decay is occurring as expected and the selected decay period (until 2073) is justified. See **Attachment 5** for additional information. The water (from precipitation) generated from the stack is routinely pumped-out and disposed of.

HFBR Opportunities for Optimization

Removal of the reactor and its components requires underwater cutting for size reduction to fit into shipping containers. There have been no major advances in this field in the past several years. There are no technique or technology developments that would allow for the removal of the reactor vessel prior to the current 65-year-decay period.

An evaluation was performed of covering the stack to minimize the volume of water generated from precipitation events. The capital cost to install a cover compared to the existing annual water management and disposal cost through 2020 was deemed not economical.

HFBR Early Indicators of Potential Issues

Continued protection of workers during the remaining activities (demolition of the stack) is an important consideration. Controls developed and implemented for the completed remedial actions (demolition of Buildings 704 and 802, and removal of underground utilities) will be used to help mitigate potential risk.

HFBR Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

HFBR Changes in Standards and TBCs

The standards or TBCs, including DOE Orders, identified in the HFBR ROD have not changed, nor do they call into question the protectiveness of the remedy. **Attachment 5** provides a review of the standards.

HFBR Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics, and Risk Assessment Methods

- There have been no changes in the physical conditions within the HFBR complex or in the use of the site that would reduce the protectiveness of the remedies, nor render the initial risk analysis invalid. Also, the exposure assumptions have not changed since the ROD was finalized in 2009.
- No new contaminants or sources of contamination have been identified within the HFBR, and no unanticipated toxic byproducts have been detected.
- In accordance with the HFBR ROD, DOE will determine the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier taking into consideration the following factors:
    - Advancements in cleanup technologies and transportation methods.
    - Availability of waste disposal facilities.
    - Changes in standards and regulations for worker, public, and environmental protection.
    - Worker safety impacts.
    - Environmental impacts.
    - Public health impacts.
    - Economic impacts.
    - Land use.
    - Existing stabilization and safety of the facility and hazardous materials.
    - Projected future stability and safety of the facility and hazardous materials.

- As discussed in **Attachment 5**, no advances in new technologies or other factors have been identified since the ROD was finalized in 2009 that would warrant a reduction in the 65-year safe storage (decay) period.
- Recognizing that there are uncertainties inherent in activation analyses, per the ROD, DOE conducted an additional investigation involving the following steps:
  - Performed radiation surveys (measurements of radiation levels) after the removal of the control rod blades from the reactor vessel. (Surveys before the removal of control rod blades with high dose rates would not yield reliable results).
  - Reevaluated the dose rate at 1 foot from the large activated components (reactor vessel, thermal shield, and biological shield) based on the radiation surveys.
  - Using the reevaluated dose rates, determined the decay period necessary for the dose rate at 1 foot to fall below 100 mRem/hour for the large activated components, including the limiting component.
  - Used the results of the additional investigation in this Five-Year Review in assessing the feasibility of shortening the decay period.
- The following conclusions from this evaluation were reached:
  - The predicted time for when the large limiting activated component (i.e., thermal shield) will decay to 100 mRem/hour is in 65 years from 2007 (the safe storage decay period was determined based on the radiological inventory and radiation levels in 2007), or in the year 2072.
  - This predicted time was calculated based on activation analysis, and the calculations were supported by measurements of actual dose rates.
  - Radiation levels from the small highly activated components (transition plate and anti-critical grid) were within the bounds of expected levels when measured in a reactor vessel internal survey in 2009.
  - When the control rod blades were removed from the reactor, radiation levels and curie contents were in close agreement with the predicted levels.
  - Based on this close agreement between actual and predicted radiation levels, the calculated dose rates for the large activated components are also expected to be reasonably accurate. Therefore, there is no justification to change the safe storage (decay) period of 65 years.

HFBR Expected Progress in Meeting RAOs

- A significant effort has already been completed with the removal and disposal of contaminated components, structures, water, and soil at the HFBR complex. Based on sampling results, continued monitoring and surveillance of the facility, groundwater monitoring downgradient of potential source areas, and visual inspections of remediated areas, those projects completed to date continue to meet the remedial action objectives identified in the ROD.
  - A portion of the radiological inventory at the HFBR complex has been either removed or stabilized as a result of the cleanup actions.
  - The ALARA principle was extensively used to help protect workers while implementing the removal actions.
  - The implementation of long-term monitoring, maintenance, and institutional controls has been initiated for the HFBR.
- The remaining remedial actions to be implemented for stack demolition and removal of the reactor vessel are also expected to meet the overall ROD remedial action objectives.

HFBR Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No newly identified risks, impacts from natural disasters or land use changes have been found within the HFBR complex. No additional information has come to light that calls into question the protectiveness of the HFBR remedy.

7.10 Technical Assessment Summary

Currently, nine RODs have been signed at BNL. The first was signed in 1996 and the last was signed in 2009. In addition four ESDs were signed documenting changes to the OU III and BGRR RODs. With the exception of the HFBR stack and reactor vessel removal, all selected remedies for the RODs and ESDs have been implemented. This includes the excavation and off-site disposal of contaminated soil, sediment, tanks, and the installation and operation of all planned groundwater treatment systems. All closeout reports were submitted to the regulators and approved.

Remedies have been implemented in accordance with the RODs and the ESDs, based on the data presented in the closeout reports and the annual *BNL Groundwater Status Reports*, site inspections, and regulatory interviews. Soil cleanup levels were met and groundwater pump and treat systems have been functioning as intended by the RODs. The cleanup performed continues to meet the remedial action objectives identified in each ROD.

For soil excavation/disposal remedies, work was performed in accordance with the ROD, applicable design documents, and Remedial Action Work Plans. Soil cleanup levels were met for these areas. The remaining work at the HFBR will be implemented in accordance with the ROD.

There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedies. Soil and groundwater applicable or relevant and appropriate requirements in the RODs and ESDs have either been met or are expected to be met. There is no other information that calls into question the protectiveness of the remedies.

8.0 Issues

Issues are identified in **Section 9**, **Table 9-1**.

9.0 Recommendations and Follow-up Actions

The following table summarizes key recommendations developed in the Technical Assessment section of this document. These recommendations are subject to regulatory review, and implementation will be based on the availability of funding.

Table 9-1: Recommendations and Follow-up Actions

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Sr-90 in OU I Former HWMF Groundwater	Enhance monitoring well network with a combination of permanent and temporary wells on a recurring basis to track Sr-90 attenuation. Compare attenuation data with model projections prior to the next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2021	N	N
OU III Building 96 Source Removal Effectiveness	Monitor plume and continued degradation of source area. Continue treatment system operations and if capture goals are met, submit *Petition for Shutdown*.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2018	N	N
OU III Western South Boundary deep VOC contamination	Characterize nature and extent of deep VOCs identified in 2016/run model.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2017	N	N
Continuing Sr-90 source at BGRR	Monitor plume and continued degradation of source area. Perform intermittent pulsed pumping of extraction well SR-3. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Continuing Sr-90 source at Chemical Holes	Continue attenuation monitoring of former source area. Perform intermittent pulsed pumping of extraction well EW-1. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Peconic River Remedy Optimization	Complete supplemental excavation of elevated mercury at Area PR-WC-06.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2018	N	N
HFBR	Remove stack by 2020 per the ROD.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2020	N	N
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier.	BNL	DOE, EPA, NYSDEC, SCDHS	Recurring	N	N
OUs III & VI - Deeds not reflecting operating treatment systems	Record property access agreements with County Clerk	BNL	DOE, EPA, NYSDEC, SCDHS	June 2017	N	Y

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Soil contamination north of former Buildings 810/811	Add radiological soil contamination area to Building 811 Waste Concentration Facility LUIC fact sheet	BNL	DOE, EPA, NYSDEC, SCDHS	January 2017	N	N

Notes
Recommendations are subject to regulatory review; implementation will be based on the availability of funding
BGRR = Brookhaven Graphite Research Reactor
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
HFBR = High Flux Beam Reactor
NYSDEC = New York State Department of Environmental Conservation
SCDHS = Suffolk County Department of Health Services
VOCs = volatile organic compounds

10.0 Protectiveness Statements

Individual Protectiveness Statements

Protectiveness statement for the individual OUs, the BGRR, HFBR, and g-2/BLIP/USTs are presented below.

Operable Unit I: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

- All soil cleanup actions are complete and the groundwater treatment system was shut down and placed in standby mode in 2013 since the capture goal for VOCs was met. The attainment of groundwater cleanup goals for VOCs is expected to require 30 years or less to achieve (by 2030). Strontium-90 in groundwater is expected to attenuate to near the DWS at the site boundary. In the interim, exposure pathways that could result in unacceptable risks are being controlled. Institutional controls are preventing exposure to, or the ingestion of, contaminated groundwater and soil.
- Long-term protectiveness of the remedy will be verified by monitoring the movement and remediation of the plume. Current monitoring data indicate that the remedies are effective and they are functioning as required to achieve the groundwater cleanup goals.

Operable Unit II: Remedial actions for the AOCs in this OU are documented in the OU I and OU III RODs, except for BLIP and the g-2 tritium plume, which are documented in another ROD. Since there is no ROD or remedial action for this OU, a protectiveness statement cannot be prepared. A protectiveness statement for the g-2/BLIP/UST AOCs is identified below.

Operable Unit III: The remedy is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- All soil cleanup actions are complete and all groundwater treatment systems are operational, in standby mode, or decommissioned. The attainment of groundwater cleanup goals is expected to require:
  - 30 years or less to achieve MCLs for VOCs and tritium in the Upper Glacial aquifer (by 2030).
  - 40 years and 70 years or less to achieve MCLs for Sr-90 at the former Chemical Holes plume and the BGRR/WCF plumes, respectively (by 2040 and 2070, respectively).
  - 65 years or less to achieve MCLs for VOCs in the Magothy aquifer (by 2065).
- Exposure pathways that could result in unacceptable risks are being controlled. Site-specific institutional controls are preventing exposure to contaminated groundwater and soil.
- Long-term protectiveness of the remedies will be verified by continuing to monitor the movement and remediation of the plumes. Current monitoring data indicate that the remedies are functioning as required to achieve the groundwater cleanup goals.

Operable Unit IV: The remedy is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled.

- The groundwater cleanup goals have been met for the VOCs/SVOCs present at the 1977 oil/solvent spill site and the treatment system has been dismantled. Institutional controls are preventing exposure to contaminated soil and groundwater. All threats at the site have been addressed through the installation of fencing and warning signs, and the implementation of institutional controls.
- Additional groundwater characterization performed in 2011 and 2015 (and updated groundwater modeling) verified that the remaining Sr-90 contamination in groundwater will remain in the central portion of the site and attenuate to below MCLs by 2034.

Operable Unit V: The remedy is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. Revegetation of remediated areas has been completed. The 10 years of post-cleanup, long-term monitoring has demonstrated the effectiveness of the Peconic River cleanup to mitigate potential human and ecological effects.

- The soil cleanup goals for the STP filter beds/berms and the groundwater goals have been met.
- The 2004/2005 and the 2011 supplemental sediment cleanup of the Peconic River met the remediation goals of the ROD.
- Long-term monitoring has demonstrated the effectiveness of the Peconic River cleanup and it is recommended that further monitoring of the Peconic River be discontinued.
- Supplemental remediation in one small area will be completed.

Operable Unit VI: The remedy is expected to be protective of human health and the environment upon attainment of the groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The EDB groundwater treatment system is operational. The attainment of groundwater cleanup goals is expected to require 30 years or less to achieve the MCL for EDB in the Upper Glacial aquifer (by 2030).
- Exposure pathways that could result in unacceptable risks (e.g., off-site potable water supply) are being controlled and site-specific institutional controls are preventing exposure to, or the ingestion of, contaminated groundwater.

BGRR: The remedy is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled.

- The remedy is protective since the graphite pile and bioshield were removed and the final engineered cap was installed. Institutional controls are preventing exposure to contaminated structures, soil, and groundwater.
- All threats at the site have been addressed through removal or stabilization of the radiological inventory, excavation of contaminated soil, infiltration management, installation of signs, building access controls, and the implementation of specific institutional controls for the structures, soil, and groundwater.
- Long-term protectiveness of the remedy will be verified by continuing to perform health and safety monitoring, periodic structural inspections of Building 701, water intrusion monitoring, preventive maintenance of the infiltration management system, and groundwater monitoring required as part of the OU III ROD and the ESD.

g-2/BLIP/USTs: The remedy defined in the ROD is expected to be protective of human health and the environment upon attainment of groundwater cleanup goals. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

- Groundwater monitoring in the downgradient portion of the plume is complete, however monitoring of the source area continues.
- Institutional controls designed to prevent exposure to contaminated structures, soil, and groundwater, are in place.
- Long-term protectiveness of the remedy will be verified by continuing inspections and maintenance of the g-2 and BLIP facility stormwater controls, and groundwater monitoring required by the ROD.

HFBR: The completed remedy is expected to be protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The remedy is expected to be protective upon completion of the near-term actions (demolition of the stack), and the segmentation, removal, and disposal of the remaining HFBR structures, systems, and components (including the reactor vessel, internals, thermal shield and biological shield) following a safe storage decay period (not to exceed 65 years). In the interim, exposure pathways that could result in unacceptable risks are being controlled. Institutional controls are preventing exposure to contaminated structures, soil, and groundwater.

- All threats at the site are being addressed through removal or stabilization of the radiological inventory, excavation of contaminated soil, infiltration management, installation of signs, building access controls, and the implementation of specific institutional controls for the structures, soil and groundwater.
- Long-term protectiveness of the remedy will be verified by continuing to perform health and safety monitoring, periodic structural inspections of the reactor confinement building and stack, water intrusion monitoring, preventive maintenance of the infiltration management system, and groundwater monitoring required as part of the OU III ROD.

Comprehensive Protectiveness Statement

- A comprehensive sitewide protectiveness determination covering all the OUs and BGRR must be reserved at this time because HFBR remedy implementation is not yet complete, including stack demolition and reactor vessel removal.

11.0 Next Review

The fourth sitewide Five-Year Review for BNL will be submitted within five years of issuance of this final report. This will include all OUs, including the g-2 Tritium Plume, the BLIP, and USTs ROD (AOCs 16T, 16K, and 12, respectively), and the BGRR and HFBR RODs. A comprehensive sitewide protectiveness determination may be included at that time.

Frank Crescenzo, Site Manager
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U.S. Department of Energy

6/24/2016
Date

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Tables

(Tables 6-3 and 6-4)

Table 6-3
Permanent Monitoring Wells Installed Since January 2011

Permanent Well Identification	Temporary Well Identification	Installation Date
113-30	OU3-MR-MW01-2010	1/26/2011
105-67	OU3-MR-MW02-2010	2/4/2011
126-17	WSB-MW01-2010	2/16/2011
107-42	OU1-MW02-2010	3/3/2011
000-520	EDB-MW-01-2011	3/14/2011
076-417	650-MW03-2010	3/22/2011
076-416	650-MW02-2010	3/24/2011
076-415	650-MW01-2010	3/25/2011
075-701	BGRR-MW-05-2011	3/30/2011
075-700	BGRR-MW-03-2011	3/31/2011
065-402	BGRR-MW-04-2011	4/4/2011
075-699	BGRR-MW-02-2011	4/6/2011
065-401	BGRR-MW-01-2011	4/7/2011
065-404	BGRR-MWA-2011	7/27/2011
108-55	OU1-MW01-2011	8/16/2011
108-56	OU1-MW02-2011	8/17/2011
121-49	SB-MW01-2011	9/9/2011
095-314	B452-MW-11	9/14/2011
095-315	B452-MW-12	9/15/2011
085-388	B452-MW-10	9/16/2011
095-313	B452-MW-08	9/19/2011
085-387	B452-MW-09	9/20/2011
085-386	B452-MW-07	9/21/2011
085-382	B452-MW-03	9/22/2011
085-385	B452-MW-06	9/22/2011
085-384	B452-MW-05	9/23/2011
085-383	B452-MW-04	9/26/2011
085-381	B452-MW-02	9/27/2011
085-380	B452-MW-01	9/28/2011
085-389	EW-18	9/28/2011
000-526	MW-MAG	10/20/2011
065-405	065-366 Replacement	3/6/2012

Table 6-3
Permanent Monitoring Wells Installed Since January 2011

Permanent Well Identification	Temporary Well Identification	Installation Date
121-47	SB-MW01-2012	4/26/2012
121-48	SB-MW02-2012	5/2/2012
113-31	OU3-MR-MW01-2012	5/8/2012
121-46	EW-17	5/18/2012
000-530	IP-MW01-2012	5/25/2012
000-525	NSE-MW01-2012	6/1/2012
119-10	WSB-MW-01-2012	6/14/2012
085-398	BGRR-MW01-2012	8/8/2012
085-399	BGRR-MW02-2012	9/12/2012
085-402	BGRR-MW03-2012	9/13/2012
000-524	EDB-MW01-2012	9/21/2012
000-531	IP-MW02-2012	10/12/2012
105-68	MRMW-01-2013	5/23/2013
000-528	IP-MW02-2013	6/12/2013
000-529	IP-MW01-2013	6/15/2013
121-53	MRMW-03-2013	8/21/2013
113-33	RW-7	8/22/2013
000-527	EDB-MW01-2013	9/10/2013
800-138	AP-MW01-2013	9/19/2013
000-541	IP-MW-05-2014	6/17/2014
127-08	IP-MW-03-2014	6/25/2014
127-09	IP-MW-04-2014	6/26/2014
000-537	IP-MW-01-2014	7/2/2014
000-538	IP-MW-02-2014	7/9/2014
095-322	MR-MW02-2014	7/22/2014
095-323	MR-MW01-2014	7/24/2014
121-54	SB-MW02-2014	8/20/2014
000-542	IP-MW-06-2014	9/26/2014
000-533	IP-EW-9	10/1/2014
000-543	IP-MW-07-2014	10/2/2014
000-532	IP-EW-8	10/20/2014
000-544	IP-MW-08-2014	10/22/2014

Table 6-3
Permanent Monitoring Wells Installed Since January 2011

Permanent Well Identification	Temporary Well Identification	Installation Date
TBD	CAH-MW01-2015	5/6/2015
TBD	BGRR-MW01-2015	5/7/2015
TBD	CAH-MW02-2015	5/7/2015
TBD	CAH-MW03-2015	5/7/2015
TBD	CAH-MW04-2015	6/3/2015
TBD	IP-MW01-2015	6/15/2015

TBD = To be determined following receipt of survey coordinates

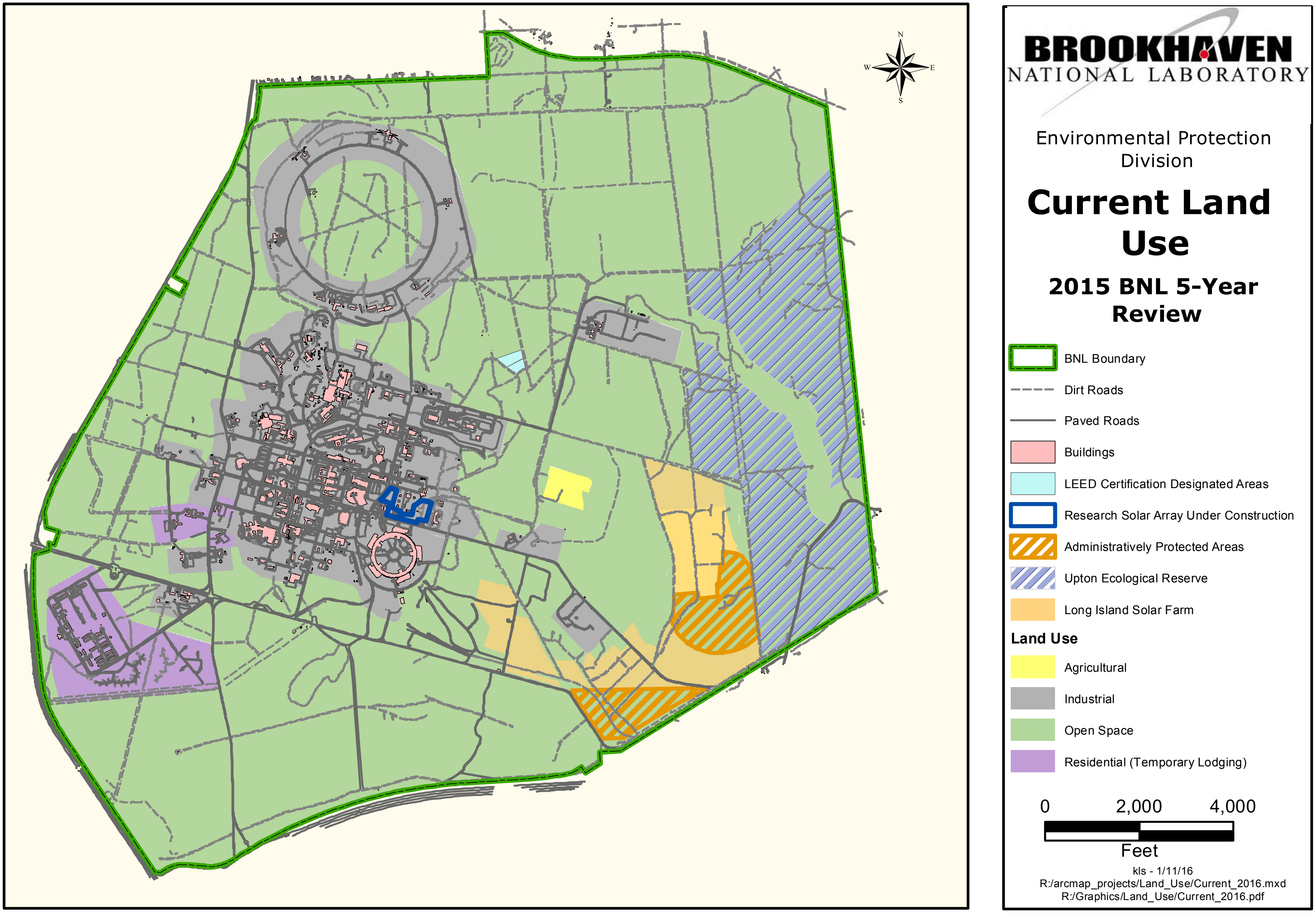
Table 6-4
Monitoring Wells Decommissioned Since January 2011

Permanent Well Identification	Decommissioned Date
041-01	9/5/2013
600-20	9/5/2013
600-23	9/5/2013
600-26	9/5/2013
000-513	9/6/2013
000-514	9/6/2013
095-300	9/20/2013
049-05	9/23/2013
066-190	9/23/2013
095-53	9/23/2013
095-42	9/24/2013
095-90	9/24/2013
085-162	9/26/2013
085-163	9/26/2013
095-277	9/26/2013
095-279	9/26/2013
076-314	9/27/2013
095-280	9/27/2013
000-489	10/3/2013
000-493	10/4/2013
000-433	10/18/2013
038-03	6/30/2014
000-436	9/18/2014
000-215	9/17/2015
084-02	9/27/2015

Figures

(Figures 3-1 through 7-2)

Figure 3-1


N
S
E
W
BROOKHAVEN
NATIONAL LABORATORY
Environmental Protection Division
Current Land Use
2015 BNL 5-Year Review
BNL Boundary
Dirt Roads
Paved Roads
Buildings
LEED Certification Designated Areas
Research Solar Array Under Construction
Administratively Protected Areas
Upton Ecological Reserve
Long Island Solar Farm
Land Use
Agricultural
Industrial
Open Space
Residential (Temporary Lodging)
0
2,000
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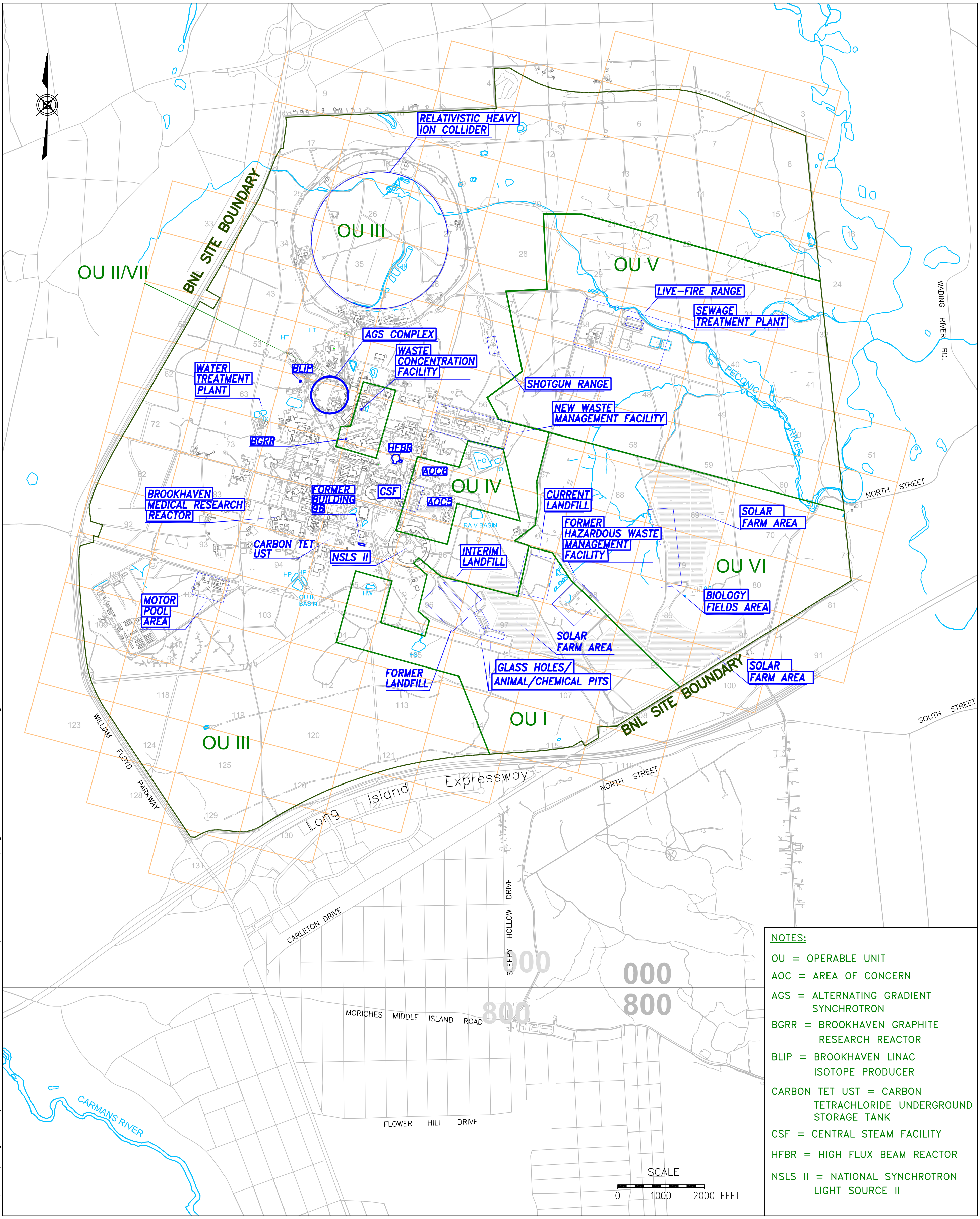


NOTES:

OU = OPERABLE UNIT

AOC = AREA OF CONCERN

AGS = ALTERNATING GRADIENT SYNCHROTRON

BGRR = BROOKHAVEN GRAPHITE RESEARCH REACTOR

BLIP = BROOKHAVEN LINAC ISOTOPE PRODUCER

CARBON TET UST = CARBON TETRACHLORIDE UNDERGROUND STORAGE TANK

CSF = CENTRAL STEAM FACILITY

HFBR = HIGH FLUX BEAM REACTOR

NSLS II = NATIONAL SYNCHROTRON LIGHT SOURCE II

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

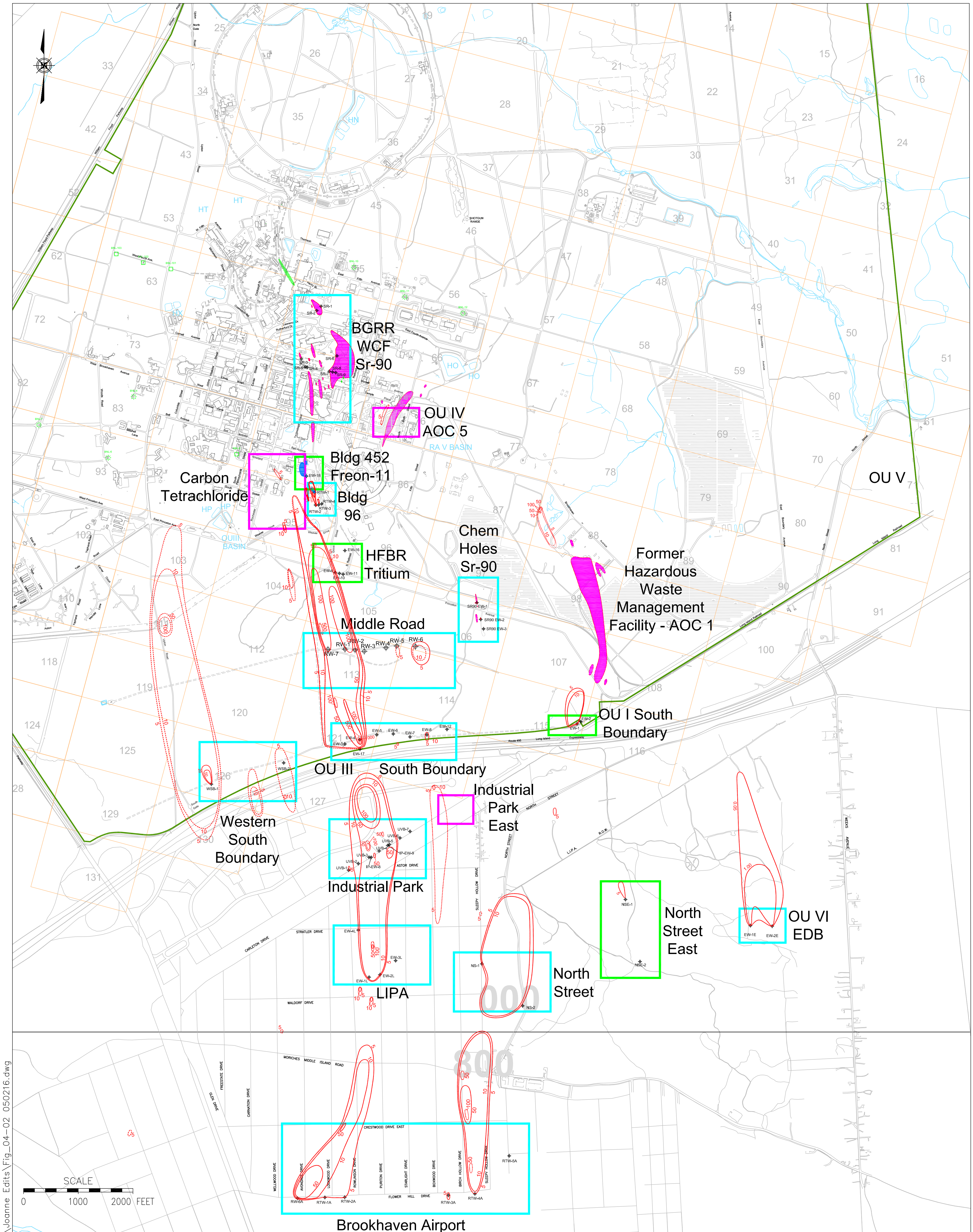
TITLE:

OU LOCATIONS

2015 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/02/16	–
CHKD:	APPD:	REV.:	NOTES:
JEB	WRD	–	–

FIGURE NO.: 4–1



LEGEND

32	BNL GRID NUMBER
EW-12	BNL REMEDIATION WELL
BNL-12	BNL SUPPLY / PROCESS WELL
	OPERATING REMEDIATION SYSTEMS
	REMEDIATION SYSTEM PLACED IN STANDBY MODE
	DECOMMISSIONED REMEDIATION SYSTEM

2015 TVOC PLUME UNLESS SPECIFIED. CONCENTRATION AS INDICATED. (DASHED WHERE INFERRED)

2015 TRITIUM PLUME. OUTLINE IS 20,000 pCi/L.

2015 STRONTIUM-90 PLUME. OUTLINE IS 8 pCi/L.

2015 FREON-11 PLUME. OUTLINE IS 5 pCi/L.

AOC - AREA OF CONCERN

TVOC - TOTAL VOLATILE ORGANIC COMPOUNDS

pCi/L - picoCurie PER LITER

EDB - ETHYLENE DIBROMIDE

LIPA - LONG ISLAND POWER AUTHORITY

BGRR WCF - BROOKHAVEN GRAPHIC RESEARCH REACTOR WASTE CONCENTRATION FACILITY

HFBR - HIGH FLUX BEAM REACTOR

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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

GROUNDWATER REMEDIATION SYSTEMS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VS: HS.: –	DATE: 05/02/16	PROJECT NO.: –
CHKD: –	APPD: –	REV.: –	NOTES: –
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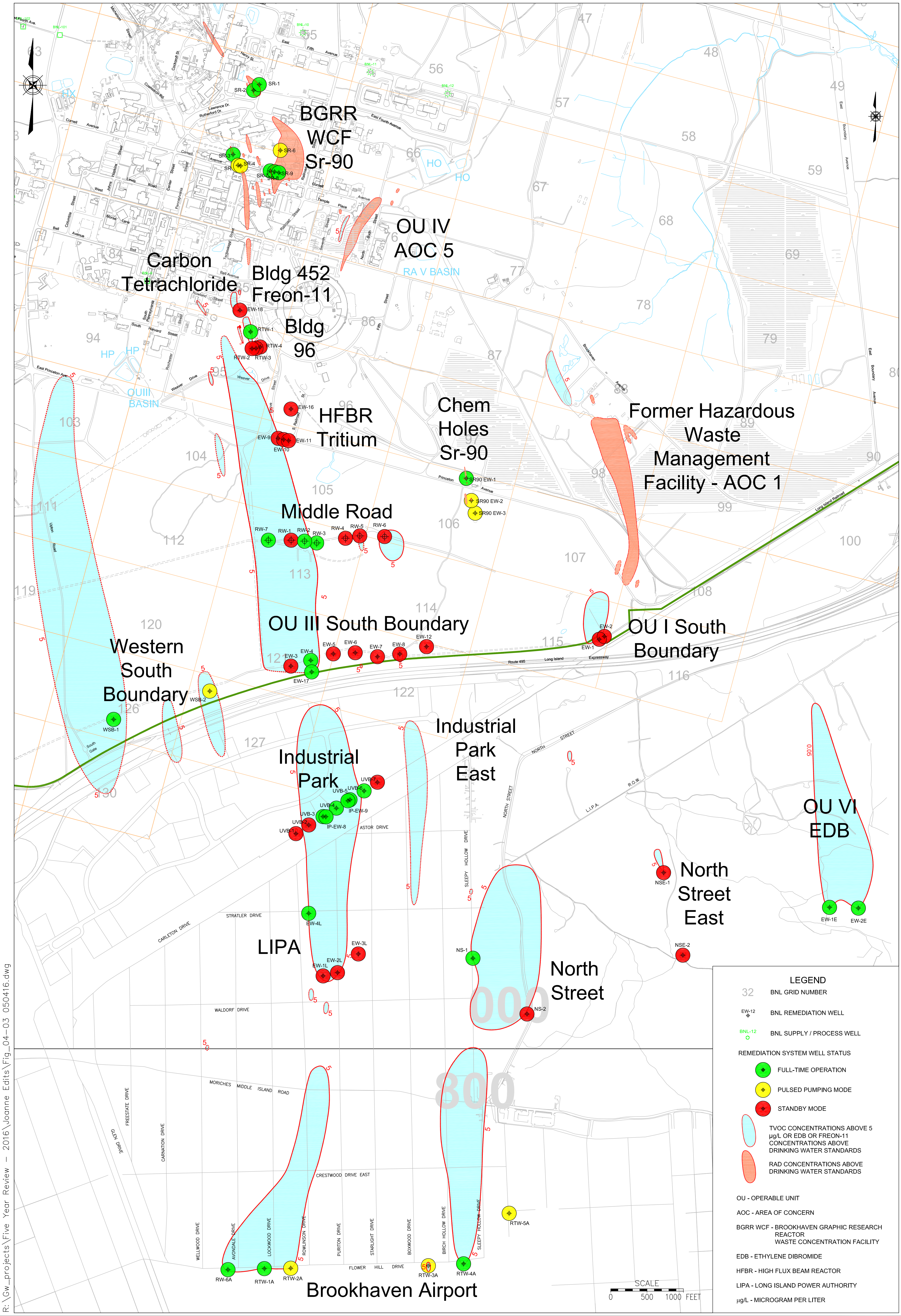


BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

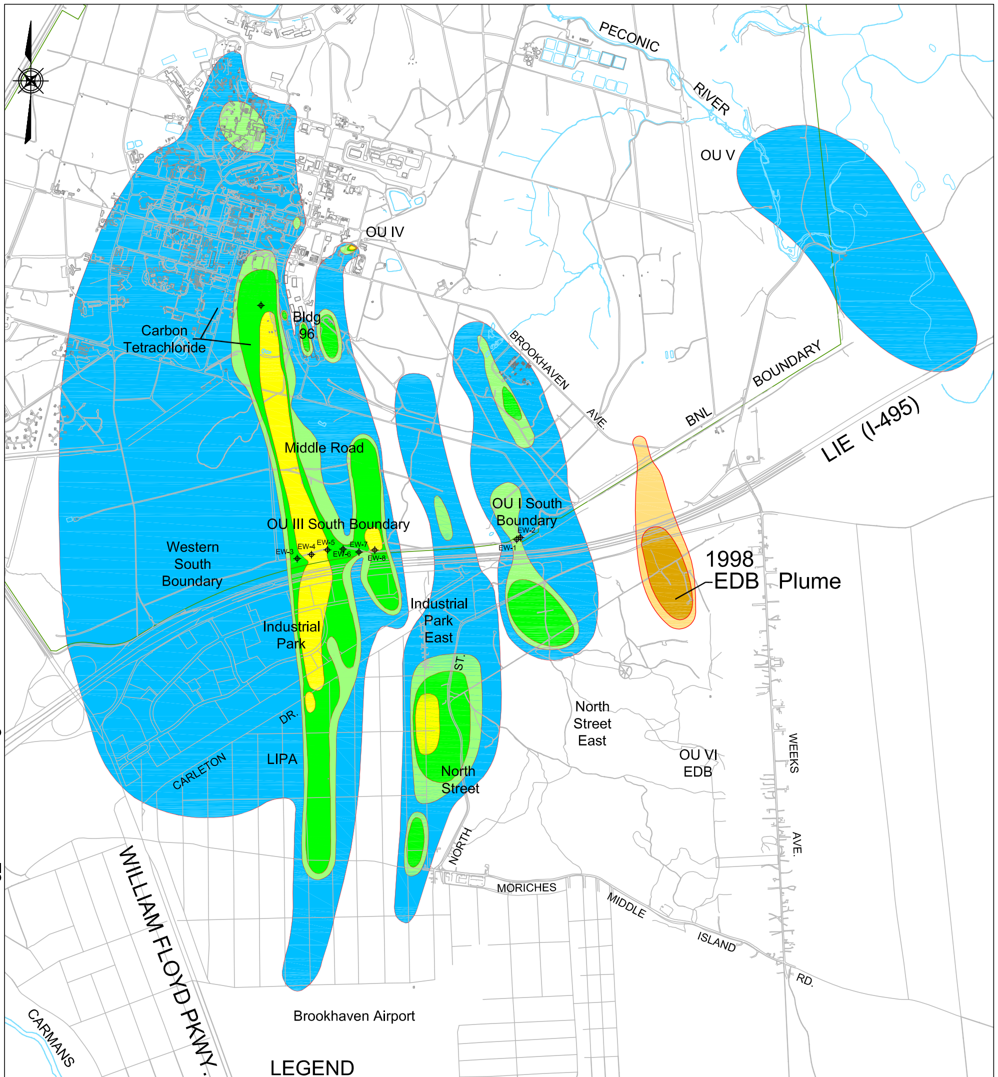
TITLE:

OPERATIONAL STATUS OF GROUNDWATER REMEDIATION SYSTEM WELLS

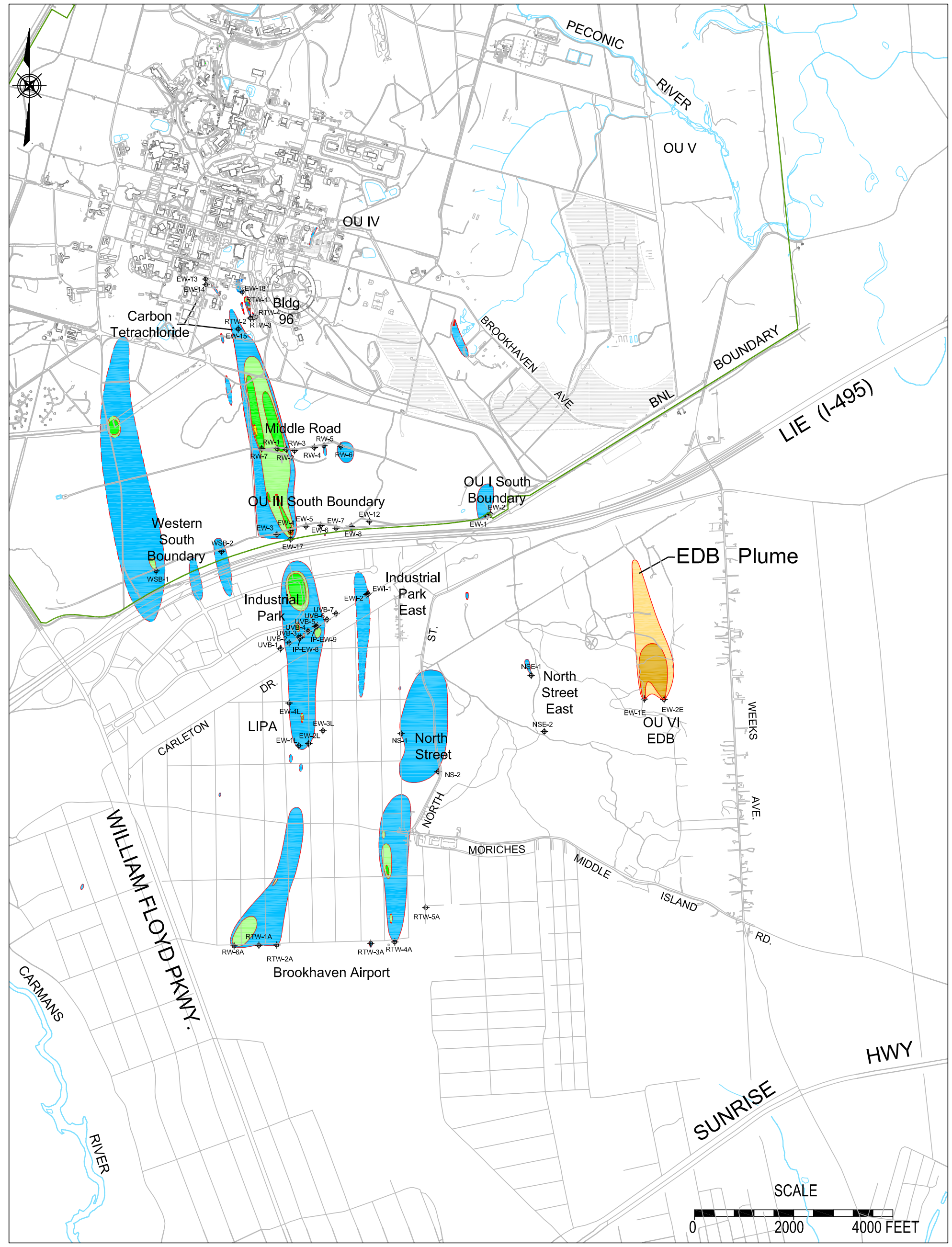
2015 BNL FIVE-YEAR REVIEW

DWN:	VS: HS.:	DATE:	PROJECT NO.:
AJZ	–	05/04/16	–
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 4–3			

1997 TVOC/EDB PLUME DISTRIBUTION



2015 TVOC/EDB PLUME DISTRIBUTION



LEGEND

- 5 - 49 µg/L TVOC CONCENTRATION
- 50 - 99 µg/L TVOC CONCENTRATION
- 100 - 499 µg/L TVOC CONCENTRATION
- ≥ 500 µg/L TVOC CONCENTRATION
- 0.05 - 0.99 µg/L EDB CONCENTRATION
- ≥ 1.00 µg/L EDB CONCENTRATION
- RTW-4A GROUNDWATER REMEDIATION WELL
- EDB - ETHYLENE DIBROMIDE
- TVOC - TOTAL VOLATILE ORGANIC COMPOUNDS
- µg/L - MICROGRAM PER LITER

R:\Gw_projects\Five Year Review - 2016\Joanne Edits\Fig_05-01 050216.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

TVOC/EDB PLUME COMPARISON
1997/1998 - 2015

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT:HZ.: -	DATE: 05/02/16	PROJECT NO.: -
CHKD: -	APPD: -	REV.: -	NOTES: -
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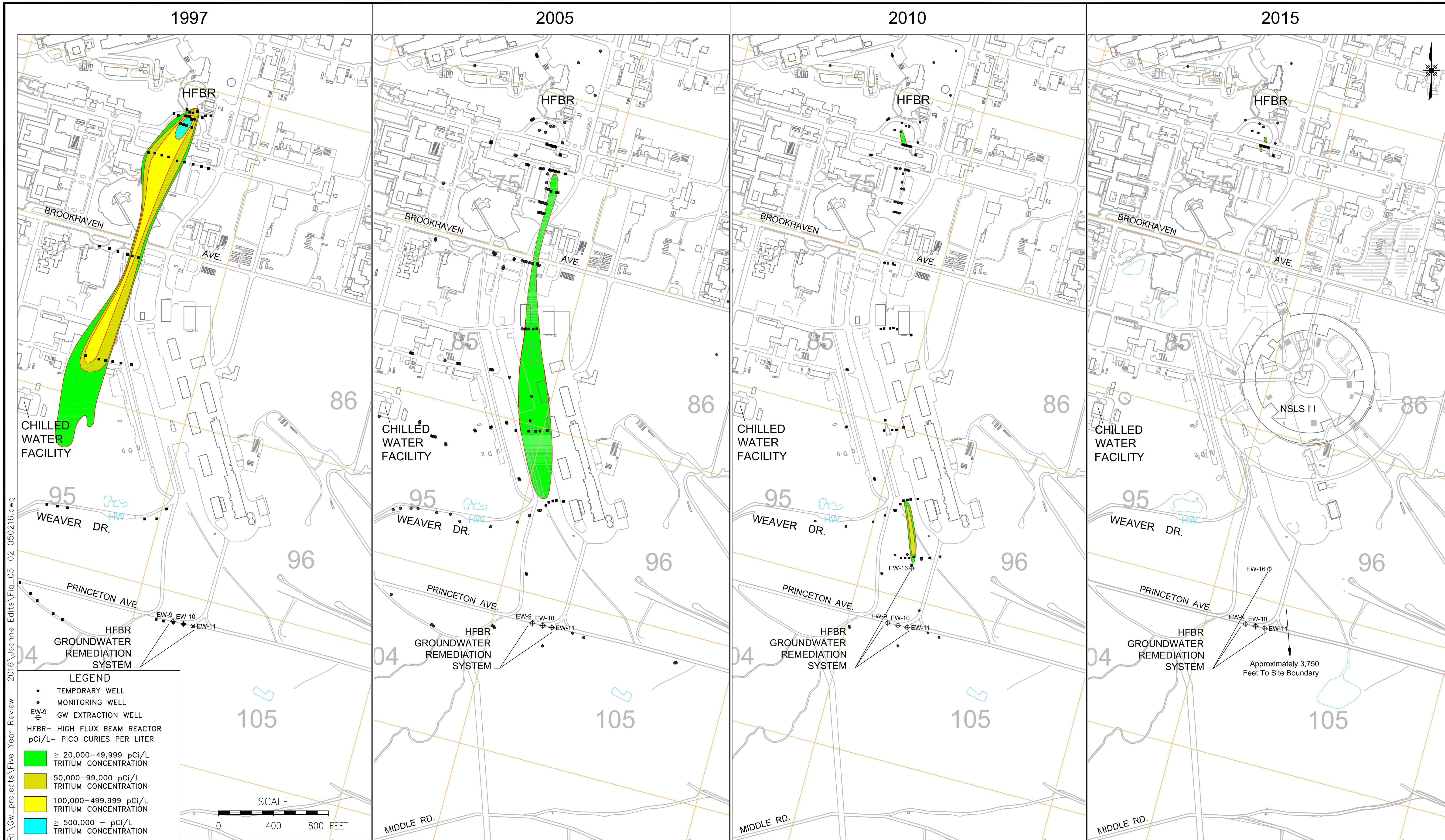

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BROOKHAVEN
NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III HFBR AOC 29
TRITIUM PLUME COMPARISON 1997, 2005, 2010 AND 2015

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT: HZ.: –	DATE: 05/02/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
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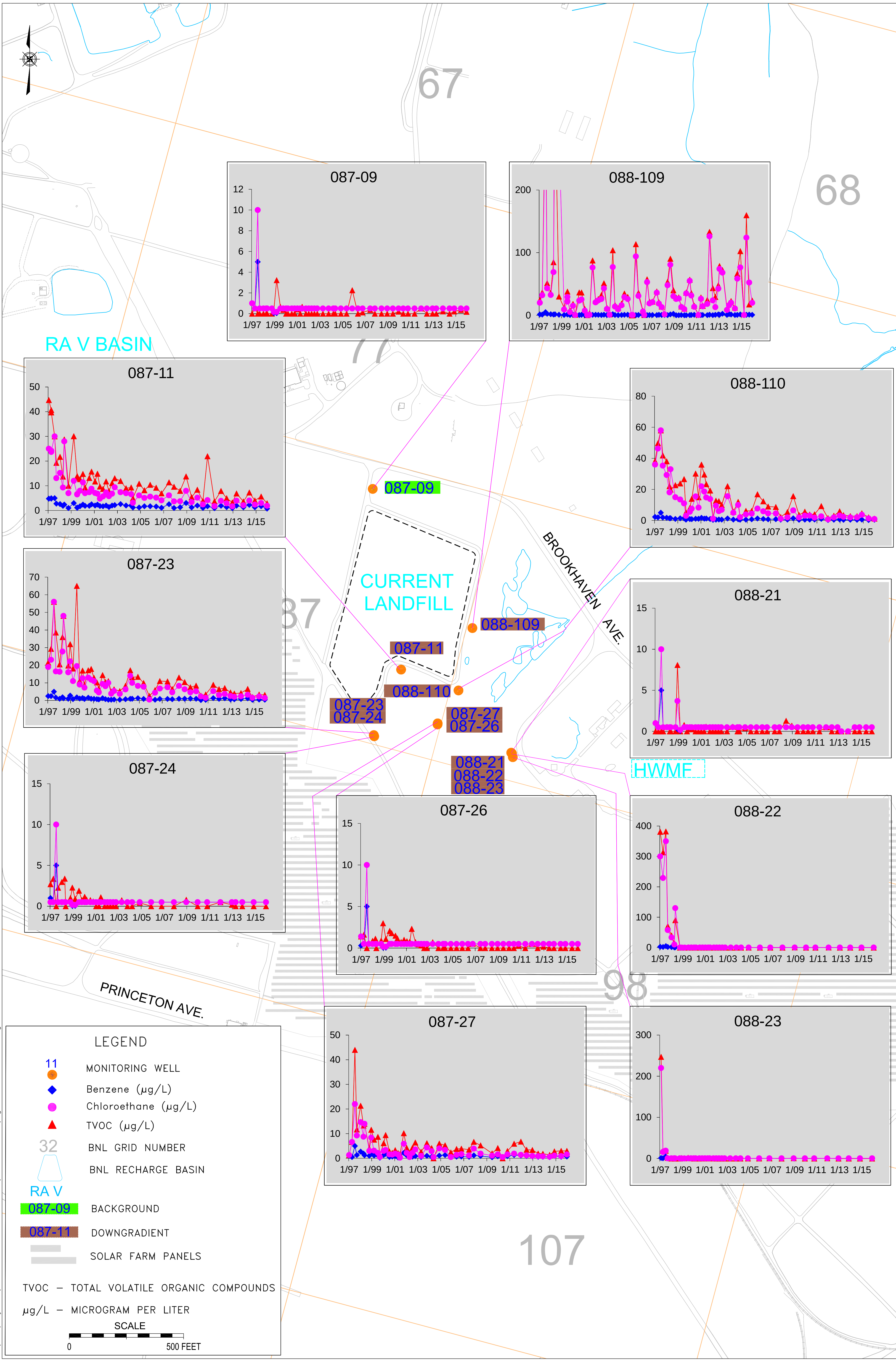


BROOKHAVEN NATIONAL LABORATORY

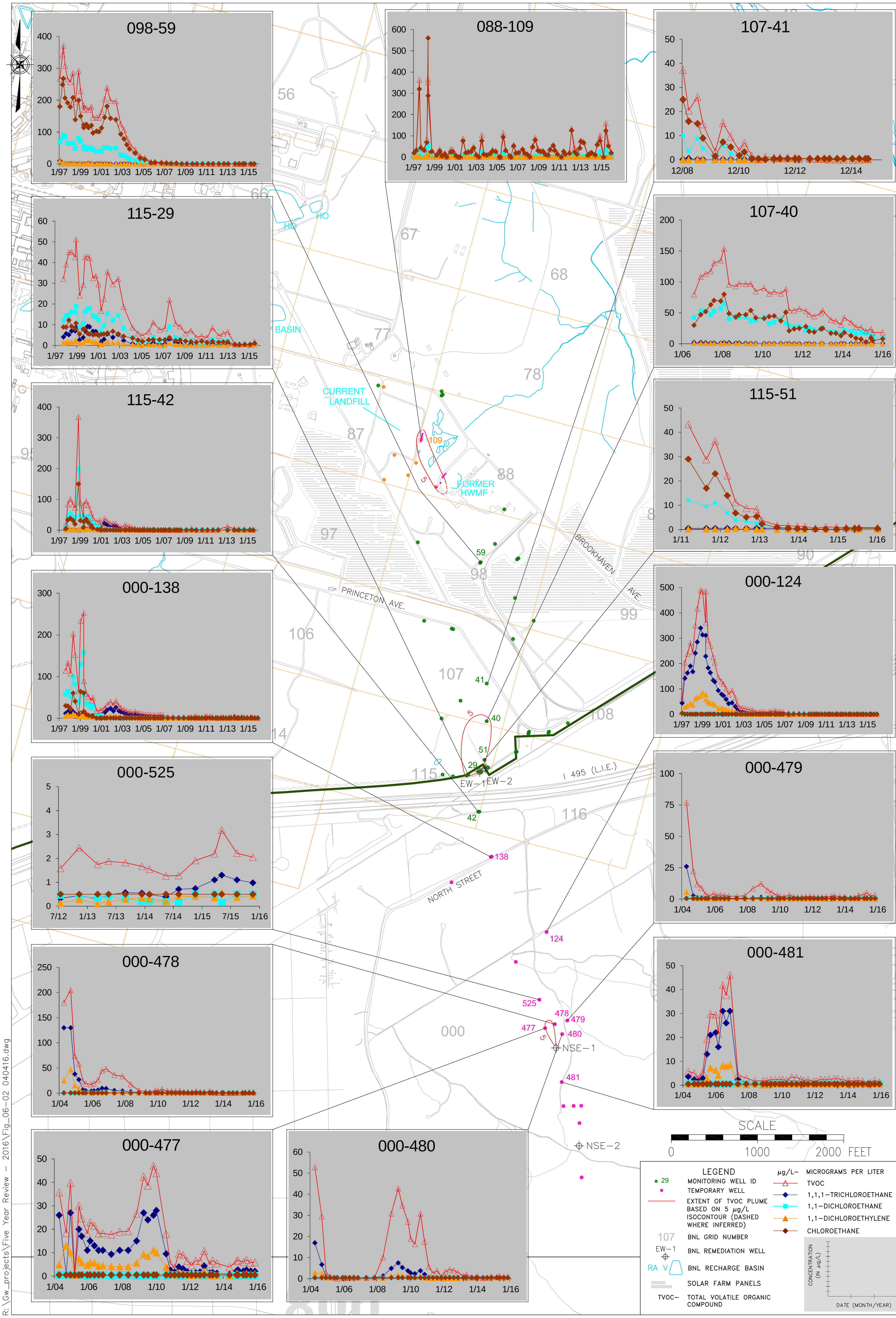
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

CURRENT LANDFILL HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT:HZ.: –	DATE: 05/02/16	PROJECT NO.: –
CHKD: JEB	APPD: RFH	REV.: –	NOTES: –
FIGURE NO.: 6–1			



BROOKHAVEN NATIONAL LABORATORY

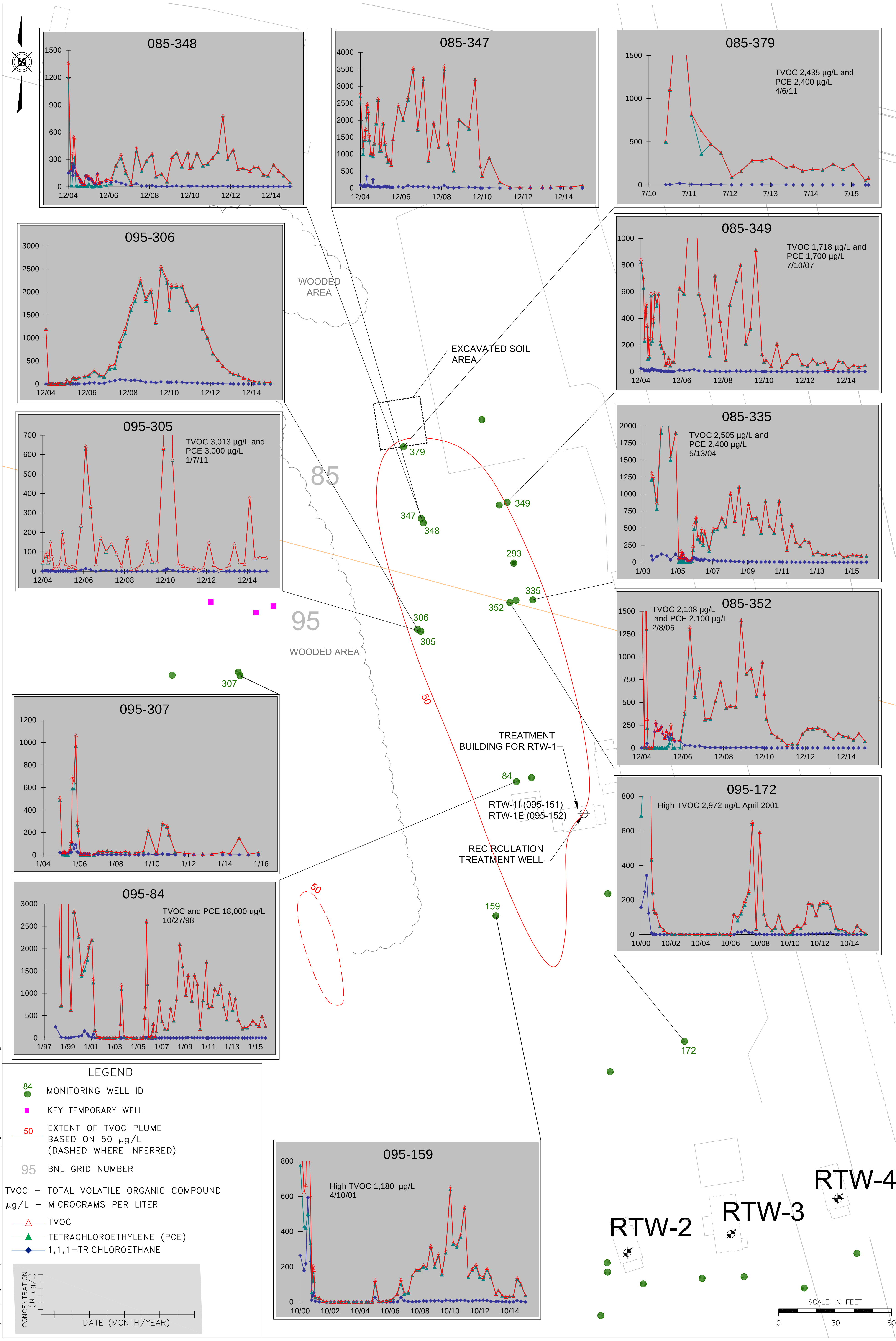
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU I CURRENT LANDFILL/ SOUTH BOUNDARY/ NORTH STREET EAST HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT: HZ.: –	DATE: 04/04/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–2			



BROOKHAVEN NATIONAL LABORATORY

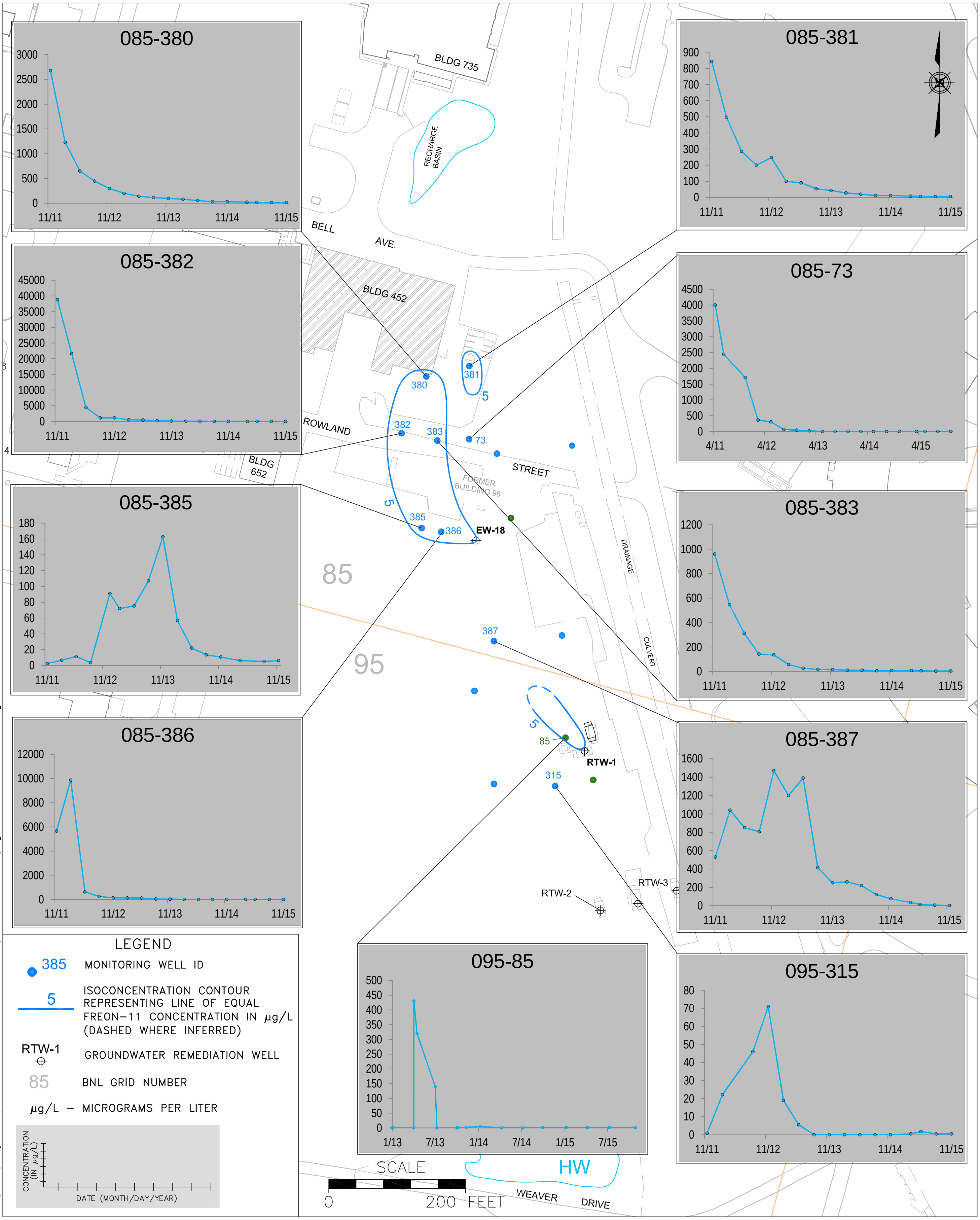
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III BUILDING 96 AREA HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VS: HS.: –	DATE: 04/19/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–3			



BROOKHAVEN NATIONAL LABORATORY

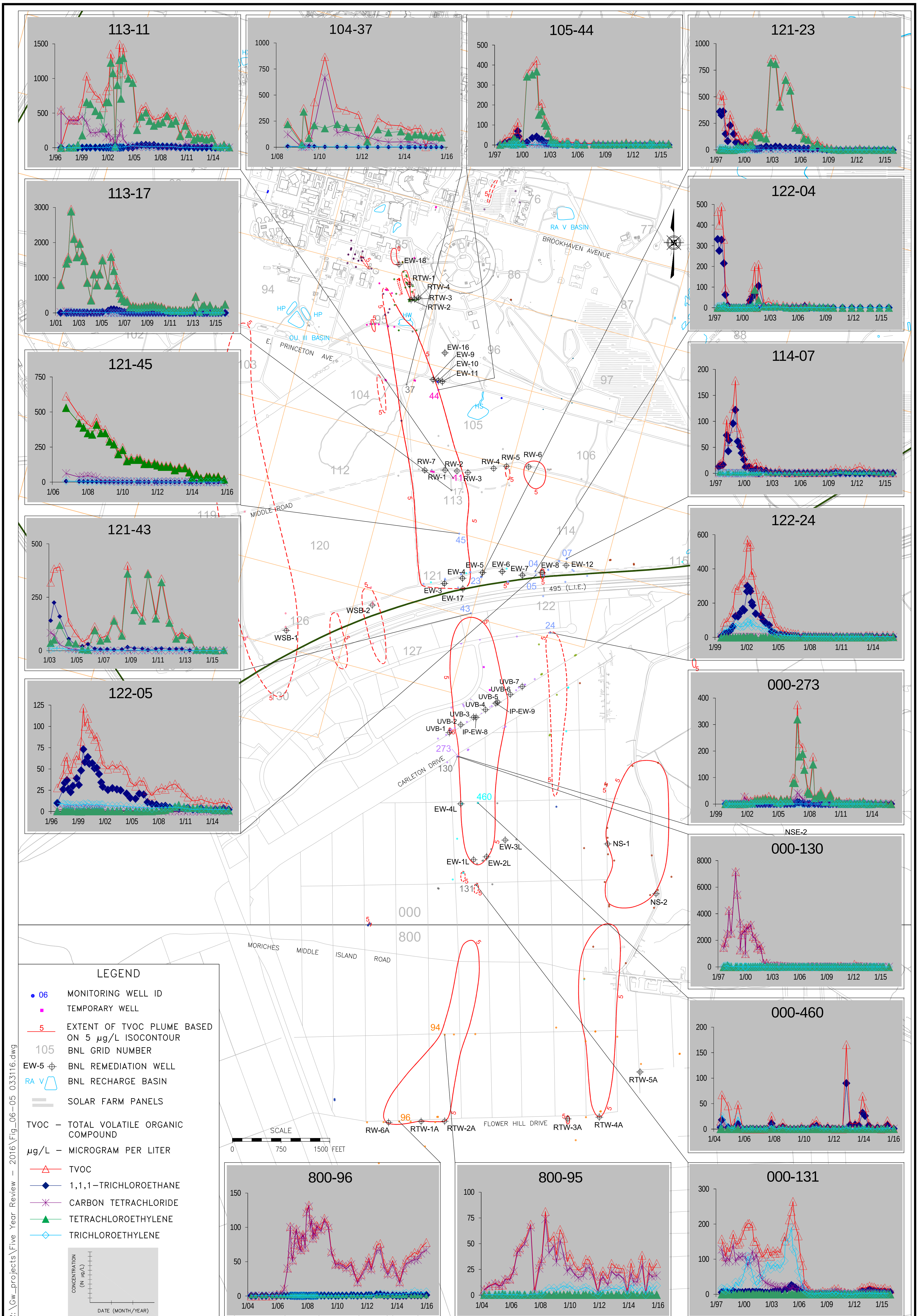
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU−III BUILDING 452 AREA HISTORICAL FREON−11 TRENDS

2015 BNL FIVE−YEAR REVIEW

DWN: AJZ	VT: HZ.: −	DATE: 05/02/16	PROJECT NO.: −
CHKD: JEB	APPD: DEP	REV.: −	NOTES: −
FIGURE NO.: 6−4			



BROOKHAVEN NATIONAL LABORATORY

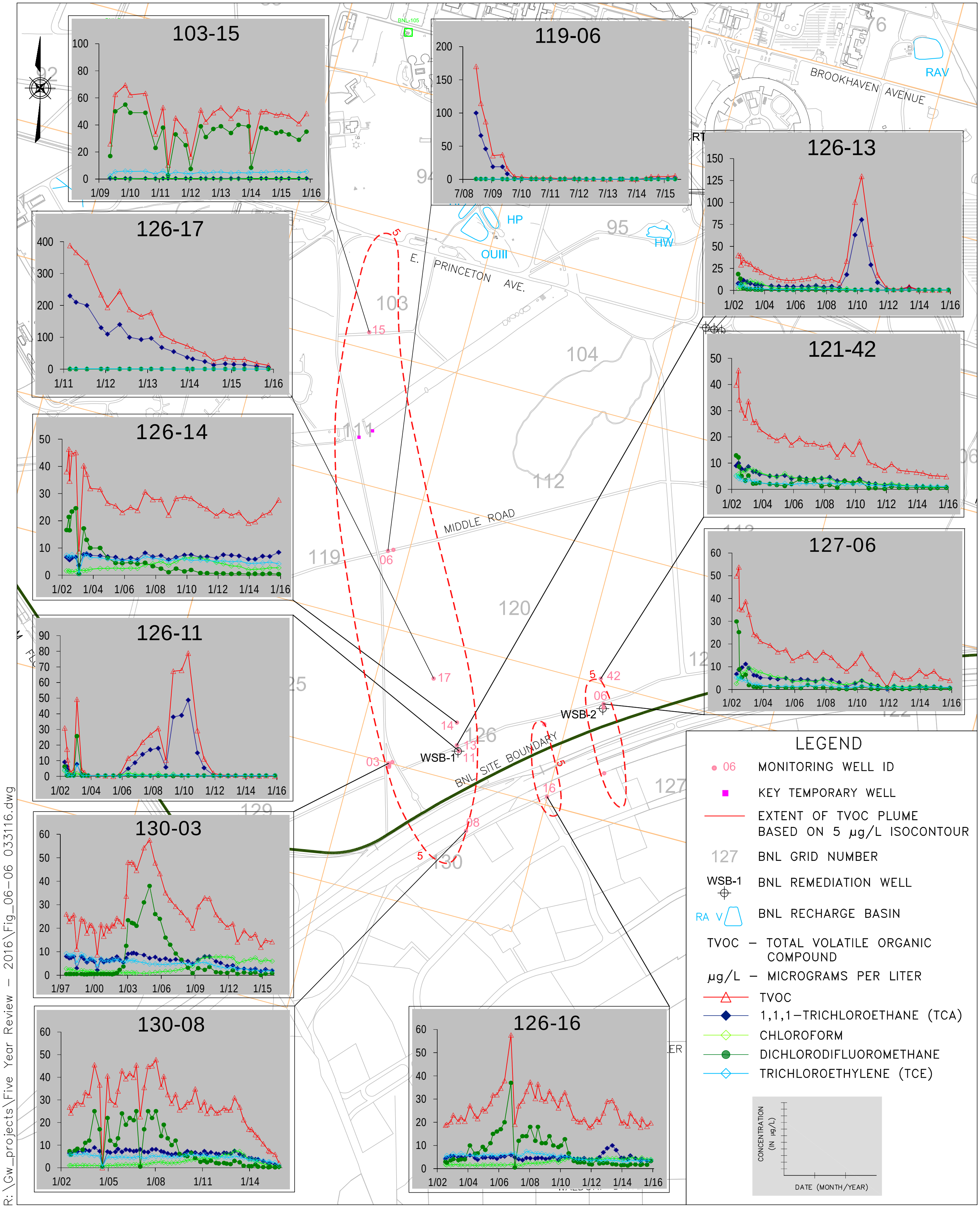
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III AND OU IV PLUME(S) HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT: HZ.: –	DATE: 03/31/15	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–5			



BROOKHAVEN NATIONAL LABORATORY

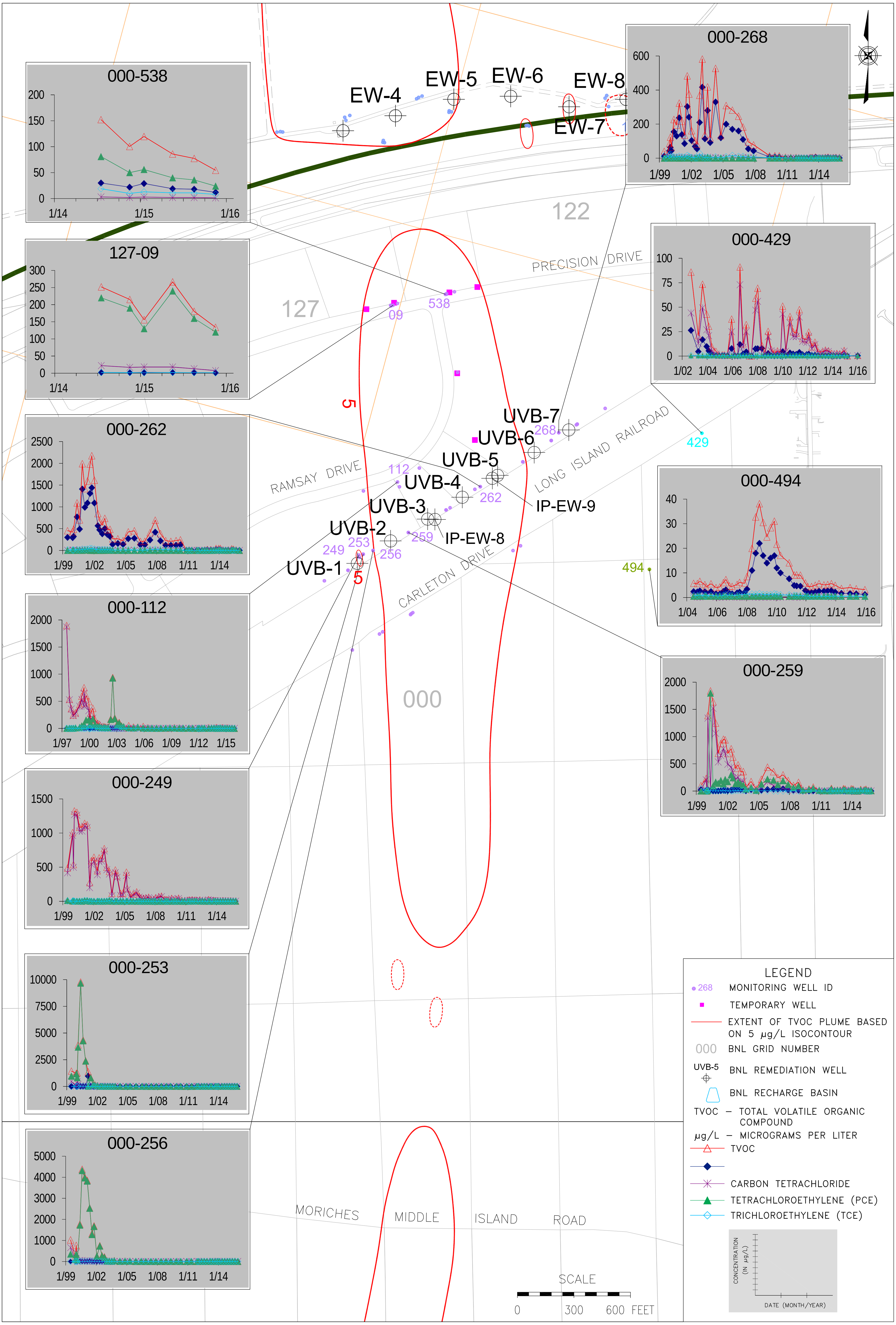
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III WESTERN SOUTH BOUNDARY HISTORICAL VOC TRENDS

2015 BNL FIVE–YEAR REVIEW

DWN: AJZ	VT:HZ.: –	DATE: 03/31/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–6			



BROOKHAVEN NATIONAL LABORATORY

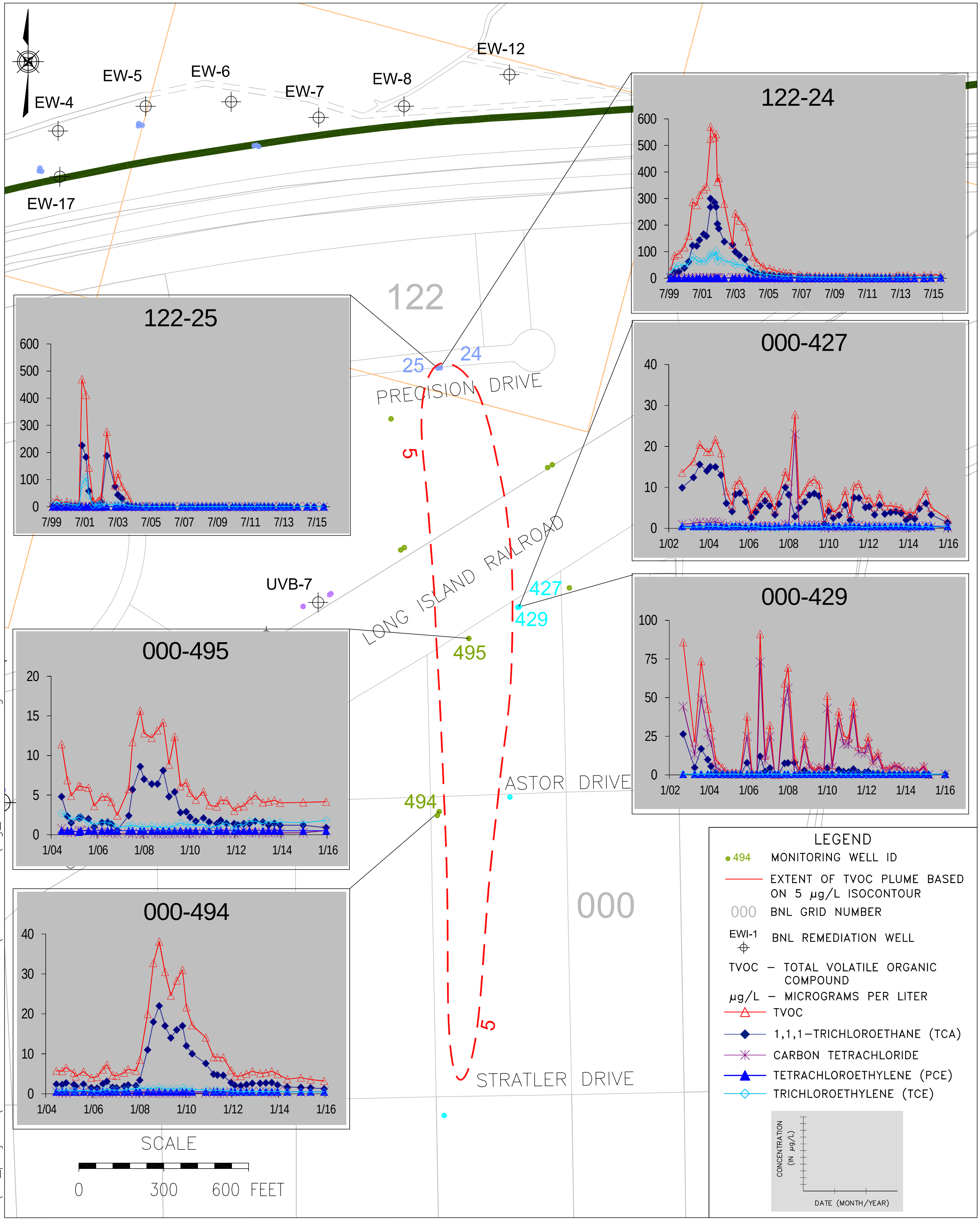
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III INDUSTRIAL PARK HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT: HZ.: –	DATE: 04/19/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–7			



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BROOKHAVEN NATIONAL LABORATORY

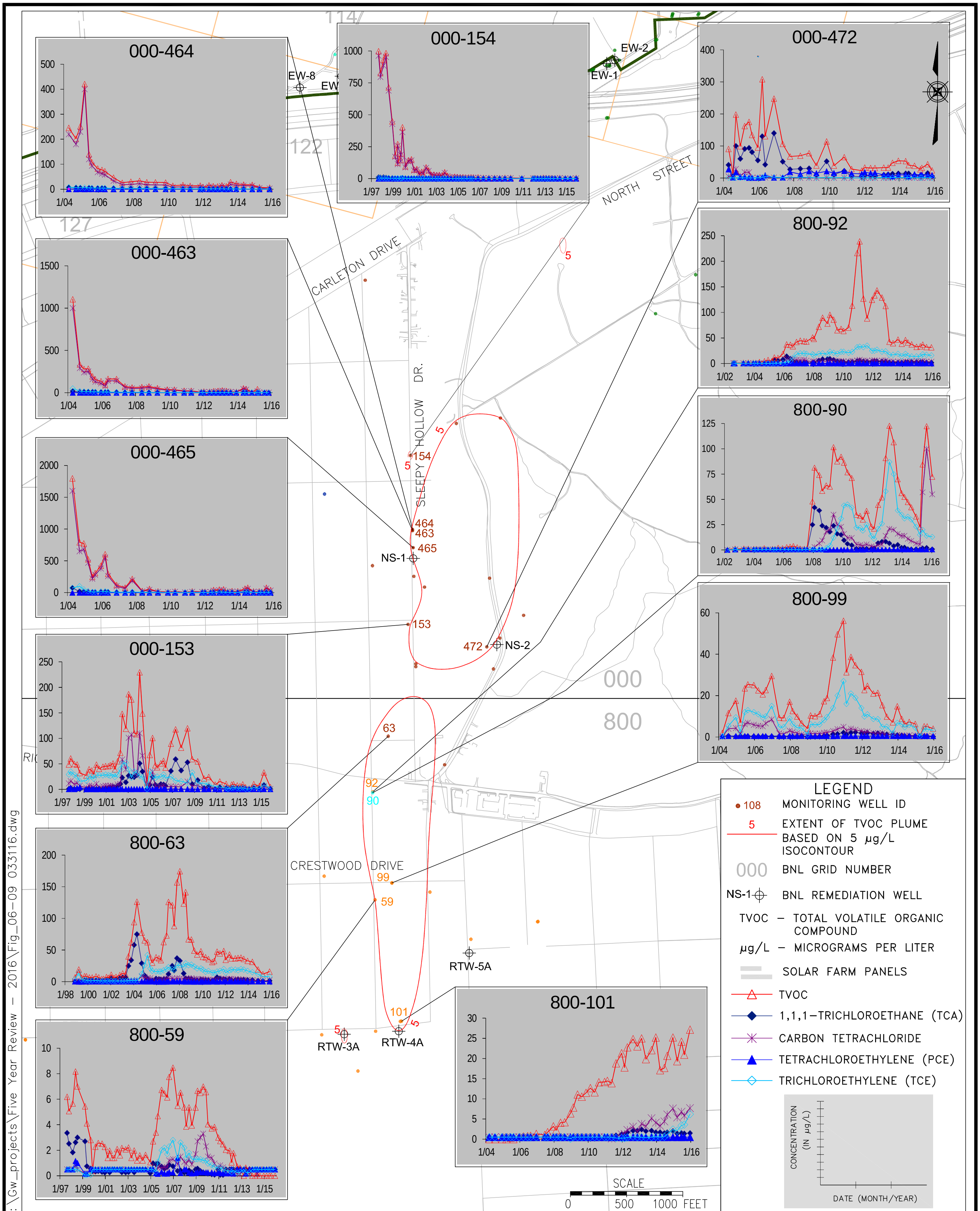
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III INDUSTRIAL PARK EAST HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/02/16	–
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–8			



BROOKHAVEN NATIONAL LABORATORY

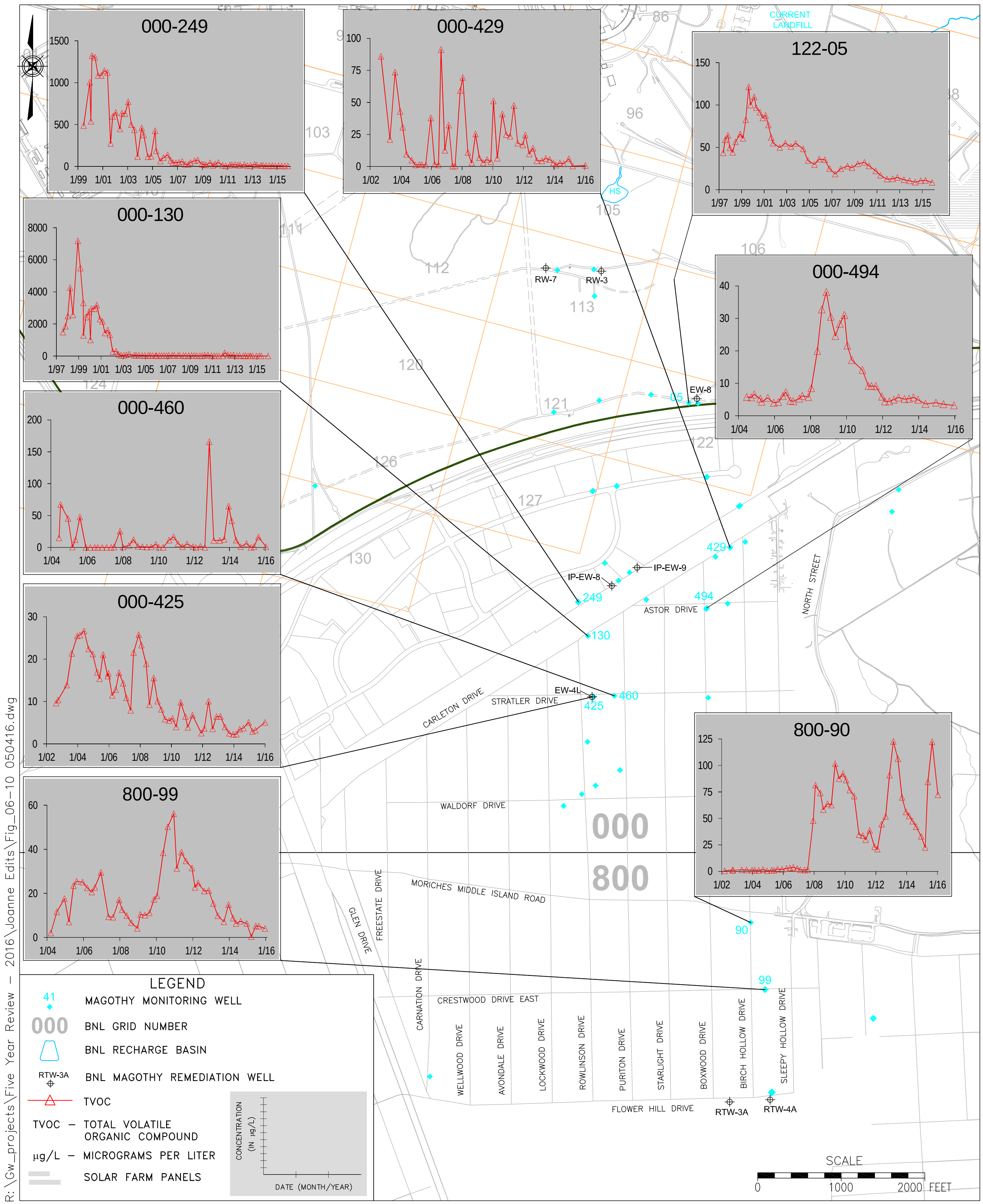
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

NORTH STREET (OU I/IV FORMER LANDFILL, CHEMICAL/ANIMAL HOLES) HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT:HZ.: –	DATE: 03/31/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–9			



BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

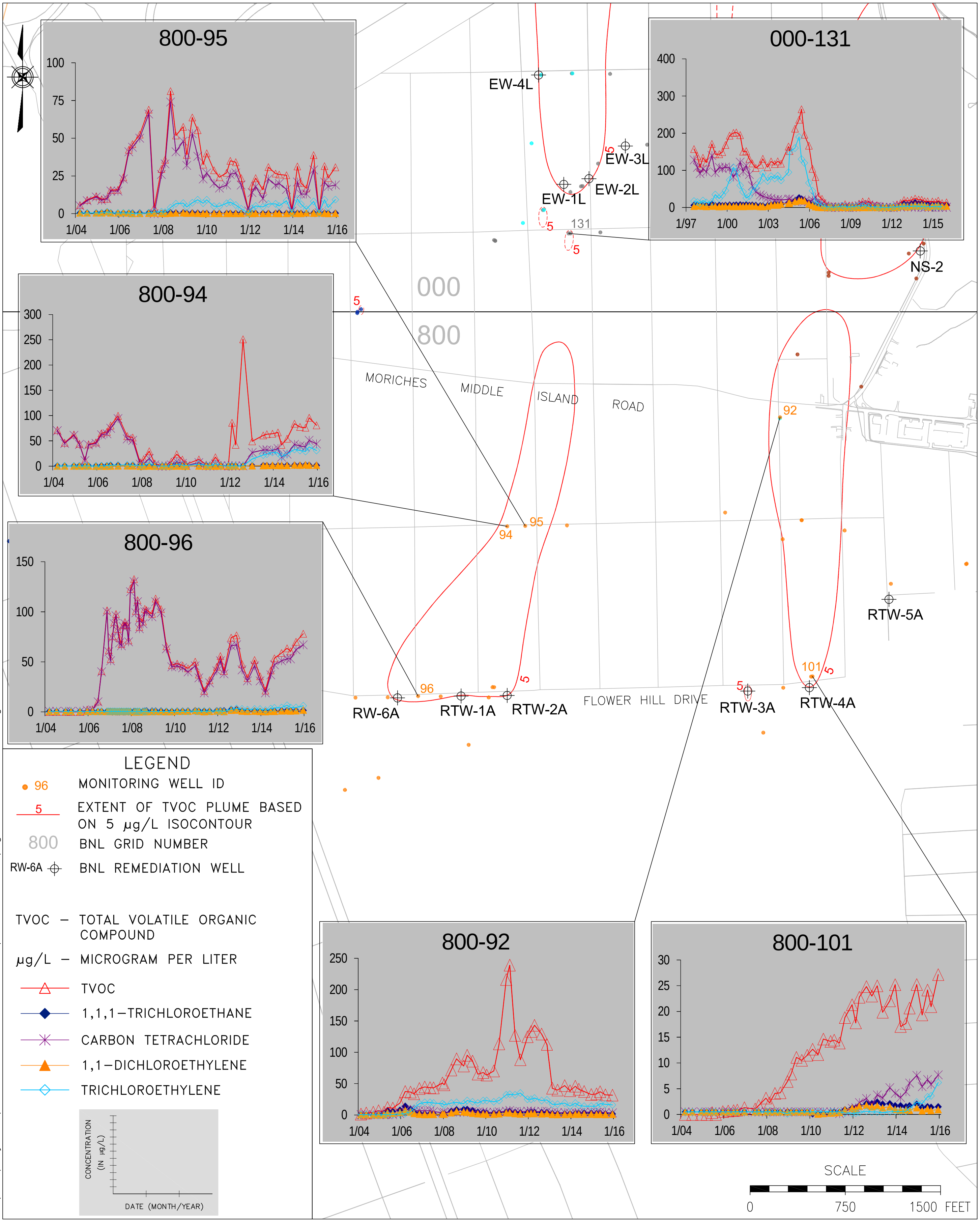
TITLE:

MAGOTHY HISTORICAL TVOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/04/16	–
CHKD:	APPD:	REV.:	NOTES:
JEB	WRD	–	–

FIGURE NO.: 6–10



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BROOKHAVEN NATIONAL LABORATORY

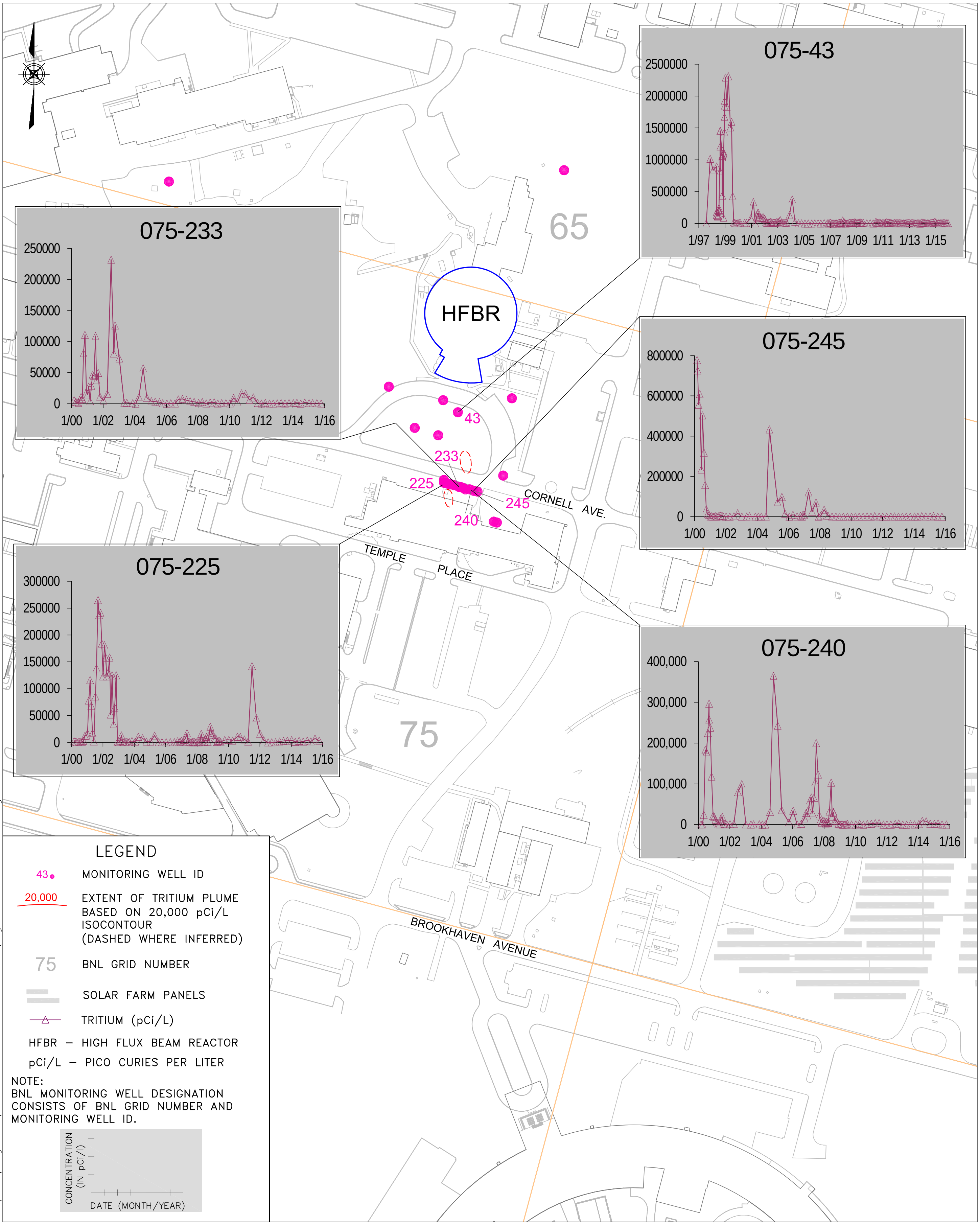
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III LIPA/AIRPORT HISTORICAL VOC TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/02/16	–
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–11			



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BROOKHAVEN NATIONAL LABORATORY

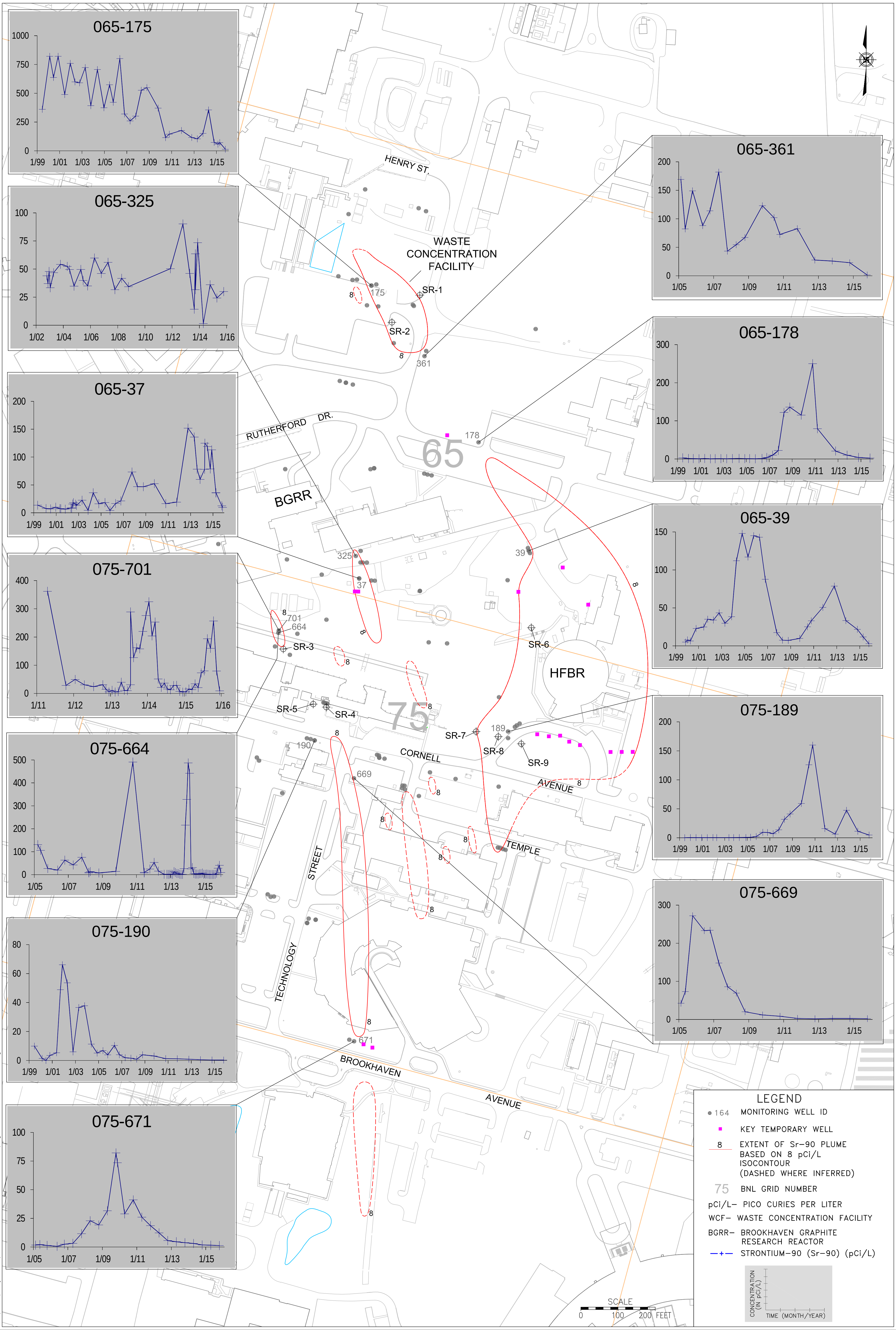
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III HFBR AOC 29
HISTORICAL TRITIUM TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT:HZ.: –	DATE: 03/31/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6–12			



BROOKHAVEN NATIONAL LABORATORY

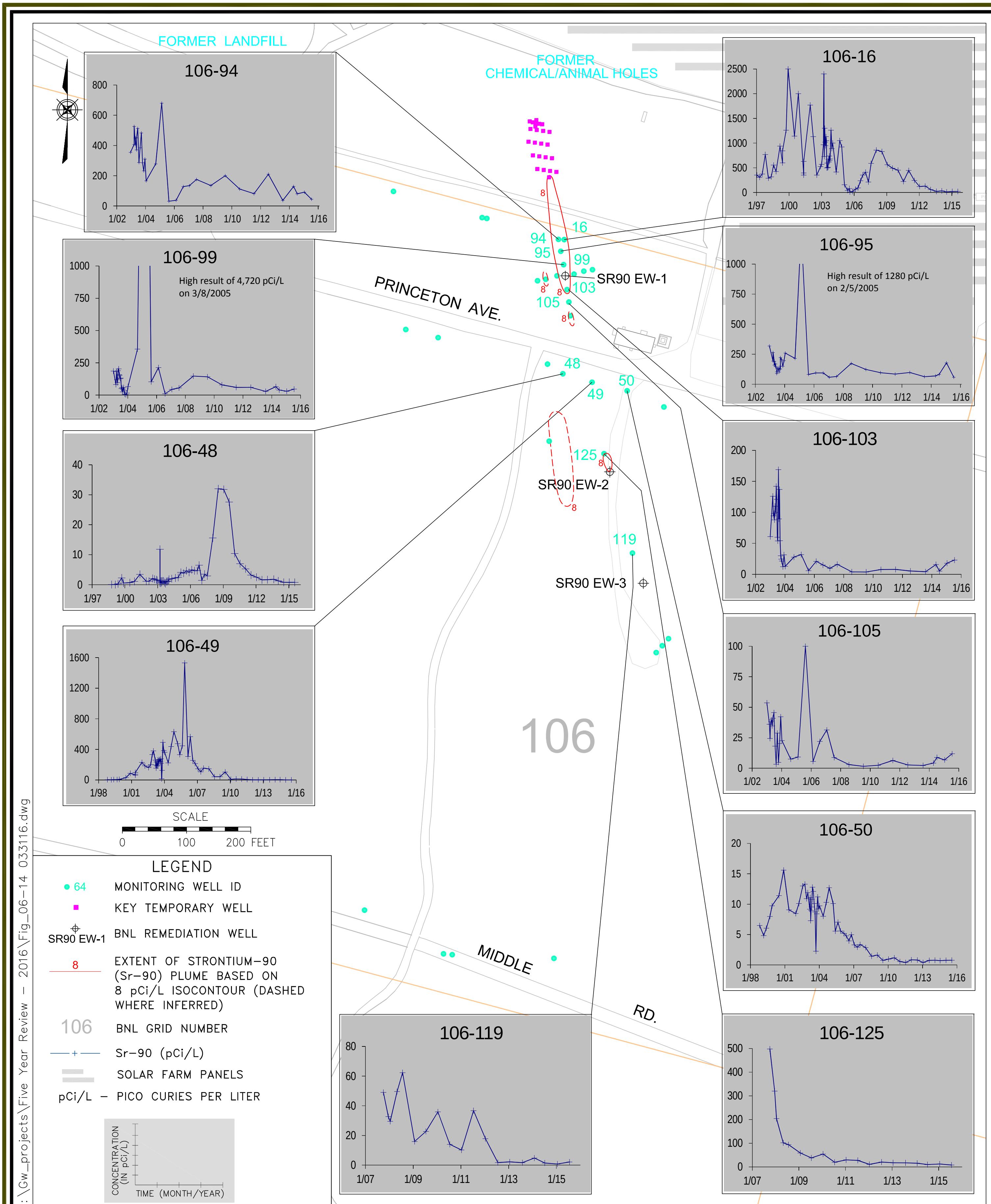
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III BGRR/WCF
HISTORICAL Sr−90 TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT: HZ.: –	DATE: 04/19/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6−13			



BROOKHAVEN NATIONAL LABORATORY

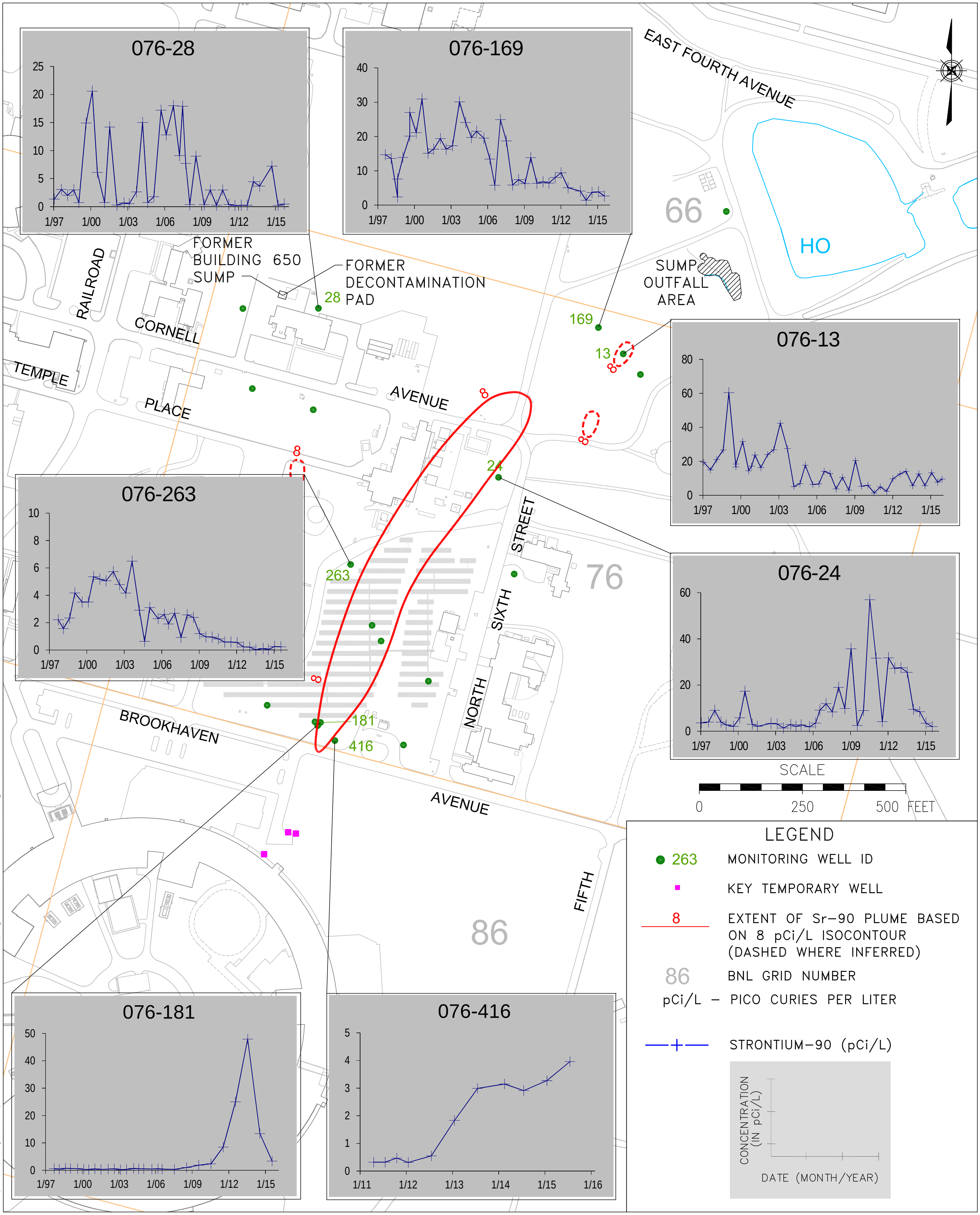
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

OU III CHEMICAL/ANIMAL HOLES HISTORICAL Sr-90 TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VT:HZ.: –	DATE: 03/31/16	PROJECT NO.: –
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –
FIGURE NO.: 6-14			



BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

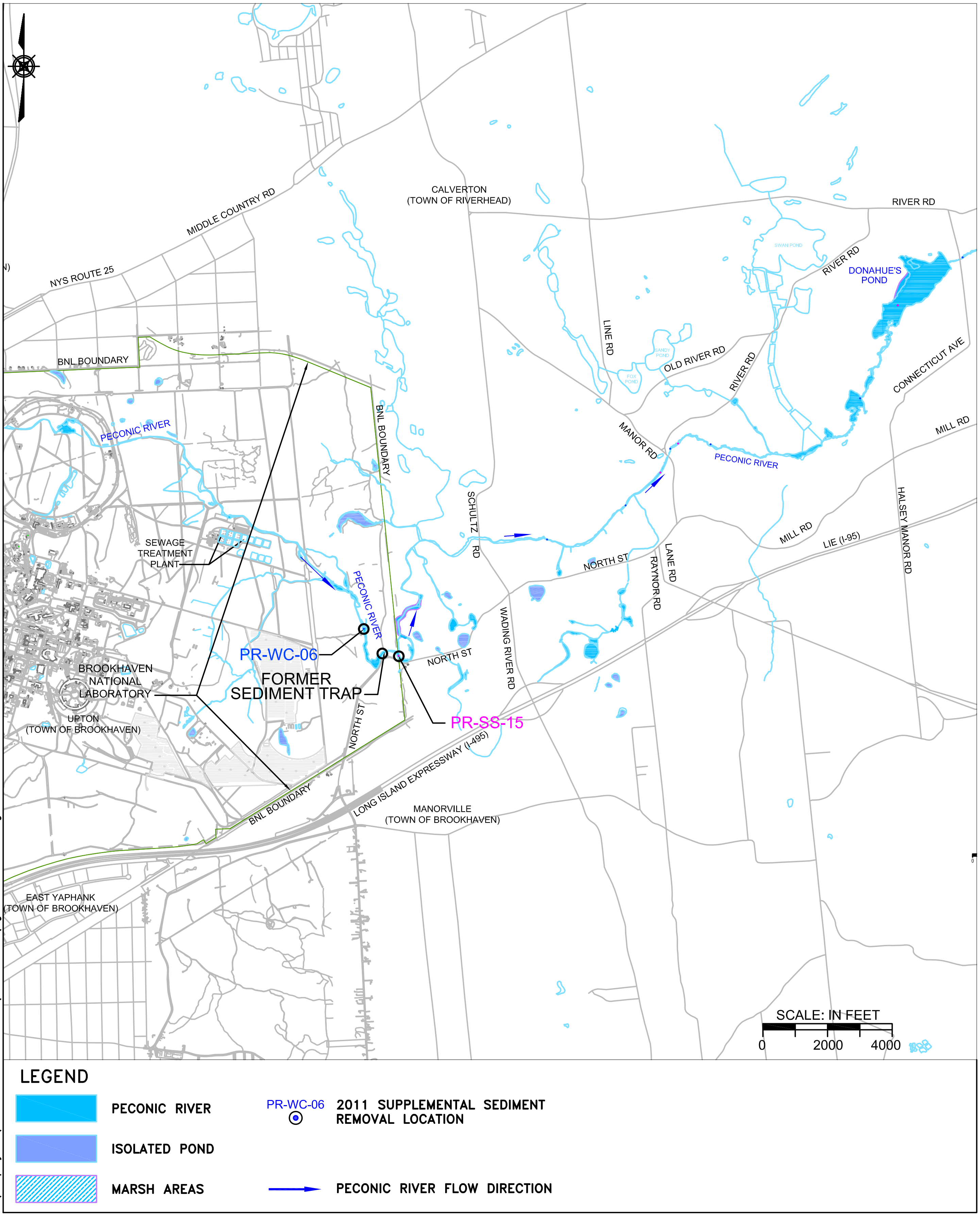
TITLE:

OU IV AOC 6
HISTORICAL Sr-90 TRENDS

2015 BNL FIVE-YEAR REVIEW

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	03/31/16	–
CHKD:	APPD:	REV.:	NOTES:
JEB	WRD	–	–

FIGURE NO.: 6-15



BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

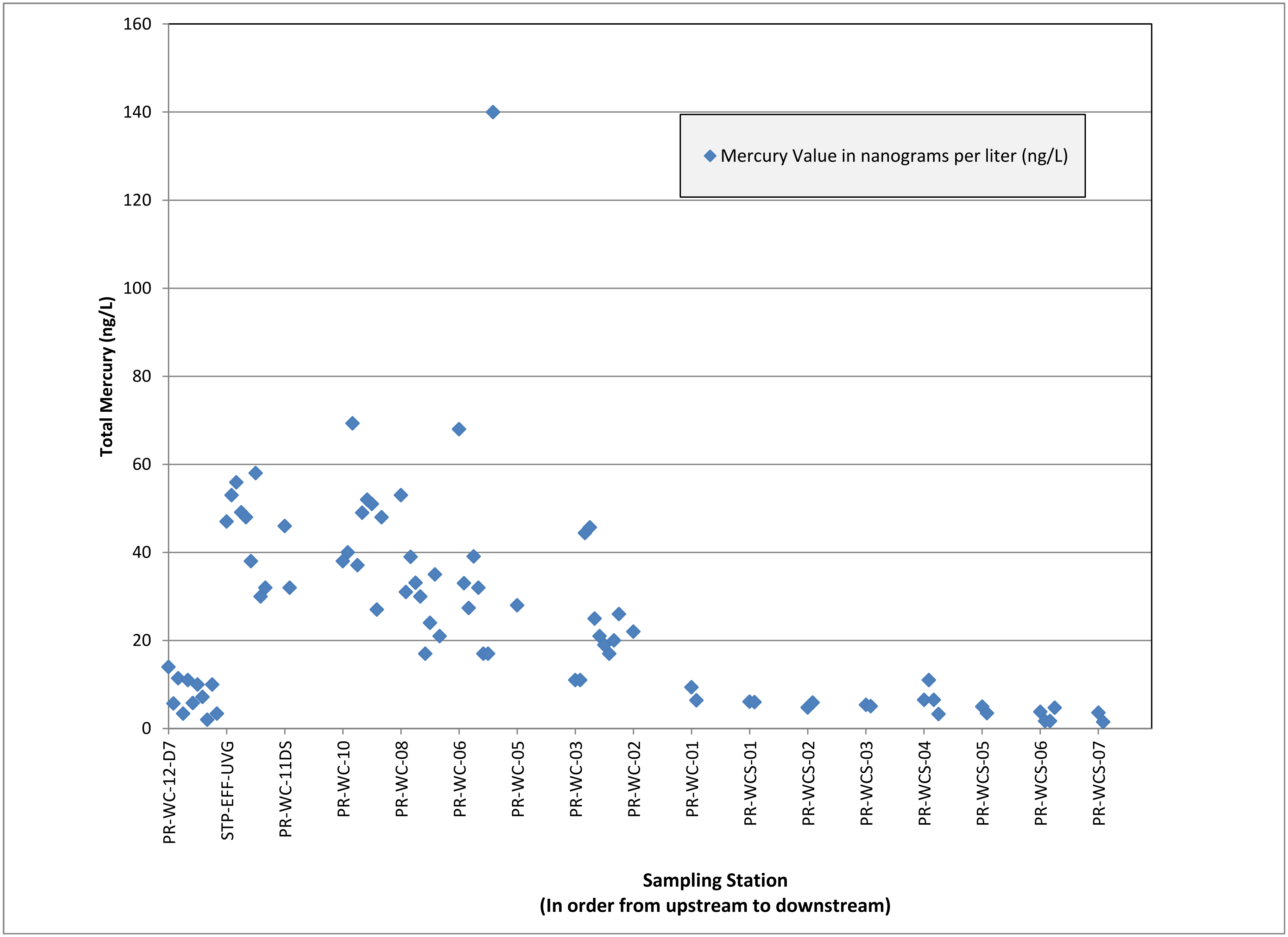
TITLE:

PECONIC RIVER SEDIMENT TRAP AND 2011 SUPPLEMENTAL REMOVAL LOCATIONS

2015 BNL FIVE-YEAR REVIEW

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	05/02/16	–
CHKD: WM	APPD: –	REV.: –	NOTES: –
FIGURE NO.: 6–16			

Figure 6-17: 2011 through 2015 Peconic River Mercury in Surface Water



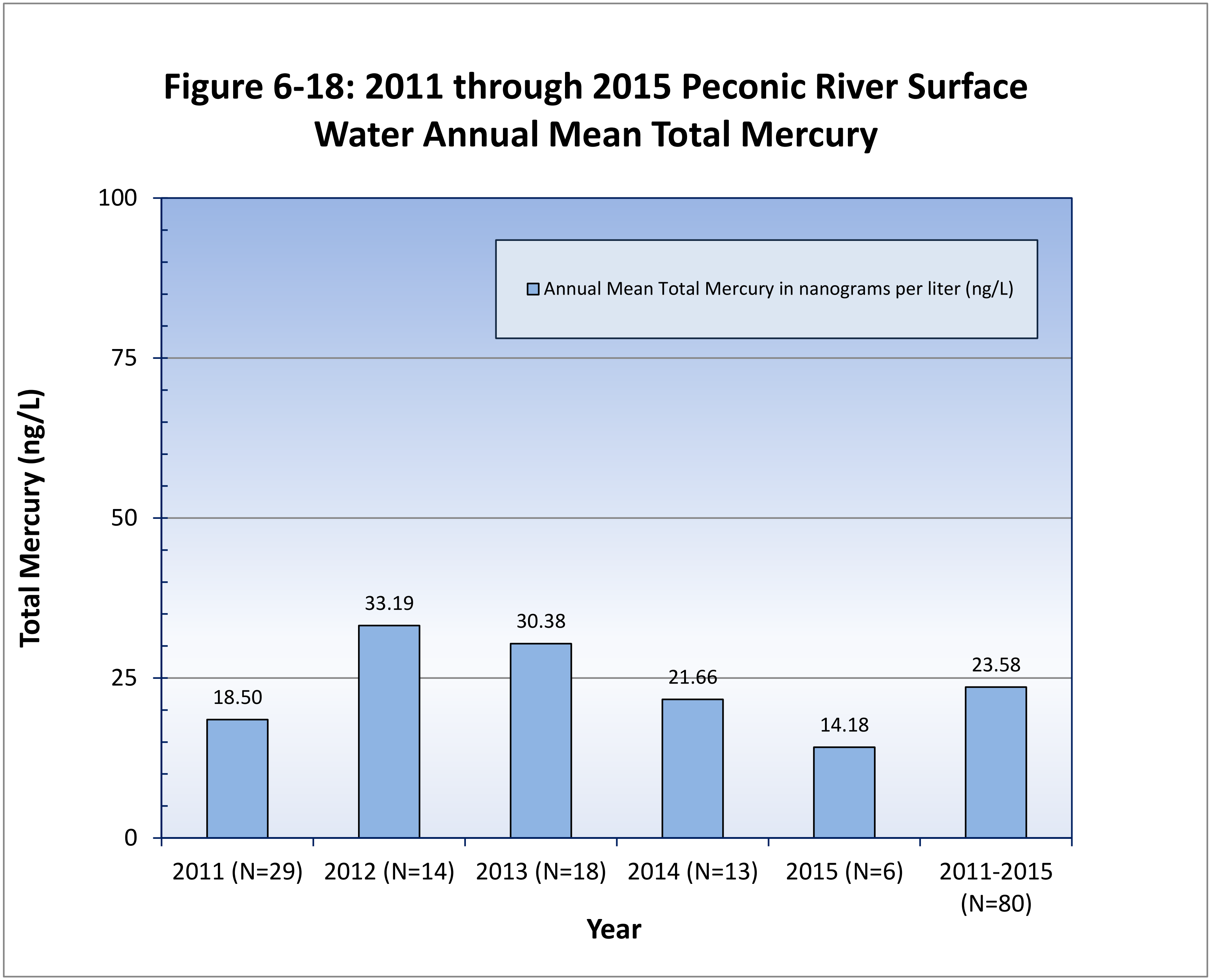
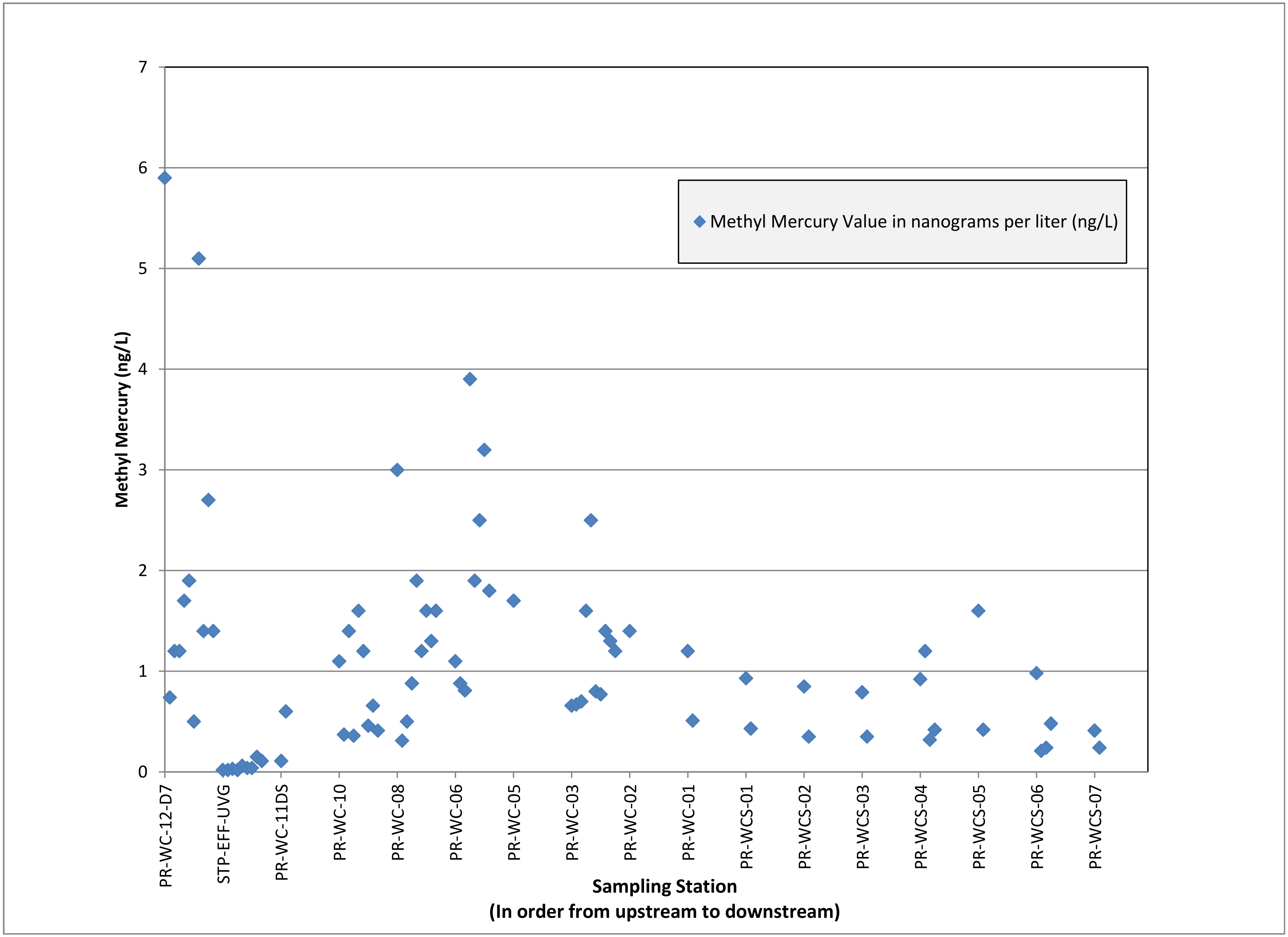


Figure 6-18: 2011 through 2015 Peconic River Surface Water Annual Mean Total Mercury
Annual Mean Total Mercury in nanograms per liter (ng/L)
Total Mercury (ng/L)
100
75
50
25
0
18.50
33.19
30.38
21.66
14.18
23.58
2011 (N=29)
2012 (N=14)
2013 (N=18)
2014 (N=13)
2015 (N=6)
2011-2015 (N=80)
Year

Figure 6-19 2011 through 2015 Peconic River Methyl Mercury in Surface Water



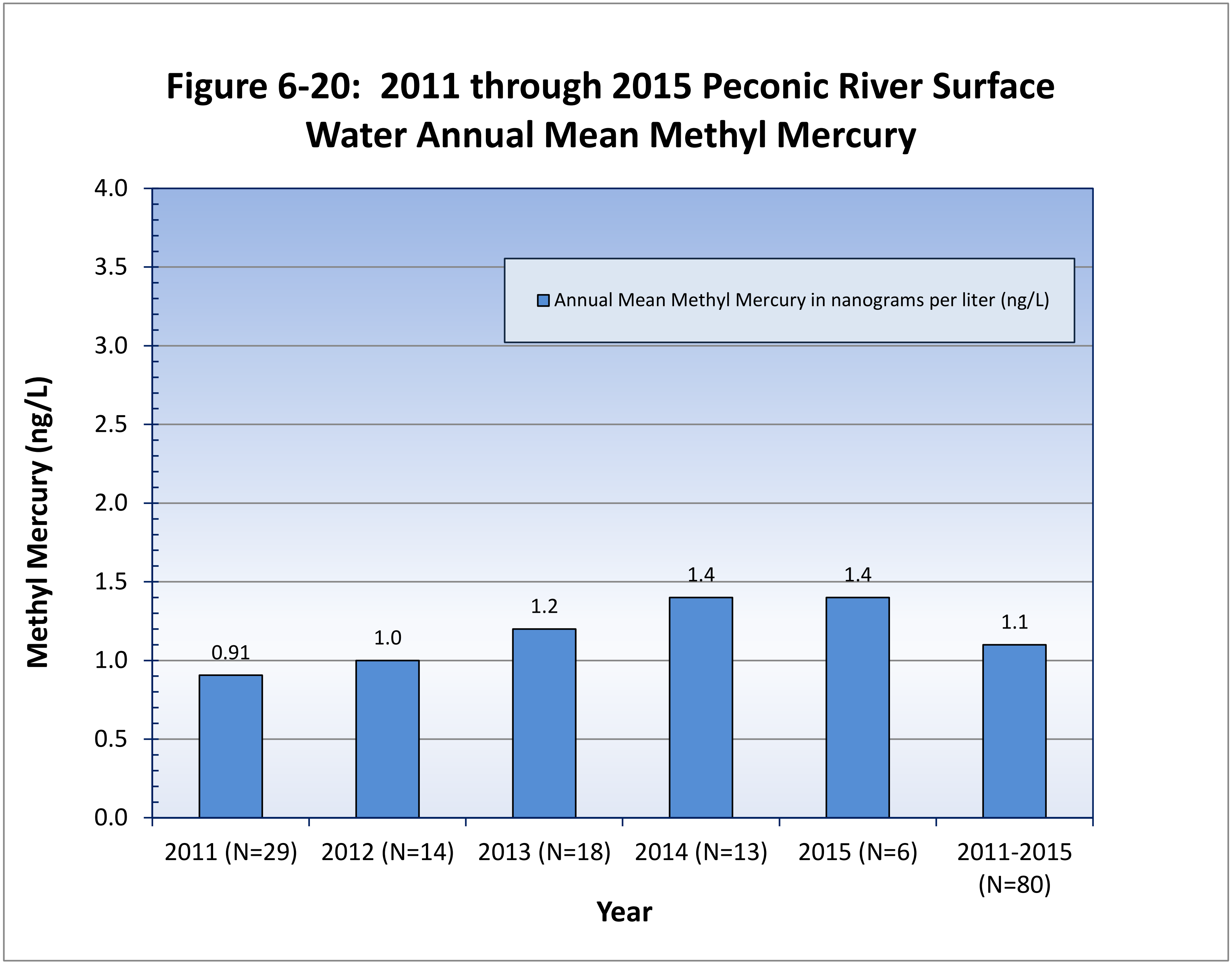
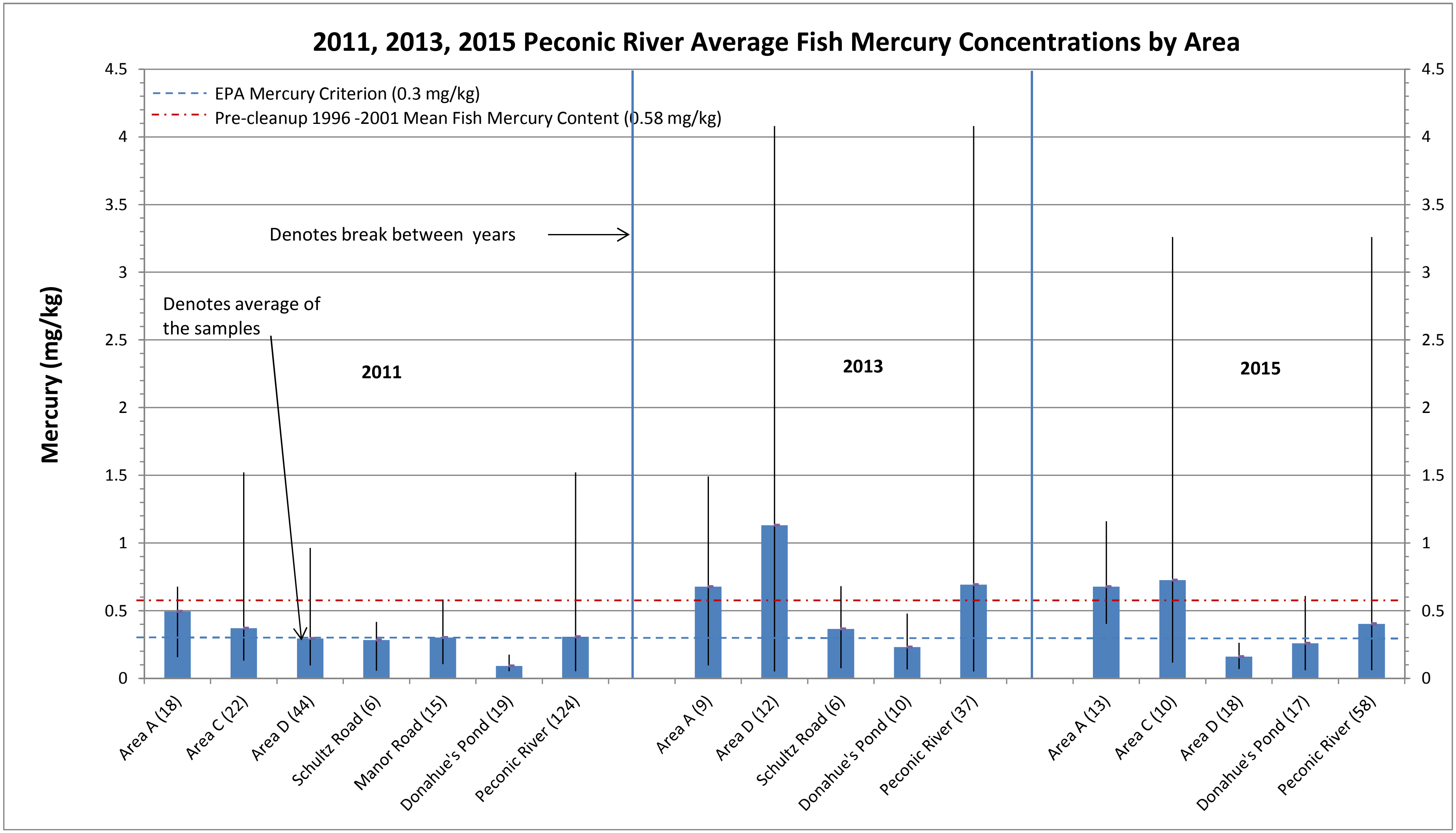
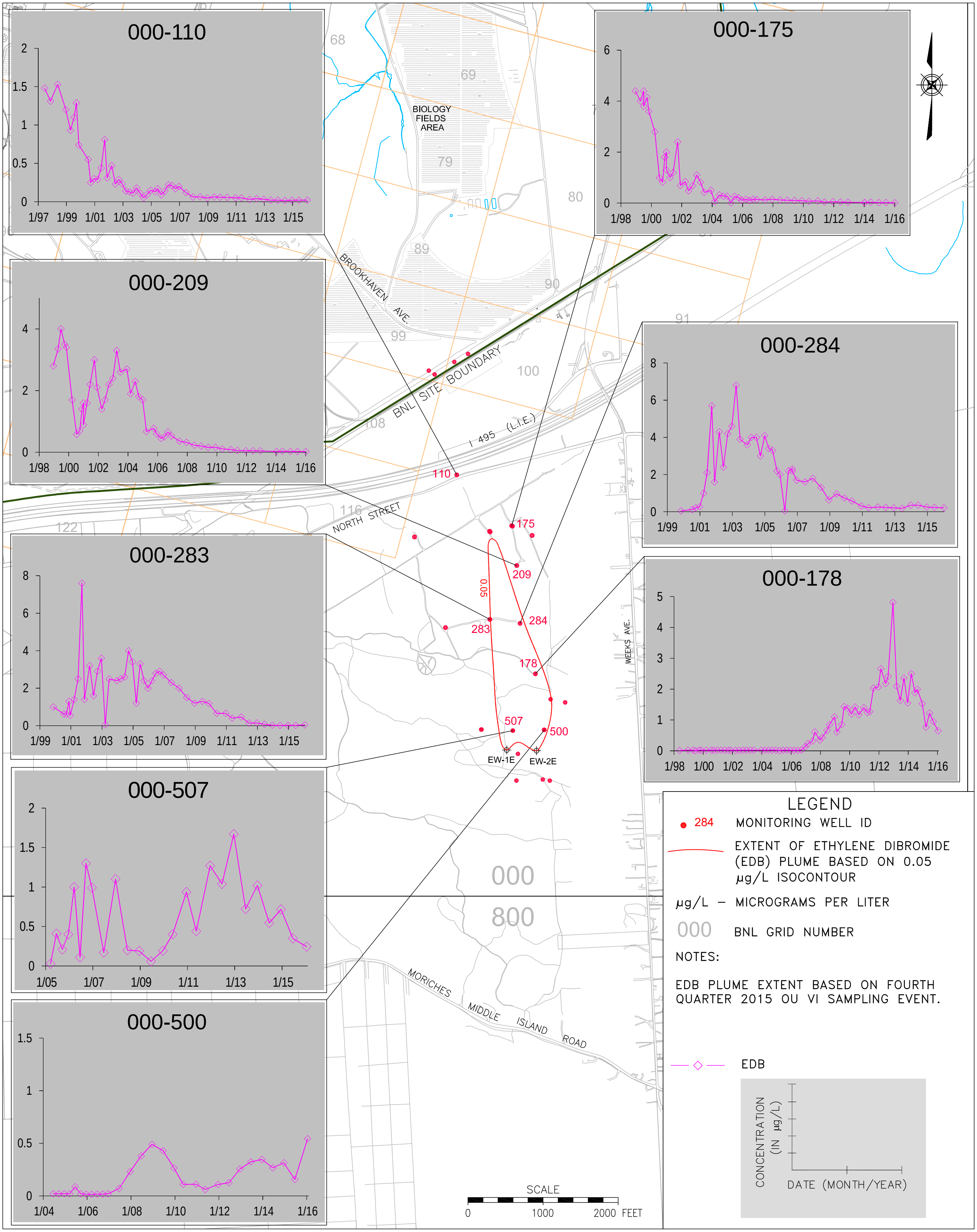


Figure 6-20: 2011 through 2015 Peconic River Surface Water Annual Mean Methyl Mercury
Annual Mean Methyl Mercury in nanograms per liter (ng/L)
Methyl Mercury (ng/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.91
1.0
1.2
1.4
1.4
1.1
2011 (N=29)
2012 (N=14)
2013 (N=18)
2014 (N=13)
2015 (N=6)
2011-2015 (N=80)
Year

Figure 6-21



2011, 2013, 2015 Peconic River Average Fish Mercury Concentrations by Area
EPA Mercury Criterion (0.3 mg/kg)
Pre-cleanup 1996 -2001 Mean Fish Mercury Content (0.58 mg/kg)
Denotes break between years
Denotes average of the samples
2011
2013
2015
Mercury (mg/kg)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Area A (18)
Area C (22)
Area D (44)
Schultz Road (6)
Manor Road (15)
Donahue's Pond (19)
Peconic River (124)
Area A (9)
Area D (12)
Schultz Road (6)
Donahue's Pond (10)
Peconic River (37)
Area A (13)
Area C (10)
Area D (18)
Donahue's Pond (17)
Peconic River (58)



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BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

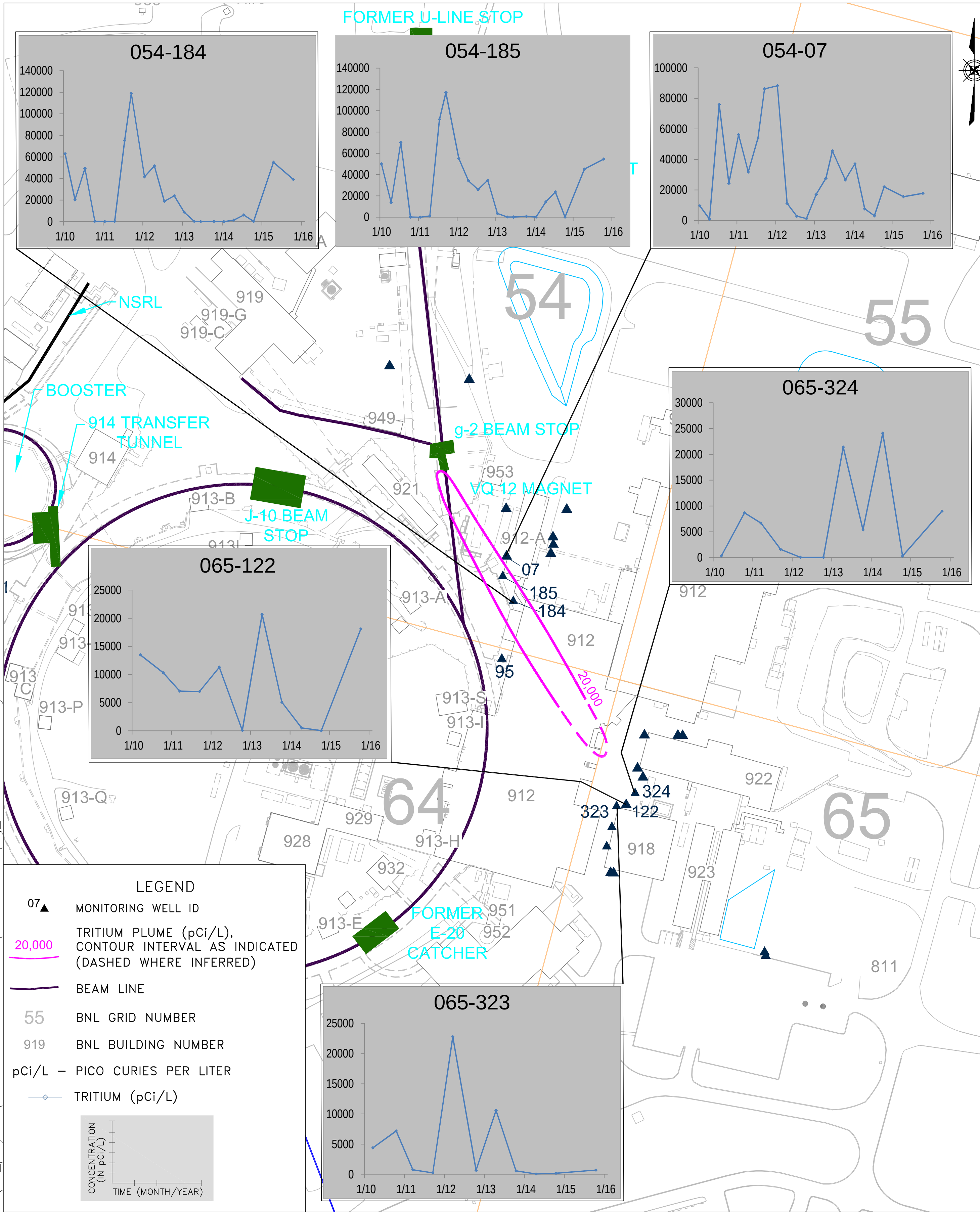
TITLE:

OU VI HISTORICAL EDB TRENDS

2015 BNL FIVE–YEAR REVIEW

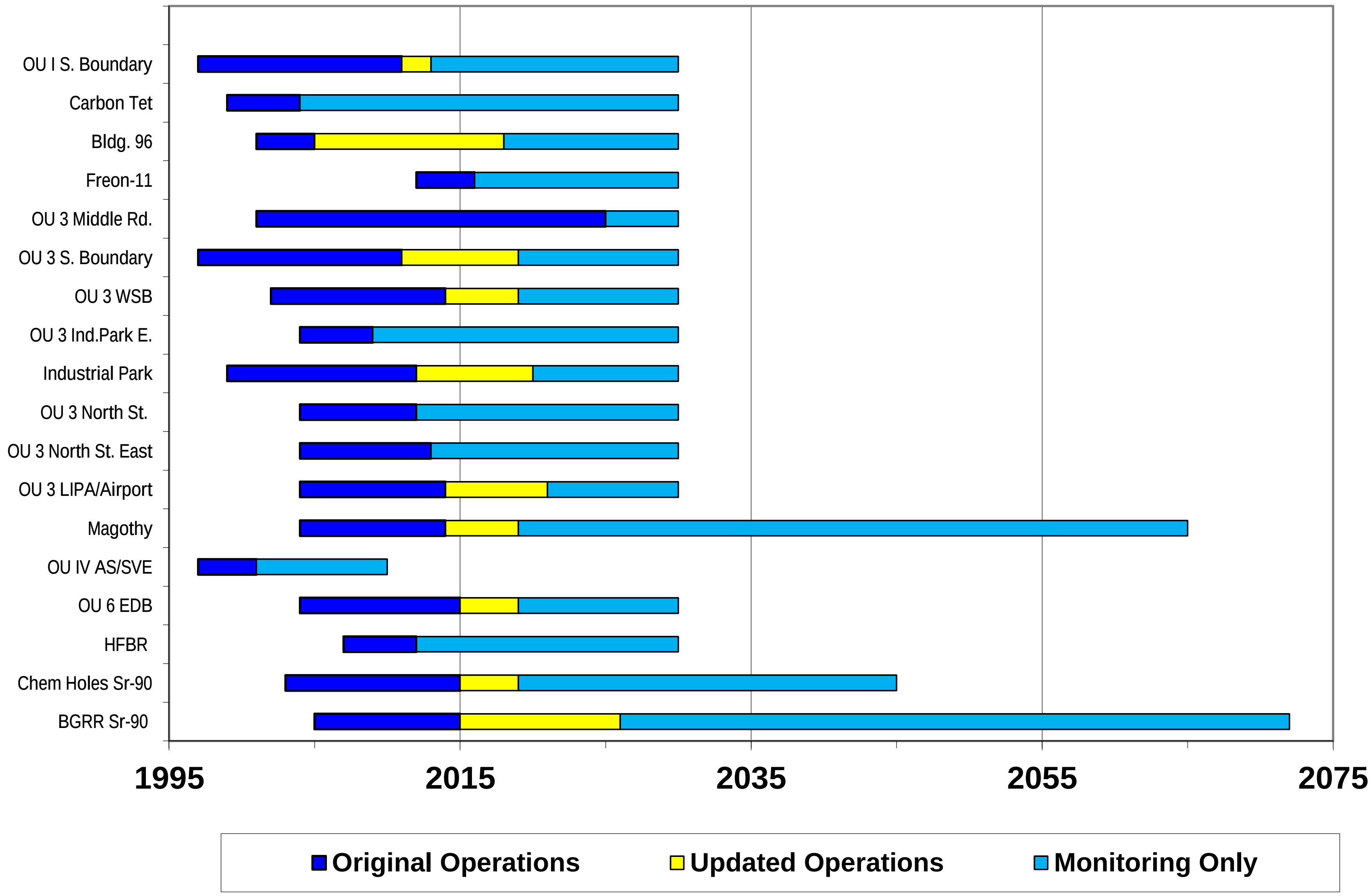
DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	04/11/16	–
CHKD: JEB	APPD: WRD	REV.: –	NOTES: –

FIGURE NO.: 6–22

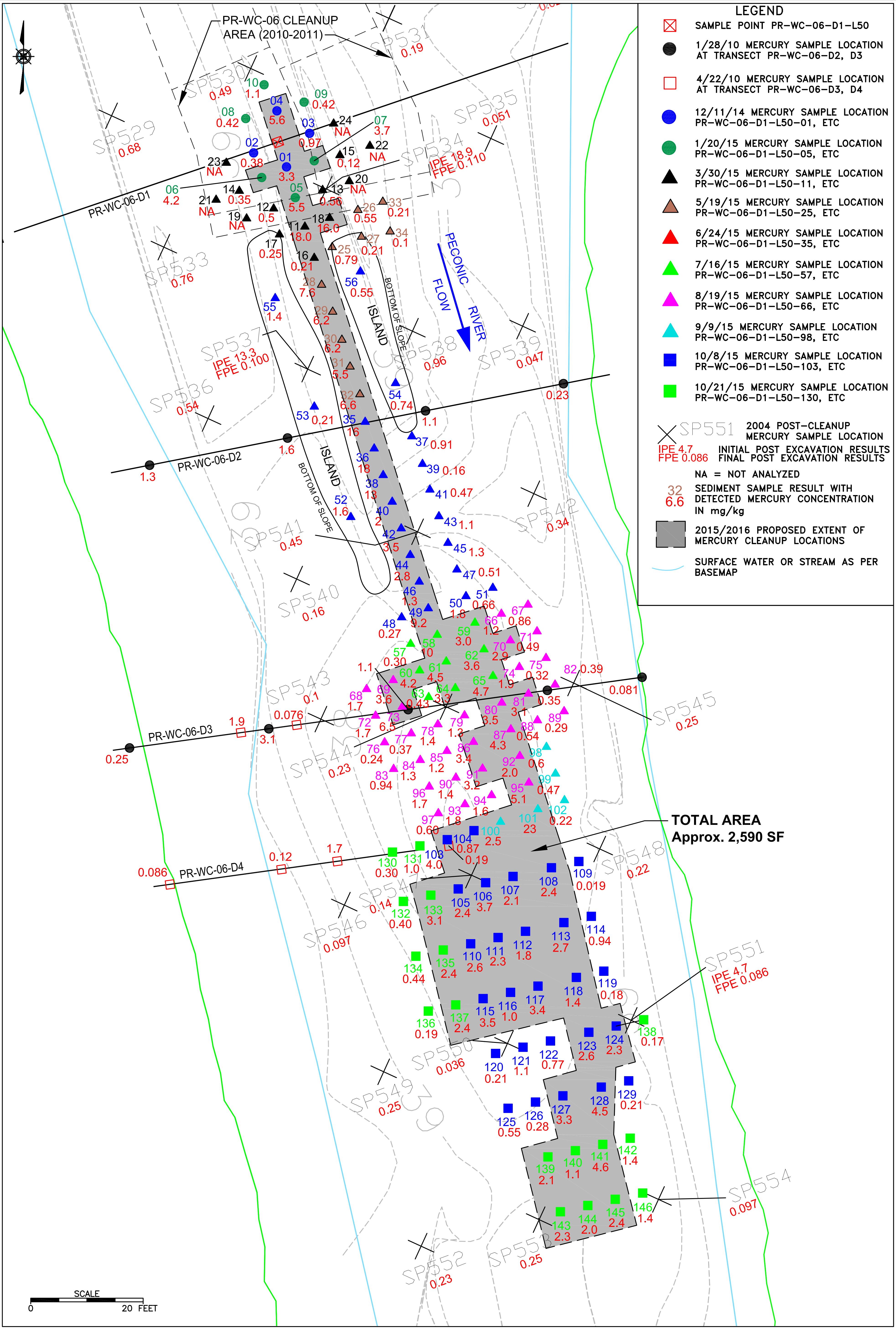


BROOKHAVEN NATIONAL LABORATORY ENVIRONMENTAL PROTECTION DIVISION	TITLE: AOC 16T g–2 HISTORICAL TRITIUM TRENDS 2015 BNL FIVE–YEAR REVIEW	DWN: AJZ	VT: HZ.: –	DATE: 05/02/16	PROJECT NO.: –
		CHKD: JEB	APPD: DEP	REV.: –	NOTES: –
		FIGURE NO.: 6–23			

Figure 7-1
Groundwater Treatment System Status



X:\Five Year Review\2016 Five Year Review\Figures\Figure 7-1 - System Timeline



BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
PECONIC RIVER PR-WC-06 MERCURY SEDIMENT DATA/PROPOSED CLEANUP AREA

2015 BNL FIVE-YEAR REVIEW

DWN: AJZ	VS: HS.: –	DATE: 6/24/10	PROJECT NO.: –
CHKD: RH	APPD: RH	REV.: 05/02/16	NOTES: –
FIGURE NO.: 7-2			

Attachment 1

Poll from October 8, 2015 BNL Community Advisory Council Meeting

Five-Year CERCLA Review

Community Advisory Council Input
October 8, 2015

October Meeting Survey

The Community Advisory Council members present at the October 8, 2015 meeting provided comments on the following questions. The comments are to serve as their input into the 2016 Five-Year Review. Additionally, some CAC members also provided written comments in response to the questions.

1. What is your overall impression of BNL's cleanup and do you feel well informed about the cleanup activities and progress?

Member Peskin, Brookhaven Retired Employee's Association, said his impression of the cleanup is extremely positive and he feels quite well informed about the activities and progress. He said he has been on the CAC as a member or alternate for about 10 years. Prior to that he was a stakeholder as an employee, he remembers the bad ole days when a group like this was sorely needed, he said the information flow is vital, these are no longer the bad ole days and said the Lab should be commended for the support they gave the CAC and the community in general.

Member Talbot, Middle Island Civic Association, said BNL's cleanup is and has been a central activity of attention to all operating departments. A large and continuing effort has been in place to keep the status of the cleanup in the forefront.

Member Chaudhry said he thinks there should be more of a focus on radioactivity and radionuclides and cleanup associated with them as opposed to the nonradioactive substances.

Member Sprintzen, Long Island Progressive Coalition, said excellent and yes!

2. Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. RODs, cleanup goals, community input, etc.)

Member Esposito, Citizens Campaign for the Environment, said just to make sure her comments were received, the 70-year timeline for Sr-90 plume that she is still unhappy about, since we have several years of monitoring, should be looked at to see if it can be shortened to less than 70 years. That was the longest remediation timeline that was approved for any of the areas at BNL so we should look at current and new data to see if it can be shortened. The timeline for the High Flux Beam Reactor should also be looked at to see if that can be shortened. She said we should not leave this for the next generation. She also wanted to focus on new technologies for denitrification for the sewage treatment plant.

Member Muether, Long Island Pine Barrens Society, asked if there was some kind of a report that compared what the CAC recommended and voted on for the cleanup many years ago and compared that to what was really done showing details about how the costs compared, time spent, and the degree of the cleanup. She wondered if there was a comparison done on the recommendations the CAC voted on.

Member Murdocco, Teachers Federal Credit Union, thinks it's important to keep a focus on making sure that, since the Lab is a science facility, it is easy to get lost and spiral down into a well of jargon and terms that the public isn't that familiar with outside of this group, make sure to keep that focus because it will be key for stakeholder relations.

Member Esposito added that she thinks that the Lab also needs to begin focusing on the Medical Reactor as there is not yet a D&D process established for it.

3. Do you feel confident in BNL and DOE's management of the long-term cleanup operations for the site?

Member Kaplan, Friends of Brookhaven, BNL the confidence in the management of the long-term cleanup, it's hard to say anything about DOE. We haven't been given as many presentations by DOE people here at the CAC concerning their input. You might say if I'm confident about BNL then by default one could say that about BSA and DOE, however, speaking for myself I don't feel that I could definitely give any comment about DOE's role and that's why I asked at our last meeting to see more input from DOE and from the regulators.

Member Peskin, said that you can only feel as confident as you are that you know who the management of the site will be. Directors change, strategic documents change. There was even a time when DOE didn't exist but Brookhaven Lab did. So you can't feel too confident because things can change, hopefully, for the better but you don't know.

Member Chaudhry said he might not agree with Member Kaplan regarding the DOE, but he gives them credit for what they are supposed to be doing. They are a management entity, not an implementing entity really, so they stay in the background. He gave a 9 out of 10 to BNL and DOE.

Member Heil, Town of Brookhaven Senior Citizens, said over the past few years BNL management has certainly earned our confidence and maybe along the same way DOE also because certainly BNL can't do much beyond the DOE approvals and funding. It's hard to predict the future. Changes of administration, changes of theories of life in the US, how future funding and availability of personnel, all those things that make up the program, how will they evolve, will they be there in the same way, hopefully it will continue, but it's always subject to change.

Karen Blumer said apparently DOE is really competent and diligent, however, in terms of trust and working or getting input from them here, we've noticed that everything is kept separate. Even on the nuclear discussion tonight everything is separated. So their performance on projects that we have seen and experienced here, input on the NEPA forms for example, our input was dismissed, therefore, our confidence level is shaken.

4. Do you have any comments, suggestions, or recommendations regarding BNL / DOE's management and communications of the cleanup?

Karen Blumer said she'd like to see a chart showing a summary of the progress overtime for all the cleanup projects so that it's not fragmented, so you can get a whole concept of what's happening. An easy chart that can be referred to. Progress was defined as where we are, as compared to where we were in the beginning.

Member Carlin, Huntington Breast Cancer Coalition, said he always felt like the website materials are organized for engineers and that's not for most people, it's easy to get lost. He'd like to see a high-level overview for the general public of all the different cleanup and oversight kinds of things happening at the Lab and liked what Member Blumer had said.

Member Martin also seconded Member Blumer's request for a chronological chart possibly broken down into different areas.

Written Reponses

Rite Biss
Lake Panamoka Civic Association

The cleanup appears to be going well from the talks we have heard at the BNL meetings.

What are the permanent results or is it just in the local area discussed. Is this material in other local areas. Is the clean-up permanent or just temporary in the local area.

The cleanup appear to be going well, the quantities is down is it just in the local area. Did you choose the worst area correctly.

You have presented a reasonable discussion of local areas. What happens in the future.

Karen Blumer / Michael Madigan
Individual

Very good. Still work to do. Even though some/most of the work is in response to agency or CAC goading and/or presence, who cares? The job is progressing.

RODs. How do they get created? Please share specifics on the process. Sharing of modelling to give idea of overview time projected. Analysis presentation on the medical records of workers at BNL regarding health issues related to Lab activities.

Apparently competent and diligent, however based on BNL & DOE's performance and strength of input on the issue for example solar array/BP project's environmental review (those of us on the CAC who had issues were dismissed by BNL and DOE) raises issues and shakes my confidence (BNL/DOE) in their performance in all other areas.

Make RODs more transparent. Provide a chart showing summary progress for all clean-up from inception to present. (All Sr-90, denitrification, etc.) A similar chart to include modelling into the future. Include the RODs in the history timeline, when did they enact a ROD, when made changes, status now percent-wise.

Wesley Chattaway
Ridge Civic Association

From the review of the reports and the speakers, I feel better informed about cleanup activities and progress.

Records of Decisions would be important as it provides insight on what was done and how that decision was made.

From the review of the reports, yes, I feel confident in it.

Communication of the cleanup(s) to the local area (i.e. Ridge) should be more public. I have lived here for 13+ years and have never heard of any cleanups at the Lab. Not sure if local mailing/local newspaper inserts to help bring the info to the public.

Isidore Doroski
Town of Riverhead

Very pleased about the progressing clean up

Yes – the BGRR groundwater cleanup and monitoring.

Yes!

No.

Adrienne Esposito
Citizens Campaign for the Environment

I definitely feel well informed about the cleanup activities and appreciate BNL's willingness to provide follow up information to all CAC members who have questions or seek additional information. The cleanup appears to be going well and is being completed on the agreed upon timelines established in each of the RODs for individual sites. I would like to see Decommissioning and Decontamination of the HFBR and the Medical Reactor move forward.

I would like to see if the 70-year clean up timeline for the Strontium-90 plume could be dramatically reduced. I was against that allotment of time when the CAC voted and it still seems excessive today. We should be remediating these plumes and not leaving them for the next generation.

Yes, both BNL and DOE have done a terrific job of working hard to build community trust and transparency.

No.

Don Garber
Emeritus

Feels well informed, thinks the cleanup is a model. He feels confident in the management of the cleanup.

Michael Giacomaro
East Yaphank Civic Association

BNL has taken the initiative to search for the best method to handle each particular cleanup problem, they also would monitor the results to insure that they were getting the expected outcome and if not, why? Through the CAC and the presentations made by the cleanup groups and affiliated scientists, we were able to grasp a clear understanding of the activities taking place and progress being accomplished.

Comparing the results of the actions taken place against the desired outcome and what further needed to be done if not achieving the goals, BNL has consistently provided the CAC with county, state, and federal guidelines as to what our objectives should be.

Without a doubt, I feel confident in the management team of BNL & DOE regarding site cleanup operations.

Continue the good work on past indiscretions, having said that, I believe the CAC should be involved in evaluating BNL research that could potentially cause new leaks, environmental, or economic issues for the surrounding communities.

Bonita Grandal
Lake Panamoka Civic Association

Within my understanding of the cleanup I feel BNL has done a very good job of sampling, monitoring, and cleaning the Peconic River as well as ground water.

I would like to see all efforts made to bring residual contamination as close to 0.0% as possible. I feel this is a goal of Tim Green's.

Yes.

Community – through CAC and articles in community newsletters – especially those surrounding the Lab – should be implemented and continued.

Helga Guthy
Wading River Civic Association

Yes, and I appreciate the Lab's time & effort to keep us informed of on-going happenings.

Nothing specific – please continue your efforts.

Yes, very confident.

We thank both (BNL/DOE) for their work in keeping us informed & updated.

James Heil
Town of Brookhaven Senior Citizens Office

The BNL site cleanup program has gone well. After initial difficulties were resolved the response and subsequent monitoring were performed effectively. The information provided to the CAC has been well prepared, informative, and thorough. Responses to questions were complete and informative.

Perhaps a section could describe any new techniques, procedures, equipment or methods that evolved from the multi-year, multi-phase cleanup project that are now standard procedures. A discussion of the funding of all the cleanup phases might be interesting to show the extent of the cost and how proper management saves money.

Yes, assuming funding and staff are made available by the DOE.

A published history of the cleanup, written in layman's terms and placed in local libraries would be a long-term communication effort to balance the negatives generated by the local media in response to incidents at BNL. The history could present the causes, the technical responses, costs, effectiveness, CAC, etc.

Ed Kaplan
Friends of Brookhaven

BNL has been quite transparent in describing its cleanup activities and progress. Based on data presented to the CAC it appears as though these cleanups have been quite successful.

The Review should focus on the extent to which BNL has sought community input and actually incorporated it into cleanup goals & programs.

BNL staff has demonstrated their commitment to environmental protection.

It would be interesting to learn more about the actual interactions between BNL/DOE staff & regulators. The CAC could benefit from hearing directly from regulators concerning BNL/DOE environmental programs.

Ray Keenan
Affiliated Brookhaven Civic Organizations

The cleanup appears to be progressing as required. The CAC receives an adequate amount of information regarding the cleanup.

The cleanup goals and timelines should be reviewed.

Yes, they've demonstrated a commitment to the cleanup and the ability to effectuate the plan.

I would like to see the cleanup progress publicized to the extent it is "newsworthy." Perhaps additional media outreach would be helpful – and good for P.R.

Reiny Schuhmann
American Physical Society

As a new full member of CAC (who had minimal interaction as an alternate over a few years) my impressions are of course somewhat limited. I have however kept abreast of BNL cleanup activity for many years, since environmental issues are important to me, since I work across the street from the Lab, and because as a physicist I very much want BNL to thrive. My overall impression of BNL's cleanup activity is quite positive. I am particularly impressed by the efforts to remediate VOC's in the groundwater, which to me are more pernicious than the radioisotope issues that grab so much public attention.

It seems to me that communication to the community is the most difficult issue, so it should get the most attention. One runs into the usual problem—the community wants to hear that everything has been cleaned up to the point that it is "100% safe," while the scientific perspective is based on the notion of meeting acceptable limits, to make things "as safe as one can make them." Again, I am just learning how CAC operates so my input is based on limited experience.

Yes, and I hope to continue to work with CAC to maintain my confidence.

Not at present.

Tom Talbot
Middle Island Civic Association

BNL's cleanup is and has been a central activity of attention to all operating departments. A large and continuing effort has been in place to keep the status of the cleanup in the forefront.

Cleanup goals have been openly determined and shared with community representatives via the Community Advisory Council for timely communication. All aspects of the cleanup program are deemed vital to ensure that no segment is overlooked in the final analysis.

Based on past and present performance, BNL and DOE's management has been openly candid regarding all aspects of past, current, and potential future leaks. Deviating from the past performance would be significantly detrimental to the facility.

Initiate a periodic status report to the general public describing the scope of the past, present, and planned future of the leak related program.

Ron Trotta
Brookhaven Coalition of Chambers of Commerce

I feel BNL has made the appropriate efforts to keep us informed about the cleanup activities and progress.

Community input and cleanup goals.

Since, I've only had limited time being exposed to information on the cleanup, I can only comment on that. So far I feel the long-term cleanup operations are going in a positive direction.

Just please keep the information coming so I can further educate the public.

Paul Ziems
Coram Civic Association

I believe that BNL is doing a great job of cleaning up the whole BNL site. In addition to the cleanups brought about by various experiments which were responsible for radioactive spills and mercury contamination, they also had to clean up pollution form prior uses of the property as a military base.

I have no concerns regarding the cleanup efforts, BNL personnel have been addressing all the polluted sites inside of the property. It was encouraging to see that when they were cleaning up the mercury pollution of the Peconic River that they also removed invasive plants along the river bank.

I am very confident that BNL management is committed to site cleanup for the long term. They have experience and plans showing cleanup efforts in progress with projected end dates for the cleanup and site monitoring after the cleanup.

No further comments at this time.

Attachment 2

2015 BNL Groundwater Status Report, BNL 2016 (CD Version)

(To be included in public availability version)

Attachment 3

Inspection Checklists

BNL Five-Year Review Site Inspection Checklist

I. SITE INFORMATION	
Site name: Brookhaven National Laboratory	**Date(s) of inspection:** 4/30/15 through 11/3/15
Location and Region: Upton, NY, EPA Region 2	**EPA ID:** NY7890008975
Agency, office, or company leading the five-year review: Brookhaven Science Associates (BSA) for the U.S. Department of Energy (DOE)	**Weather/temperature:** NA

Remedy Includes: (Check all that apply)

☒ Landfill cover/containment
☒ Access controls
☒ Institutional controls
☒ Groundwater pump and treatment
☐ Surface water collection and treatment
☒ Other_Annual private well testing
☒ Monitored natural attenuation
☒ Groundwater containment
☐ Vertical barrier walls

____

____

Attachments: ☒ Inspection team roster attached ☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** _ Bill Dorsch, Groundwater Protection Group (GPG) Manager_
   Interviewed ☒ at site ☒ at office ☐ by phone Phone no. _344-5186
   Problems, suggestions; ☐ Report attached _Work with on a daily basis and discuss issues weekly. ___

2. **O&M staff** Vinnie Racaniello, Eric Kramer, Adrian Steinhauff, Project Manager and Field Engineers
   Interviewed ☒ at site ☒ at office ☐ by phone Phone no. 344-5436, 8226, 2363______________
   Problems, suggestions; ☐ Report attached Work with on a daily basis and discuss issues weekly.____

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

   Agency ___EPA, NYSDEC, NYSDOH, SCDHS, DOE __________________________
   Contact ______________________________ ___________________ ________ ____________
   Name Title Date Phone no.
   Problems; suggestions; ☒ Report attached See interview records.
   ____

   Agency ______________________________
   Contact ______________________________ ___________________ ________ ____________
   Name Title Date Phone no.
   Problems; suggestions; ☐ Report attached ____
   ____

4. **Other interviews** (optional) ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**
☒ O&M manual ☒ Readily available ☒ Up to date ☐ N/A
☒ As-built drawings ☒ Readily available ☒ Up to date ☐ N/A
☐ Maintenance logs ☐ Readily available ☐ Up to date ☐ N/A
Remarks: O&M Manuals have been updated and are available in the treatment buildings, Bldg. 462 Project File, and on the internal GPG website. However, the manuals were missing from two off-site systems during the inspection. They were immediately replaced. The as-built drawings are available through the GPG and copies are available through Facility & Operations database.

2. **Site-Specific Health and Safety Plan** ☒ Readily available ☒ Up to date ☐ N/A
☒ Contingency plan/emergency response plan ☒ Readily available ☒ Up to date ☐ N/A
Remarks: The groundwater treatment systems have a contingency/emergency plan in their O&M Manuals. Project maintenance/repair on the remediation systems is performed in accordance with SBMS Work Planning and Control requirements. Contractors also perform work in accordance with their H&S Plan and Phase Hazard Analysis.
____

3. **O&M and OSHA Training Records** ☒ Readily available ☒ Up to date N/A
Remarks _Worker training records are available on the BNL training website database. __

4. **Permits and Service Agreements**
☒ Air discharge permit ☒ Readily available ☒ Up to date ☐ N/A
☒ Effluent discharge ☒ Readily available ☒ Up to date ☐ N/A
☐ Waste disposal, POTW ☐ Readily available ☐ Up to date ☐ N/A
☒ Other permits: Peconic ☒ Readily available ☒ Up to date ☐ N/A
Remarks: DEC air and SPDES equivalency permits in place for all treatment systems, as appropriate. Peconic River On-site and Off-site Supplemental Sediment Removal permit is in place. ____

5. **Gas Generation Records** ☐ Readily available ☐ Up to date ☒ N/A
Remarks: Passive gas venting only. Landfill gas testing results available in the Annual Reports.______

6. **Groundwater Monitoring Records** ☒ Readily available ☒ Up to date ☐ N/A
Remarks: Groundwater monitoring data is made available via the Quarterly System Operations Reports, as well as the Annual Groundwater Status Report. ________________

7. **Discharge Compliance Records**
☒ Air ☒ Readily available ☒ Up to date ☐ N/A
☒ Water (effluent) ☒ Readily available ☒ Up to date ☐ N/A
Remarks: Discharge Monitoring Reports (DMRs) for the treatment systems with SPDES equivalency permits are issued monthly to the DEC and are available in the GPG Project Files. Air compliance records are documented in the Annual Groundwater Status Reports. ___________________

8. **Daily Access/Security Logs** ☒ Readily available ☐ Up to date ☐ N/A
Remarks_Operating data sheets for the groundwater systems are available at the treatment buildings and the GPG Project files.

9. **Comments** ____

IV. O&M COSTS

1. **O&M Organization**

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ☒ Contractor for Federal Facility
☐ Other: Responsibility for managing BNL's Long Term Stewardship lies with the Environmental Protection Division's (EPD) GPG. ___

2. **O&M Cost Records**

☒ Readily available ☒ Up to date
☒ Funding mechanism/agreement in place

Total annual cost by year for review period if available

From	10/10	To	9/11	Avg. Annual of $293K	☒ Breakdown attached
	Date		Date	Total cost	
From	10/11	To	9/12	Avg. Annual of $207K	☒ Breakdown attached
	Date		Date	Total cost	
From	10/12	To	9/13	Avg. Annual of $159K	☒ Breakdown attached
	Date		Date	Total cost	
From	10/13	To	9/14	Avg. Annual of $179K	☒ Breakdown attached
	Date		Date	Total cost	
From	10/14	To	9/15	Avg. Annual of $159K	☒ Breakdown attached
	Date		Date	Total cost	

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons: No unusually high O&M costs identified. The annual costs for each system from FY2011 through FY2015 is identified in the Five-Year Review.

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured ☒ N/A
Remarks: _

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks: Identification signs are in place for all of the on-site and off-site groundwater treatment systems. DOE notification signs are in place for all treatment facilities located beyond BNL's property boundary. There are BNL security personnel on the BNL property 24 hours per day. For the systems located beyond the BNL boundaries, the buildings are secured with a lock and alarms. The alarms are transmitted to an alarm company, then BNL is notified. Restricted use signs are posted at former soil cleanup areas including the Former Hazardous Waste Management Facility, former Meadow Marsh, Landfills, Ash Pit, former Chemical Holes, Bldg. 96, Bldg. 650 Sump Outfall, and Bldg. 811.
____

C. Institutional Controls (ICs)

1. **Implementation and enforcement**
Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by): Routine walkdown inspections of landfills, former soil cleanup areas, and groundwater treatment systems.
____

Frequency: Varies from approximately 2x/week for treatment systems, monthly for landfills, semi-annual former soil cleanup areas.
____

Responsible party/agency: BSA under contract with DOE.
____

Contact: Name	Title	Date	Phone no.
William Dorsch	BSA GPG Manager	2/24/16	(631) 344-5186
Terri Kneitel	DOE Project Manager	2/24/16	(631) 344-2112

Reporting is up-to-date ☒ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ☒ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A
Violations have been reported ☐ Yes ☒ No ☐ N/A
Other problems or suggestions: ☐ Report attached
Remarks: There are eight access agreements in place among BSA/DOE and various property owners to allow for operation of BNL's groundwater remediation systems for plumes that have migrated beyond the BNL property. Each agreement has terms and conditions that must be adhered to. A license agreement is also in place among BSA/BHSO/Suffolk County for the supplemental sediment cleanup for the Peconic River in 2010/2011, followed by continued monitoring.____________

2. **Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks: The Land Use Controls Management Plan and institutional controls website and fact sheets continue to be updated, as needed to reflect the most recent IC's for each project. ___

D. General
1. **Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident Remarks_There has been some vandalism in the past at some of the treatment systems and manholes located near and beyond the BNL property boundary. However, additional precautions have been implemented for the off-site systems such as alarm systems to help minimize the potential risk. ____________
2. **Land use changes on site** ☒ N/A Remarks: None____
3. **Land use changes off site** ☒ N/A Remarks: None____
VI. GENERAL SITE CONDITIONS
A. Roads ☒ Applicable ☐ N/A
1. **Roads damaged** ☐ Location shown on site map ☒ Roads adequate ☐ N/A Remarks____
B. Other Site Conditions
Remarks: ____

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU I AOC 2F Ash Pit 11/2/15
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks ____________________
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☒ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: Final Closeout Report for the Ash Pit OU I AOC 2F, dated 2/5/04. Section 4.0 of the Closeout Report identifies LTS requirements (i.e., annual inspection). _
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent ______________ Depth____________ Remarks: None ____________________
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent______________ Depth____________ Remarks: None. ____________________
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress ☒ Trees/Shrubs (indicate size and locations on a diagram) Remarks: Trees surround the pit area. Excellent native grass growth on pits. ____________________
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent______________ ☐ Ponding ☐ Location shown on site map Areal extent______________ ☐ Seeps ☐ Location shown on site map Areal extent______________ ☐ Soft subgrade ☐ Location shown on site map Areal extent______________ Remarks: None. ____________________
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☐ Routinely sampled ☒ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____________________ ____________________
8. **Other Site Conditions**
Remarks: Inspection attendees include W. Dorsch, R. Howe, D. Paquette, M. Hanson ____

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A

A. Project OU I AOC 8 Meadow Marsh 10/27/15

1. **Soil Excavation Complete** ☒ Yes ☐ No
   Remarks ______

2. **S&M Documents**
   ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A
   ☒ Completion/Closeout Report ☒ Readily available ☒ Up to date ☐ N/A
   ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A
   Remarks: Final Closeout Report for the Meadow Marsh OU I AOC 8, dated 2/6/04. Section 4.0 of the Closeout Report identifies LTS requirements (i.e., ecological monitoring and inspection for Tiger Salamanders). Institutional controls are also identified in the Report.

3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
   Areal extent______ Depth______
   Remarks______

4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
   Areal extent______ Depth______
   Remarks______

5. **Vegetative Cover** ☒ Grass ☐ Cover properly established ☒ No signs of stress
   G Trees/Shrubs (indicate size and locations on a diagram)
   Remarks: Native grasses planted adjacent to the pond.

6. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent______
   ☒ Ponding ☐ Location shown on site map Areal extent______
   ☐ Seeps ☐ Location shown on site map Areal extent______
   ☐ Soft subgrade ☐ Location shown on site map Areal extent______
   Remarks: The remediated area is a pond for the Tiger Salamanders. Due to the drought, the water level in the pond is below average.______

7. **Monitoring Wells** (within the excavated area)
   ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
   ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☒ N/A
   Remarks______

8. **Other Site Conditions**
   Remarks: Inspection attendees include R. Howe, J. Burke, M. Chuc.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU I AOC 6 Bldg. 650 Sump Outfall 10/20/15
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks ______
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: Draft Final Closeout Report for AOC 6 Bldg. 650 Sump and Sump Outfall, dated 1/02.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent______ Depth______ Remarks: The entire area is graded and a drainage swale exists that routes surface runoff to the ponded sump. The pond is dry at this time.
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent______ Depth______ Remarks: ______
5. **Vegetative Cover** ☒ Grass ☐ Cover properly established ☒ No signs of stress ☒ Trees/Shrubs (indicate size and locations on a diagram) Remarks: Many trees surround the sump. Good native grass cover.
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent______ ☐ Ponding ☐ Location shown on site map Areal extent______ ☐ Seeps ☐ Location shown on site map Areal extent______ ☐ Soft subgrade ☐ Location shown on site map Areal extent______ Remarks: Pond is Tiger Salamander habitat
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks:
8. **Other Site Conditions**
Remarks: Inspection attendees include R. Howe, J. Burke, V. Racaniello. Previously installed fence partially surrounds the former sump outfall (no restrictions for entering area). ______

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU I AOC 16S Landscape Soil Areas 10/26/15
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks ____
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: Final Closeout Report for AOC 16 Landscape Soils, dated 4/10/01.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent____ Depth____ Remarks____
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent____ Depth____ Remarks____
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress G Trees/Shrubs (indicate size and locations on a diagram) Remarks____
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent____ ☐ Ponding ☐ Location shown on site map Areal extent____ ☐ Seeps ☐ Location shown on site map Areal extent____ ☐ Soft subgrade ☐ Location shown on site map Areal extent____ Remarks____
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____
8. **Other Site Conditions**
Remarks: Inspection attendees include R. Howe, J. Burke, D. Paquette.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU I AOC 1 Hazardous Waste Management Facility (HWMF)/Waste Loading Area 10/19/15_
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks:
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: The Soil and Peconic River Surveillance and Maintenance Plan, dated March 2013. The Final Closeout Report for the Former Hazardous Waste Management Facility, dated 9/29/05. Final Completion Report for the HFBR Waste Loading Area, dated July 2009.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent______________ Depth____________ Remarks:
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent______________ Depth____________ Remarks: __
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☐ No signs of stress ☒ Trees/Shrubs (indicate size and locations on a diagram) Remarks: Significant grass, shrubs, trees present.
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent__________ ☐ Ponding ☐ Location shown on site map Areal extent______________ ☐ Seeps ☐ Location shown on site map Areal extent______________ ☐ Soft subgrade ☐ Location shown on site map Areal extent______________ Remarks: Vegetation is well established. The wetland area immediately to the northwest of the FHWMF is dry due to the drought. _____
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks:
8. **Other Site Conditions**
Remarks: Inspection attendees include R. Howe, J. Burke, D. Paquette. Some of the vegetation in the yard was mowed as part of the Sr-90 groundwater characterization effort. GPG is coordinating the Geoprobe work in the FHWMF and WLA for the Sr-90 groundwater characterization. The fixed contamination signs on the foundations are in good condition and legible. The annual survey of the fixed contamination on several of the concrete foundations was performed in July 2015 by BNL RadCon. No loose contamination detected. Waste Management has a Radioactive Material Storage Area (RMA) just outside the main gate for the temporary storage of Bldg. 811 D&D project rad waste. The Waste Loading Area (WLA) has good vegetative growth. The WLA is currently being used for waste staging/rail loading for the Bldg. 811 D&D project. All RMAs are properly posted. All gates have signs and are locked.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU V AOC 30 Peconic River 11/3/15
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks: The original 2004/2005 is complete, and supplemental sediment remediation of three small areas was also completed in 2010/2011. Discussions underway with the regulators for supplemental remediation of Area WC-06. ___________________
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: The Soil and Peconic River Surveillance and Maintenance Plan, dated March 2013. Surface water, sediment, and fish monitoring requirements are identified in this Plan. Final Closeout Report for Peconic River Remediation Phases 1 and 2, 8/25/05, and Supplemental Remediation Closeout Report, dated March 2012.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent______________ Depth____________ Remarks: __________
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent______________ Depth____________ Remarks____
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress ☒ Trees/Shrubs (indicate size and locations on a diagram) Remarks:
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent______________ ☒ Ponding ☐ Location shown on site map Areal extent: Area B_______ ☒ Seeps ☐ Location shown on site map Areal extent______________ ☒ Soft subgrade ☐ Location shown on site map Areal extent______________ Remarks: The onsite portion of the river is dry from the STP to Station HQ. There is no flow upstream of the former STP outfall at station HE.
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☐ Routinely sampled ☒ Good condition ☐ Evidence of leakage at penetration ☒ Needs Maintenance ☐ N/A Remarks: River piezometer near Area WC-06 will be removed following planned excavation.
8. **Other Site Conditions**
Remarks: Inspection attendees include T. Green, R. Howe, W. Dorsch, M. Hanson. There is significant vegetation growth at all 2011 cleanup areas. Gates along E. Boundary path and gate at North Street/Z-Path are locked.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU I AOC 10 Building 811 UST and Soils 10/20/15________________________
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks: Excavation complete in 2005. Work is ongoing for the demolition of Bldg. 810/811, and associated soil excavation. ____
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: Final Closeout Report for AOC 10 Waste Concentration Facility, 9/05. The Soil and Peconic River Surveillance and Maintenance Plan, dated March 2013.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent_______________ Depth_____________ Remarks: Soil excavation in progress. ____
4. **Erosion** ☐ Location shown on site map ☐ Erosion not evident Areal extent_______________ Depth_____________ Remarks: _Hay bales and silt fence in place for erosion control during excavation._________________ ____
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress ☐ Trees/Shrubs (indicate size and locations on a diagram) Remarks: Native grasses established. _____________
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent_______________ ☐ Ponding ☐ Location shown on site map Areal extent_______________ ☐ Seeps ☐ Location shown on site map Areal extent_______________ ☐ Soft subgrade ☐ Location shown on site map Areal extent_______________ Remarks____ ____
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☒ Needs Maintenance ☐ N/A Remarks: All of the BNL monitoring wells are secured and locked.
8. **Other Site Conditions**
Remarks: Inspection attendees include V. Racaniello, R. Howe, J. Burke.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU III AOC 26B Building 96 10/27/15________________________
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks: PCB soil excavation complete in 2005. VOC source area excavation was completed in 2010.
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☐ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☒ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: OU III Building 96 PCB Soil (AOC 26B) Excavation Closeout Report, 3/05. Building 96 Soil Excavation and Disposal Closure Report, dated January 2011. The OU I Soils and OU V Long-Term Monitoring and Maintenance Plan, dated May 2006.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent_______________ Depth_____________ Remarks: ____
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent_______________ Depth_____________ Remarks: ________________________
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress ☐ Trees/Shrubs (indicate size and locations on a diagram) Remarks: Good vegetative growth. _____________
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent_______________ ☐ Ponding ☐ Location shown on site map Areal extent_______________ ☐ Seeps ☐ Location shown on site map Areal extent_______________ ☐ Soft subgrade ☐ Location shown on site map Areal extent_______________ Remarks____ ____
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☒ Needs Maintenance ☐ N/A Remarks: All of the BNL monitoring wells are secured and locked.
8. **Other Site Conditions**
Remarks: Inspection attendees include R. Howe, J. Burke, M. Chuc.

VII. SOIL CLEANUP REMEDIES ☒ Applicable ☐ N/A
A. Project OU I AOC 2B,C Chemical/Animal/Glass Holes 10/22/15______________________
1. **Soil Excavation Complete** ☒ Yes ☐ No Remarks: Soil excavation complete in 2005.
2. **S&M Documents** ☒ S&M Plan ☒ Readily available ☒ Up to date ☐ N/A ☒ Completion/Closeout Report ☒ Readily available ☐ Up to date ☐ N/A ☐ Maintenance logs ☐ Readily available ☐ Up to date ☒ N/A Remarks: Animal/Chemical Pits and Glass Holes Remedial Action Closure Report, 10/97. Animal/Chemical Pits and Glass Holes Remedial Action Closure Report Addendum, 9/05. The OU I Soils and OU V Long-Term Monitoring and Maintenance Plan, dated May 2006.
3. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent______________ Depth____________ Remarks: None. ____
4. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent______________ Depth_<1 foot___________ Remarks: None.___________
5. **Vegetative Cover** ☒ Grass ☒ Cover properly established ☒ No signs of stress ☐ Trees/Shrubs (indicate size and locations on a diagram) Remarks: Significant native grasses and pines established. ____________
6. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent______________ ☐ Ponding ☐ Location shown on site map Areal extent______________ ☐ Seeps ☐ Location shown on site map Areal extent______________ ☐ Soft subgrade ☐ Location shown on site map Areal extent______________ Remarks____ ____
7. **Monitoring Wells** (within the excavated area) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks: None.
8. **Other Site Conditions**
Remarks: Inspection attendees include R. Howe, J. Burke, V. Racaniello, D. Paquette.

Location (AOC): Sewage Treatment Plant
Date of Inspection: 11/3/15______________________________________
Name of Inspector(s): R. Howe, W. Dorsch, T. Green, M. Hanson
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐Heavy Rainfall ☐Reported Incident

A. Inspection Checklist

Component	Observed Condition				Further Action Req'd	
	Excell.	**Fair**	**Poor**	**Not Applic.**	**Yes (describe)**	**No**
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)		X				X
Soil (Cap/Cover/Fill)	X				No erosion evident	X
Other: ________________________						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage	X					X
Pipes/Outfalls				X		X
Manholes	X					X
Filter Berms				X		X
Roof Drains	X					X
Recharge Areas						
Other: ____________						
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells	X					X
Gas Vents				X		X
Other: ________________________						
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road		X				X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other:						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: __________

B. Description of Other Observations

Observed Conditions/Recommendations: I called Rich Izzo (x2982) at the STP to let him know we'll be performing an inspection of the STP sand filters. There was no flow from the former STP outfall since the effluent discharge was changed in September 2014 to groundwater via the new recharge basins. There was no flow upstream at station HE. No erosion of soil cover is evident on the sand filter berms or sludge drying beds remediated areas. No unauthorized work visible at the abandoned sewer line area. The former outfall Building 580 which was used for UV disinfection, was demolished in October 2015. LUIC Fact Sheet Changes: Fix link to reports.

Location (AOC): Current Landfill and Wooded Wetland______________________
Date of Inspection: 10/26/15_____________________________________
Name of Inspector(s): R. Howe, J. Burke, D. Paquette
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐Heavy Rainfall ☐Reported Incident

A. Inspection Checklist

	Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1.	**Landfill Cap/Wetlands:**						
	Vegetation (e.g. grass)	X					X
	Soil (Cap/Cover/Fill)		X			Fill-in burrow/ruts	
	Other: ________________________						
2.	**Drainage Structures:**						
	Standing Water	X				Dry	X
	Toe Drain	X					X
	Drainage Channels	X				Some vegetation	
	French Drains/Outfalls				X		X
	Subsurface Drainage		X				X
	Pipes/Outfalls				X		X
	Manholes				X		X
	Berms				X		X
	Roof Drains	X					X
	Recharge Areas						
	Other: _______________________						
3.	**Monitoring System:**						
	Soil Gas Wells	X				Minimal weeds	X
	Groundwater Wells	X					X
	Gas Vents	X				No nests or damage	X
	Other: __						
4.	**Site Access:**						
	Asphalt Access Road	X				Seal asphalt cracks	
	Crushed-concrete Access Road				X		X
	Fence	X					X
	Gates/locks	X				Good	X
	Radiological Postings				X		X
	Other: Stairs access to cap	X					X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: _ ____

B. Description of Other Observations

Observed Conditions/Recommendations: The grass on the cap was cut a few weeks ago. An area of minor erosion on the west slope and a large animal burrow on the south east slope needs to be filled-in and seeded by Facilities and Operations (F&O). The burrow appears to be about 12 inches in depth. Vegetation in the south culvert needs to be sprayed, and other vegetation along the west road mechanically cut. The Wooded Wetland was dry. Signs in place and all gates locked. Replaced the rusted lock on the SW gate following the spring inspection. LUIC Factsheet Changes: No changes for Current Landfill or Wooded Wetlands

Location (AOC): Former Landfill Area (includes the former and interim landfills and slit trench)
Date of Inspection: 10/22/15____________________________________
Name of Inspector(s): R. Howe, Paquette, J. Burke, V. Racaniello
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1. Landfill Cap/Wetlands:						
Vegetation (e.g. grass)	X				Grass was just cut	X
Soil (Cap/Cover/Fill)	X				Fill in burrows	
Other: ________________________						
2. Drainage Structures:						
Standing Water	X				No water	X
Toe Drain	X					X
Drainage Channels		X			Veg in west channel	
French Drains/Outfalls	X					X
Subsurface Drainage	X					X
Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains	X				Significant vegetation	X
Recharge Areas						
Other: _________________						
3. Monitoring System:						
Soil Gas Wells	X					X
Groundwater Wells	X					X
Gas Vents	X				No nests in vents	X
Other: ________________	X					X
4. Site Access:						
Asphalt Access Road		X			Repair pothole to east	
Crushed-concrete Access Road		X				X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other: LUIC Signs	X				All signs in place	X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: ____

B. Description of Other Observations

Observed Conditions/Recommendations: Former Landfill, Interim Landfill, and Slit Trench caps are in good condition. Three burrows and shallow erosional areas observed on west slope of Former Landfill need to be filled-in by Facilities and Operations (F&O). The grass on all three landfills was cut within the last two weeks. F&O needs to remove small pine seedlings on west slope of Former Landfill, spray vegetation in western drainage channels, fill asphalt cracks, and repair pothole. Met with the Nonproliferation and National Security Department 10/14/15 to discuss potential upgrades to the Radiation Detector Test and Evaluation Center facility located adjacent to the Former Landfill. Any changes adjacent to the landfill will be discussed with the regulators first. LUIC Factsheet Changes: None.

Location (AOC): Former Hazardous Waste Management Facility Perimeter Soils
Date of Inspection: 10/19/15______________________________________
Name of Inspector(s): R. Howe, J. Burke, D. Paquette
Purpose of Inspection: ☒ Routine (Sched Freq of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

	Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1.	**Soil Covers/Wetlands:**						
	Vegetation (e.g. grass)	X					X
	Soil (Cap/Cover/Fill)	X					X
	Other: ____________________						
2.	**Drainage Structures:**						
	Standing Water	X				None	X
	Toe Drain				X		X
	Drainage Channels				X		X
	French Drains/Outfalls				X		X
	Subsurface Drainage				X		X
	Pipes/Outfalls				X		X
	Manholes				X		X
	Berms				X		X
	Roof Drains				X		X
	Recharge Areas						
	Other: __						
3.	**Monitoring System:**						
	Soil Gas Wells				X		X
	Groundwater Wells				X		X
	Gas Vents				X		X
	Other: ____________________						
4.	**Site Access:**						
	Asphalt Access Road				X		X
	Crushed-concrete Access Road				X		X
	Fence				X		X
	Gates/locks				X		X
	Radiological Postings				X		X
	Other:						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: ____

B. Description of Other Observations

Observed Conditions/Recommendations: The soil cover for the Phase 1 cleanup areas was in place and no erosion was evident. The Phase 3 cleanup was completed in the fall 2014. There was good vegetative growth in both areas. LUIC Factsheet Changes: Add links for the Phase III cleanup documents.

Location (AOC): Building 811 Former A/B Waste Transfer Lines________________________
Date of Inspection: 10/20/15______________________
Name of Inspector(s): R. Howe, J. Burke, V. Racaniello
Purpose of Inspection: ☒ Routine (Sched Freq of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

	Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1.	**Soil Covers/Wetlands:**						
	Vegetation (e.g. grass)	X					X
	Soil (Cap/Cover/Fill)	X				No erosion evident	X
	Other: ____________________						
2.	**Drainage Structures:**						
	Standing Water				X		X
	Toe Drain				X		X
	Drainage Channels				X		X
	French Drains/Outfalls				X		X
	Subsurface Drainage				X		X
	Pipes/Outfalls				X		X
	Manholes				X		X
	Berms				X		X
	Roof Drains				X		X
	Recharge Areas						
	Other: ________________________						
3.	**Monitoring System:**						
	Soil Gas Wells				X		X
	Groundwater Wells	X					X
	Gas Vents				X		X
	Other: ________________________						
4.	**Site Access:**						
	Asphalt Access Road	X					X
	Crushed-concrete Access Road				X		X
	Fence				X		X
	Gates/locks				X	B 811	X
	Radiological Postings	X				B 811	X
	Other: LUIC POC Signs				X		X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No

B. Description of Other Observations

Observed Conditions/Recommendations: Good vegetation growth and no erosion evident. Area in front of Bldg. 811is temporarily fenced for the demolition work. LUIC Factsheet Changes: None.

Location (AOC): Old Incinerator Facility_______________________
Date of Inspection: 11/2/15_____________________________________
Name of Inspector(s): R. Howe, W. Dorsch, D. Paquette, M. Hanson
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 2x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1. Landfill Cap/Soil Covers:						
Vegetation (e.g. grass)	X					X
Soil (Cap/Cover/Fill)	X				No erosion visible	X
Other: ___________________						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage				X		X
Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas						
Other: ________________________						
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells	X					X
Gas Vents				X		X
Other: ________________________						
4. Site Access:						
Asphalt Access Road				X		X
Crushed-concrete Access Road				X		X
Fence				X		X
Gates/locks				X		X
Radiological Postings				X		X
Other: ________________________				X		X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: __________

B. Description of Other Observations

Observed Conditions/Recommendations: Excellent vegetative growth, no erosion evident. LUIC Factsheet Changes: None.

Location (AOC): Low Mass Criticality Facility
Date of Inspection: 4/30/15
Name of Inspector(s): R. Howe, D. Paquette, K. Schwager
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

	Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1.	**Soil Covers/Wetlands:**						
	Vegetation (e.g. grass)		X				X
	Soil (Cap/Cover/Fill)				X		X
	Other: ____________						
2.	**Drainage Structures:**						
	Standing Water	X				Little water in basin	X
	Toe Drain				X		X
	Drainage Channels				X		X
	French Drains/Outfalls				X		X
	Subsurface Drainage	X					X
	Pipes/Outfalls	X					X
	Manholes				X		X
	Berms	X					X
	Roof Drains		X			Phragmites in basin	X
	Recharge Areas				X		X
	Other: ____________						
3.	**Monitoring System:**						
	Soil Gas Wells				X		X
	Groundwater Wells	X					X
	Gas Vents				X		X
	Other: ____________				X		X
4.	**Site Access:**						
	Asphalt Access Road				X		X
	Crushed-concrete Access Road		X				X
	Fence				X		X
	Gates/locks				X		X
	Radiological Postings				X		X
	Other: ____________						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence:
____

B. Description of Other Observations

Observed Conditions/Recommendations: No institutional control issues. LUIC Factsheet: No changes.

Location (AOC): AGS Storage Yards (1 and 2)
Date of Inspection: 4/30/15________________________________
Name of Inspector(s): R. Howe, F. Craner (EPD ECR), D. Paquette, K. Schwager, W. Needrith
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐Heavy Rainfall ☐Reported Incident

A. Inspection Checklist

	Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1.	**Soil Covers/Wetlands:**						
	Vegetation (e.g. grass)		X				X
	Soil (Cap/Cover/Fill)				X		X
	Other: ______________						
2.	**Drainage Structures:**						
	Standing Water				X		X
	Toe Drain				X		X
	Drainage Channels				X		X
	French Drains/Outfalls				X		X
	Subsurface Drainage				X		X
	Pipes/Outfalls				X		X
	Manholes				X		X
	Berms				X		X
	Roof Drains				X		X
	Recharge Areas				X		X
	Other: ___________				X		X
3.	**Monitoring System:**						
	Soil Gas Wells				X		X
	Groundwater Wells		X				X
	Gas Vents				X		X
	Other: ________				X		X
4.	**Site Access:**						
	Asphalt Access Road				X		X
	Crushed-concrete Access Road				X		X
	Fence		X			No fence in Yard 2	X
	Gates/locks		X			No gate in Yard 2	X
	Radiological Postings		X			RMA postings good	X
	Other: ______________						X

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: F. Craner (the ECR from EPD) and Bill Needrith representing CA-D attended the inspection and said there has been no unauthorized access to the posted/fenced rad storage areas. They are aware of the walkover survey that was done for B801/811 yard and that there is some contamination on the C-A D side of the fence. They moved some of the materials away from the fence due to the shine during the survey.

B. Description of Other Observations

Observed Conditions/Recommendations: The Bldg. 912 Steel Yard (Yard 1A) is a Radioactive Material Area (RMA). It is fenced, rad posted with a chain, and C-AD contact sign. The Bldg. 912 Steel/Lead Yard (Yard 1B), is also identified as a RMA, is rad posted, and secured with a fence, gate, lock, and C-AD contact sign. Yard 2 is a vacant field to the east of Bldg. 811 with no rad postings. Coordinate with F&O Grounds to have the street sweeper sand piles removed from Yard 2. The sand was removed last year but it is accumulating again.LUIC Factsheet Changes: None.

Location (AOC): Bubble Chamber
Date of Inspection: 4/30/15
Name of Inspector(s): R. Howe, F. Craner (EPD ECR), D. Paquette, K. Schwager, W. Needrith
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

	Component	Observed Condition: Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1.	**Soil Covers/Wetlands:**						
	Vegetation (e.g. grass)		X				X
	Soil (Cap/Cover/Fill)				X		X
	Other: ____________________						
2.	**Drainage Structures:**						
	Standing Water	X					X
	Toe Drain				X		X
	Drainage Channels				X		X
	French Drains/Outfalls				X		X
	Subsurface Drainage				X		X
	Pipes/Outfalls				X		X
	Manholes				X		X
	Berms				X		X
	Roof Drains				X		X
	Recharge Areas				X		X
	Other: _______________				X		X
3.	**Monitoring System:**						
	Soil Gas Wells				X		X
	Groundwater Wells		X				X
	Gas Vents				X		X
	Other: __________				X		X
4.	**Site Access:**						
	Asphalt Access Road		X				X
	Crushed-concrete Access Road				X		X
	Fence	X					X
	Gates/locks	X				B960 gate locked	X
	Radiological Postings	X				C-AD Rad Storage	X
	Other: _______________________						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: Frank Craner (the ECR from EPD) and Bill Needrith representing C-AD attended the inspection and said there has been no unauthorized access to the posted/fenced rad storage area. In addition, any digging proposed for the area would be reviewed by the Groundwater Protection Group via the digging permit process. Frank did mention that C-AD may be moving their hazardous waste storage from Bldg. 919 to adjacent to the yard at Bldg. 960, but it's not definite.

B. Description of Other Observations

Observed Conditions/Recommendations: The fenced area is controlled by Collider-Accelerator Dept. (C-AD) and is designated as the Bldg. 960 Waste Yard. It is used for outdoor storage of rad materials. It is fenced, locked, with rad postings, and paved. The remainder of the area to the north is open and consists of grass, pavement, and concrete slabs (no postings). LUIC Factsheet Changes: No changes.

Location (AOC): Bldg. 830 USTs and Pipe Leak
Date of Inspection: 4/30/15______________________________________
Name of Inspector(s): R. Howe, D. Paquette, K. Schwager
Purpose of Inspection: ☒ Routine (Scheduled Freq. of 1x/yr) ☐ Heavy Rainfall ☐ Reported Incident

A. Inspection Checklist

Component	Excell.	Fair	Poor	Not Applic.	Further Action Req'd: Yes (describe)	No
1. Soil Covers/Wetlands:						
Vegetation (e.g. grass)				X		X
Soil (Cap/Cover/Fill)				X		X
Other: ____________________						
2. Drainage Structures:						
Standing Water				X		X
Toe Drain				X		X
Drainage Channels				X		X
French Drains/Outfalls				X		X
Subsurface Drainage				X		X
Pipes/Outfalls				X		X
Manholes				X		X
Berms				X		X
Roof Drains				X		X
Recharge Areas				X		X
Other: ________________				X		X
3. Monitoring System:						
Soil Gas Wells				X		X
Groundwater Wells		X				X
Gas Vents				X		X
Other: ___________				X		X
4. Site Access:						
Asphalt Access Road	X					X
Crushed-concrete Access Road				X		X
Fence				X		X
Gates/locks				X		X
Radiological Postings	X				For Rad Storage Area	X
Other: ________________________						

5. Evidence of unauthorized work activities and/or unauthorized access has occurred? ☐ Yes ☒ No
If yes, describe evidence: Digging proposed for the area would be reviewed by the Groundwater Protection Group via the digging permit process.

B. Description of Other Observations

Observed Conditions/Recommendations: The area currently consists of Bldg. 830 (occupied) by the Nonproliferation and National Security Department within the Global and Regional Solutions Directorate. The NSLS II Project Offices are located in the mod trailer to the north. Outdoor connex storage, waste collection area, and rad waste storage areas are present. LUIC Factsheet Changes: No changes.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/7/15

A. System OU III LIPA/Airport. Inspection attendees include V. Racaniello, R. Howe, A. Steinhauff, E. Kramer, M. Chuc, K. Schwager

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: Construction is complete, system operating. Airport wells RTW-2, RTW-3, and RTW-5 are pulse pumping, and LIPA wells EW-1L, EW-2L, and EW-3L are in standby.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒Good condition ☐ All required wells properly operating ☒ Needs Maintenance

Remarks: LIPA extraction well EW-4L is not operating due to the loss of wireless communication with the Airport treatment building. This is due to repairs being performed on the BNL meterological tower which holds the communications antenna. The work should be completed in July 2015.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks____

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation

☐ Air stripping ☒ Carbon adsorbers

☐ Filters______________________________

☐ Additive (*e.g.*, chelation agent, flocculent):

☐ Others______________________________

☒ Good condition ☐ Needs Maintenance

☒ Sampling ports properly marked and functional

☒ Sampling/maintenance log displayed and up to date

☒ Equipment properly identified

☒ Quantity of groundwater treated annually________________

☐ Quantity of surface water treated annually________________

Remarks_ ____

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks:

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☐ Proper secondary containment ☒ Needs Maintenance

Remarks: The guard rails on the LIPA well vault needs to be repaired.

4.	**Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☒ Needs Maintenance Remarks: Injection and recirculation wells require routine maintenance to prevent clogging. Flow meters on two Airport injection wells need to be replaced. ____
5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks: ____
6.	**Monitoring Wells** (pump and treatment remedy) ☐ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☒ Needs Maintenance ☐ N/A Remarks_Monitoring wells 000-104 and 000-105, adjacent to the LIPA well vault were missing the outer bolts and the inside of the wells weren't locked. Repairs will be made. ____
D. Monitoring Data	
1.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
2.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: VOC concentrations in LIPA EWs EW-1L, EW-2L, and EW-3L have remained low over the last several years. VOCs in EW-4L has been steadily dropping. VOCs in Airport EWs have been low and stable, while VOCs in RW-6A are slightly higher.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/7/15
A. System OU III North Street/North Street East. Inspection attendees include V. Racaniello, A. Steinhauff, R. Howe, E. Kramer, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: Construction is complete, both systems operating. NSE system was shut down and placed in stand-by mode in June 2014. NS EWs were shut off June 2015 and placed in standby mode.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: Well NS-1 and NSE-1 are pulse pumping. Well NSE-2 is in standby. ____
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks____
3. **Spare Parts and Equipment** ☐ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks____
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☒ Carbon adsorbers ☐ Filters____________________ ☐ Additive (*e.g.*, chelation agent, flocculent): ☐ Others____________________ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually________________ ☐ Quantity of surface water treated annually________________ Remarks____
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks____
4. **Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: Injection wells need routine maintenance due to fouling (every 6 to 12 months).

5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair ☐ Chemicals and equipment properly stored Remarks: Weeds growing in the gutters need to be removed.
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
3.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
4.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/7/15
A. System OU VI AOC 28 EDB. Inspection attendees include V. Racaniello, A. Steinhauff, R. Howe, E. Kramer, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: ___
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks___ ___
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks___ ___
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☒ Carbon adsorbers ☐ Filters___ ☐ Additive (*e.g.*, chelation agent, flocculent): ☐ Others___ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually___ ☐ Quantity of surface water treated annually___ Remarks___ ___
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks___ ___
4. **Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:

5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair ☐ Chemicals and equipment properly stored Remarks: One of the air conditioners and the front door stop need repair.
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks_Monitoring well 000-520 is missing outer bolts, but it is located within the locked fence by the building.____
D. Monitoring Data	
5.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
6.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining Remarks: The plume is progressing to the extraction wells slower than originally projected.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/7/15
A. System OU III Deep VOCs in Industrial Park. Inspection attendees include V. Racaniello, A. Steinhauff, R. Howe, E. Kramer, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: The Industrial Park East system was approved for closure in 2013, and the extraction wells and several monitoring wells were abandoned. Starting in late 2014, the building and associated utilities, the carbon units, and injection wells are being used to treat the deep VOC plume in the Industrial Park.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks:
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks__________
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks__________
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☒ Carbon adsorbers ☐ Filters__________ ☐ Additive (*e.g.*, chelation agent, flocculent): ☐ Others__________ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually__________ ☐ Quantity of surface water treated annually__________ Remarks__________
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks__________
4. **Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: The injection wells require periodic maintenance

5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks:
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks:
D. Monitoring Data	
7.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
8.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining Remarks: The VOCs in the Upper Glacial/Magothy aquifer interface are moving slower than projected toward the extraction wells.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/7/15
A. System OU III Industrial Park. Inspection attendees include V. Racaniello, A. Steinhauff, R. Howe, E. Kramer, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: The system is currently in stand-by mode.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☐ All required wells properly operating ☒ Needs Maintenance ☐ N/A Remarks: Treatment wells UVB-1, UVB-2 and UVB-7 are shutdown due to low VOC concentrations in these wells. Wells UVB-3, UVB-4, UVB-5 and UVB-6 are off pending maintenance to install float switched in the extraction well vaults. Update: The switches were installed and these wells were restarted 7/9/15.
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks____
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks____
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☒ Air stripping ☒ Carbon adsorbers (vapor phase) ☐ Filters____________________ ☐ Additive (*e.g.*, chelation agent, flocculent): ☐ Others____________________ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually____________ ☐ Quantity of surface water treated annually____________ Remarks____
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks____

4.	**Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: These wells are recirculation wells with two screens and require frequent cleaning to keep them operational
5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks: ________________
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks____ ____
D. Monitoring Data	
9.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
10.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: System was approved for shutdown in 2013 but wells UVB-3, UVB-4, UVB-5, UVB-6 were restarted due to rebounding VOCs.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15
A. System OU III AOC 29 HFBR Tritium Pump and Recharge. Inspection attendees include V. Racaniello, E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: The system is currently in standby mode.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: The four extraction wells are in standby mode.
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☒ Carbon adsorbers ☐ Filters____________________ ☐ Additive (*e.g.*, chelation agent, flocculent): ☐ Others____________________ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually____________ ☐ Quantity of surface water treated annually____________ Remarks: The carbon was removed from the vessels in Sept. 2014 and not replaced.
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks____________________
4. **Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks:
5. **Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks: The inside of Bldg. 598 needs housekeeping.

6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
11.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
12.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: Approval was received from the regulators on the Petition for Shutdown since the system met its cleanup goals. The system was shut down and placed in stand-by mode in May 2013.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15
A. System OU I South Boundary (Bldg. 598 and 645) Inspection attendees include V. Racaniello, , E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: The system is currently in standby mode.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: Both extraction wells are in standby mode.
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks____
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☒ Air stripping ☐ Carbon adsorbers ☐ Filters____ ☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used________ ☐ Others____ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☐ Quantity of groundwater treated annually________________________ ☐ Quantity of surface water treated annually________________________ Remarks____ ____
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☒ Needs Maintenance Remarks_Repairs are being made on the electrical system and controllers that were damaged due to lightning strike in early July. ____ ____
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
4. **Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: Recharge Basin is in good condition.

5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair ☐ Chemicals and equipment properly stored Remarks: The inside of Bldg. 598 needs housekeeping. In June, graffiti was found on two of the outside walls and door of Bldg. 645 (near the LIE). A police report was filed. The graffiti will be removed.
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
13.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
14.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: Approval was received from the regulators on the Petition for Shutdown since the system met its cleanup goals. The system was shut down and placed in stand-by mode in July 2013.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15	
A. System OU III South Boundary (Bldg.517 and Bldg 518) Inspection attendees include V. Racaniello, E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager	
1.	**Construction Complete/System Operating** ☒ Yes ☐ No Remarks: Wells EW-6,7,8 and 12 are in standby due to low VOC concentrations.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A	
1.	**Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: Wells EW-3,4,5 and 17 are operating.
2.	**Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks
3.	**Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks_______________
C. Treatment System ☒ Applicable ☐ N/A	
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☒ Air stripping ☐ Carbon adsorbers ☐ Filters_______________ ☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used________ ☐ Others_______________ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually_______________ ☐ Quantity of surface water treated annually_______________ Remarks_______________
2.	**Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks_______________
3.	**Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
4.	**Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: Recharge Basins are in excellent condition but require occasional maintenance
5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks:

6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
15.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
16.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining Remarks: Four of the eight extraction wells are currently operating. The four eastern wells have met the cleanup goals. A new extraction well, EW-17 was installed and became operational in 2012 to address the deeper VOC contamination between EW-3 and EW-4.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15
A. System OU III Middle Road (Bldg.516 and 519) Inspection attendees include V. Racaniello, , E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: The three eastern extraction wells RW-4, RW-5 and RW-6 are in standby and have met the Remedial Action Objectives for this project.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☐ Good condition ☒ All required wells properly operating ☒ Needs Maintenance ☐ N/A Remarks: RW-1, 3, and 7 are operating. In May, well RW-2 was found with water coming out of the above ground pitless adapter. This was due to a hole in the well screen. The well was shut down and a new screen is currently being installed. This was reported as a treatment system bypass in the May SPDES Equivalency Permit Discharge Monitoring Report.
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks____
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☒ Air stripping ☐ Carbon adsorbers ☐ Filters____ ☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used________ ☐ Others____ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually________________________ ☐ Quantity of surface water treated annually________________________ Remarks____ ____
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks____ ____
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4.	**Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: Recharge Basins are is in good condition.
5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks:
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
17.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
18.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining Remarks: The three eastern extraction wells have met cleanup goals and are in standby. A new extraction well, RW-7 was installed and became operational in 2013 to address the deeper VOC contamination in the western portion of the plume.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15
A. System OU III Western South Boundary (Bldg. 539) Inspection attendees include V. Racaniello, E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager
1. **Construction Complete/System Operating** ☒ Yes ☐ No Remarks: Both wells are currently operating.
B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: Well WSB-2 is being pulsed pumped, one month on and two months off.
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks
3. **Spare Parts and Equipment** ☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks____
C. Treatment System ☒ Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☒ Air stripping ☐ Carbon adsorbers ☐ Filters____ ☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used________ ☐ Others____ ☒ Good condition ☐ Needs Maintenance ☒ Sampling ports properly marked and functional ☒ Sampling/maintenance log displayed and up to date ☒ Equipment properly identified ☒ Quantity of groundwater treated annually________________________ ☐ Quantity of surface water treated annually________________________ Remarks_The O&M Manual is missing from the building. A replacement will be provided.____ ____
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks____ ____
3. **Tanks, Vaults, Storage Vessels** ☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
4. **Discharge Structure and Appurtenances** ☐ N/A ☒ Good condition ☐ Needs Maintenance Remarks: Recharge Basin is in good condition
5. **Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks:

6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
19.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
20.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks:

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15

A. System OU III Building 96 (Bldg. TR-854, TR-866, TR-867, TR_868) Inspection attendees include V. Racaniello, , E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager

1. Construction Complete/System Operating ☒ Yes ☐ No

Remarks: Well RTW-4 is on standby mode due to low VOCs. .

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. Pumps, Wellhead Plumbing, and Electrical
☐ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks: RTW-1, 2, and 3 are operating.

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances
☒ Good condition ☐ Needs Maintenance
Remarks

3. Spare Parts and Equipment
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks____

C. Treatment System ☒ Applicable ☐ N/A

1. Treatment Train (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☒ Filters The air inlet port screens on the side of the buildings need to be cleaned of debris._______
☐ Additive (*e.g.*, chelation agent, flocculent)________
☐ Others____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☒ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually________________________
☐ Quantity of surface water treated annually________________________
Remarks: Well RTW-1, 2, and 3 are also capturing and treating low levels of Freon-11 from the Bldg. 452 plume.

2. Electrical Enclosures and Panels (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks____
____

3. Tanks, Vaults, Storage Vessels
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4. Discharge Structure and Appurtenances
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Recharge Basin is in excellent condition

5. Treatment Building(s)
☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6.	Monitoring Wells (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks
D. Monitoring Data	
21.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
22.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: As of the third quarter of 2015, hexavalent chromium is no longer sampled for in the monitoring wells. A soil vapor survey on the western portion of the plume will be performed.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15

A. System OU III Freon-11 (Bldg. 644) Inspection attendees include V. Racaniello, E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager

1. **Construction Complete/System Operating** ☒ Yes ☐ No
Remarks: The system began pulse pumping (one month on and one month off) in February 2015.

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks:

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☐ Filters_ The air inlet port screens on the side of the building needs to be cleaned of debris.________
☐ Additive (*e.g.*, chelation agent, flocculent)_sodium polyphosphate is not used________
☐ Others____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☒ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually________________________
☐ Quantity of surface water treated annually________________________
Remarks:

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks____
____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☐ Proper secondary containment ☐ Needs Maintenance

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Recharge Basin is in good condition

5. **Treatment Building(s)**
☐ N/A ☒ Good condition (esp. roof and doorways) ☒ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. **Monitoring Wells** (pump and treatment remedy)
☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition
☒ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks

D. Monitoring Data

23. Monitoring Data
☒ Is routinely submitted on time ☒ Is of acceptable quality

24. Monitoring data suggests:
☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining
Remarks: Freon-11 concentrations have significantly declined to below the capture goal. A Petition for Shutdown will be prepared in 2015 for submittal to the regulators.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/14/15

A. System OU III Sr-90 Chemical Holes (Bldg. 670) Inspection attendees include V. Racaniello, E. Kramer, A. Steinhauff, R. Howe, M. Chuc, K. Schwager

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: System is currently off in pulsed pumping mode (one month on and two months off).

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**

☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A

Remarks:

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

☒ Good condition ☐ Needs Maintenance

Remarks: A minor water leak at one of the tank vessel fittings needs to be repaired.

3. **Spare Parts and Equipment**

☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☐ Metals removal ☐ Oil/water separation ☐ Bioremediation

☐ Air stripping ☐ Carbon adsorbers

☒ Filters: ion exchange

☐ Additive (*e.g.*, chelation agent, flocculent)

☐ Others

☒ Good condition ☐ Needs Maintenance

☒ Sampling ports properly marked and functional

☒ Sampling/maintenance log displayed and up to date

☒ Equipment properly identified

☒ Quantity of groundwater treated annually

☐ Quantity of surface water treated annually

Remarks:

2. **Electrical Enclosures and Panels** (properly rated and functional)

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks

3. **Tanks, Vaults, Storage Vessels**

☐ N/A ☒ Good condition ☒ Proper secondary containment ☐ Needs Maintenance

Remarks: Six, 210 gal. tanks used to store purge water are registered by SCDHS.

4. **Discharge Structure and Appurtenances**

☐ N/A ☒ Good condition ☐ Needs Maintenance

Remarks: Drywells have never required maintenance.

5. **Treatment Building(s)**

☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair

☐ Chemicals and equipment properly stored

Remarks:

6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks____
D. Monitoring Data	
25.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
26.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: Concentrations in all extraction wells have significantly declined. However, elevated Sr-90 persists upgradient of EW-1. Soil sampling in the vadose zone is planned for this area.

VIII. GROUNDWATER REMEDIES ☒ Applicable ☐ N/A 7/15/15

A. System OU III Sr-90 BGRR/WCF (Bldg. 855) Inspection attendees include R. Howe

1. **Construction Complete/System Operating** ☒ Yes ☐ No

Remarks: All wells operational

B. Groundwater Extraction Wells, Pumps, and Pipelines ☒ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☒ Good condition ☒ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks_Wells SR-4, 5 and 6 are being pulsed pumped (one month on and one month off).
____

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☒ Good condition ☐ Needs Maintenance
Remarks: ________________

3. **Spare Parts and Equipment**
☒ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks____
____

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☒ Carbon adsorbers
☒ Filters: ion exchange ___
☐ Additive (*e.g.*, chelation agent, flocculent)_______________________________
☐ Others____
☒ Good condition ☐ Needs Maintenance
☒ Sampling ports properly marked and functional
☒ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☒ Quantity of groundwater treated annually________________________
☐ Quantity of surface water treated annually________________________
Remarks:

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks____
____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☒ Good condition ☒ Proper secondary containment ☐ Needs Maintenance
Remarks____
____

4. **Discharge Structure and Appurtenances**
☐ N/A ☒ Good condition ☐ Needs Maintenance
Remarks: Drywells were cleaned in 2014 due to clogging.

5.	**Treatment Building(s)** ☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks____
6.	**Monitoring Wells** (pump and treatment remedy) ☒ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☒ Good condition ☐ All required wells located ☐ Needs Maintenance ☐ N/A Remarks____
D. Monitoring Data	
27.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
28.	Monitoring data suggests: ☒ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining Remarks: Removal of Bldg. 811 and associated contaminated soil at the Waste Concentration Facility area is underway in July 2015.

E. Monitored Natural Attenuation
1. **Monitoring Wells** (natural attenuation remedy) ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks: A portion of each groundwater remedy relies on some natural attenuation.________________

IX. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

X. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). With the exception of the HFBR stack and reactor vessel removal, all soil, sediment, and groundwater remedies for the nine RODs at the site have been implemented and are functioned as designed. This includes the excavation and off-site disposal of contaminated soils, sediments, tanks, as well as the installation and operations initiated for all groundwater treatment systems. All of the remedies are being implemented in accordance with the RODs and the ESDs. The remedies are expected to be protective upon attainment of soil cleanup goals once excavation is complete, and groundwater cleanup goals. ____
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The VOC treatment systems operated without any significant down time or issues over the last five years and have consistently met the state equivalency discharge requirements (although there have been a few pH excursions due to the natural groundwater conditions). Typically, the systems have been physically inspected two times per week since 2011. All of the treatment systems are also monitored remotely via the wireless monitoring/alarms system. System O&M has been very effective . ____
C. Early Indicators of Potential Remedy Problems
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. • See Five Year Review Section 7.0. ____
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Opportunities are routinely identified. See Five Year Review Section 7.0_____________ ____

Attachment 4

Interview Records

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**
Subject: 2016 Five-Year Review	**Time:** 2 pm **Date:** 9/29/15
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**	☐ Incoming ☐ Outgoing

Contact Made By:

Name: S. Johnson	**Title:**	**Organization:** BNL Stakeholder Relations

Individual Contacted:

Name: Jessica Mollin	**Title:** Remedial Project Manager	**Organization:** EPA II
Telephone No.: 212-637-3921 **Fax No.:** **E-Mail Address:** mollin.jessica@epa.gov	**Street Address: 290 Broadway** **City, State, Zip:** New York, NY 10007-1866	

Summary of Conversation

Ms. Mollin stated that her overall impression of the cleanup at BNL is actually very good. She said everyone is incredibly organized and the effort of communication is good.

Regarding specific aspects of the cleanup to focus on during the review she said that the Peconic River should be a focus based on what is going on currently.

She does believe that the remedies are functioning as expected by the RODs. She is not aware of any upcoming changes to any federal laws or regulations for Brookhaven.

Ms. Mollin's initial feeling is that there aren't any big risks that would get in the way of achieving the soil and groundwater cleanup objectives but she wanted to take some time to reflect on the question and may provide additional comments in the next few days.

She feels that BNL and DOE are "absolutely" actively managing the long-term cleanup operations and are properly maintaining appropriate institutional controls.

She did not have any comments or suggestions or recommendations; she said that it is a pleasure to work with BNL and they should show everyone else how to do it.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory			**EPA ID No.:**
Subject: 2016 Five-Year Review			**Time:** 3:10 pm **Date:** 9/29/15
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**			☐ Incoming ☐ Outgoing
Contact Made By:			
Name: S. Johnson	**Title:**		**Organization:** BNL Stakeholder Relations
Individual Contacted:			
Name: Mindy Pensak	**Title:** Ecological Risk Assessor		**Organization:** EPA
Telephone No.: 732-321-6705 **Fax No.:** **E-Mail Address:** pensak.mindy@epa.gov		**Street Address:** 2890 Woodbridge Avenue **City, State, Zip:** Edison, NJ 08837	

Summary of Conversation

Ms. Pensak has only been participating on the IAG calls since November 2014.

She felt that determining what is going to be done with the Peconic River should be a focus of the Review. She isn't sure what the purpose is of continuing to sample to get to the cleanup goal; is this the way to reach the ROD goal? It isn't clear to her what the number was based on, and questions what it will mean if we don't get to that number. She feels the number (goal) needs to be re-evaluated.

She was not aware of any upcoming changes to federal laws or regulations in regard to sediment.

Her thoughts were that if the goal was re-evaluated there might not be a need for continually sampling.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**
Subject: 2016 Five-Year Review	**Time:** 10 am **Date:** 9/29/15
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**	☐ Incoming ☐ Outgoing

Contact Made By:

Name: S. Johnson	**Title:**	**Organization:** BNL Stakeholder Relations

Individual Contacted:

Name: Brian Jankauskas	**Title:** Project Manager	**Organization:** NYSDEC

Telephone No.: 518-402-9626 **Fax No.:** **E-Mail Address:** brian.jankauskas@dec.ny.gov	**Street Address:** 625 Broadway, 11th Floor **City, State, Zip:** Albany, NY 12233

Summary of Conversation

- *What is your overall impression of the cleanup at BNL?*

  BNL's actions have made significant progress in cleaning up the environment and BNL continues to remediate known areas of contamination as well as new areas of contamination that are identified.

- *Are there any specific aspects of the cleanup that you feel should be of particular focus during the review?*

  The contamination detected in the Peconic River warrants further evaluation. BNL is currently defining the extents of contamination within a portion of the river. BNL may want to review historical documents to try and understand why this contamination is present since a remedial action and subsequent action were conducted within this portion of the river.

- *Do you feel well informed about BNL's cleanup activities and progress?*

  Yes.

- *Do you believe the public is sufficiently informed of the cleanup progress?*

  Yes.

- *Do you believe the remedies are functioning as expected by the RODs?*

  Sediment contamination within a portion of the Peconic River has been detected above the cleanup goals for the ROD. This is presently being evaluated to determine the appropriate action. Remedies for the other portions of the site are functioning as expected by the RODs.

- *Are you aware of any particular component of the cleanup decisions that pose a higher degree of difficulty in achieving?*

  The sediment goals for a portion of the Peconic River were not achieved following the remedial action and subsequent action. This may be due to the complexity of working within a river.

- *Are you aware of any recent or upcoming changes to federal or New York State laws, regulations, or cleanup standards that may impact protectiveness of human health and the environment at BNL?*

  No.

- *Do you believe there are current opportunities to optimize operations and maintenance, or sampling efforts at BNL that could result in cost savings or improved efficiency?*

  No.

- *What do you think are the biggest risks to achieving the soil and groundwater cleanup objectives at BNL?*

  The sensitive environments of the Peconic River need to be assessed when trying to determine the next step and obtaining the cleanup objectives. The groundwater cleanup objectives appear to be attainable, but unknown contamination outside the capture zones may be identified in the future.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory		**EPA ID No.:**
Subject: 2016 Five-Year Review		**Time:** 2:33pm **Date:** 9/28/15
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**		☐ Incoming ☐ Outgoing
Contact Made By:		
Name: S. Johnson	**Title:**	**Organization:** Stakeholder Relations
Individual Contacted:		
Name: Steve Karpinski	**Title:** Public Health Specialist, Bureau of Environmental Exposure Investigation	**Organization:** NYSDOH
Telephone No.: 518-402-7860 **Fax No.:** **E-Mail Address:** steven.karpinski@health.ny.gov	**Street Address:** Empire Plaza, Corning Tower, Room 1787 **City, State, Zip:** Albany, NY 12237	

Summary of Conversation

Mr. Karpinski stated that he is very impressed and extremely happy with the way things are going with the cleanup at BNL. This is one of the easiest sites to deal with. Everything that he would expect to have addressed has been. It has been an interesting and rewarding experience to be involved with the IAG for the past seven years.

He said nothing of particular focus nor any specific aspects of the cleanup jump out at him. The additional time spent on the Peconic River is the closest thing that he can see that could be any kind of public health issue but that's not expected because of the location.

Mr. Karpinski stated that he believes the remedies are functioning as expected by the RODs. The only changes to federal or state regulations that he is aware of were to the Soil Vapor Guidance document, which aren't tremendous changes, and changes to the air guideline action levels for TCE and PCE, however, they're not issues at BNL.

With regard to the biggest risk to achieving the soil and groundwater cleanup objectives Mr. Karpinski said that just the pure technical aspect of knowing where the groundwater contamination is and isn't and making the necessary changes to get ahead of the contamination.

Yes, Mr. Karpinski feels that BNL and DOE are actively managing the long-term cleanup operations for the site and are properly maintaining appropriate institutional controls. He had no comments or suggestions; the work that is put in to maintain the programs is impressive compared to other sites that he is involved with.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**
Subject: 2016 Five-Year Review	**Time:** 9:09 am **Date:** 10/7
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**	☐ Incoming ☐ Outgoing

Contact Made By:		
Name: S. Johnson	**Title:**	**Organization:** BNL Stakeholder Relations

Individual Contacted:		
Name: David O'Hehir	**Title:** Associate Radiological Health Specialist	**Organization:** NYSDOH
Telephone No.: 518-402-7550 **Fax No.:** **E-Mail Address:** david.ohehir@health.ny.gov	**Street Address:** Empire Plaza, Corning Tower **City, State, Zip:** Albany, NY 12237	

Summary of Conversation

Mr. O'Hehir's overall impression of the cleanup is that it is going well, moving forward. DOE and the contractor are being responsive to his concerns and comments.

The specific aspect of the cleanup that Mr. O'Hehir thinks should be focused on is the one item that hasn't been remediated yet, which is the stack. Remediation was tried with ARRA funding but wasn't successful. He's wondering what the path forward and plan is to get it done in a timely manner (by 2020).

Mr. O'Hehir said that he believes the remedies are functioning as expected with the caveat that there have been some issues. He said both DOE and the contractor have addressed the minor issues as is expected. He is not aware of any component of the cleanup that poses difficulty in achieving, nor is he aware of any recent or upcoming changes to state laws, from the radiological perspective.

Mr. O'Hehir felt that the biggest risk to achieving cleanup right now is the unknown source terms for groundwater which are being investigated by DOE and the contractor. He does feel that BNL and DOE are actively managing the long-term cleanup operations and are properly maintaining appropriate institutional controls. He had no additional comments, suggestions, or recommendations.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory		**EPA ID No.:**
Subject: 2016 Five-Year Review		**Time:** 9:15 am **Date:** 10/7
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**		☐ Incoming ☐ Outgoing
Contact Made By:		
Name: S. Johnson	**Title:**	**Organization:** BNL Stakeholder Relations
Individual Contacted:		
Name: Andrew Rapiejko	**Title:** Associate Hydrogeologist	**Organization:** SCDHS
Telephone No.: 631-852-5786 **Fax No.:** **E-Mail Address:** Andrew.rapiekjo@suffolkcountyny.gov	**Street Address:** 360 Yaphank Ave., Ste. 3B **City, State, Zip:** Yaphank, NY 11980	

Summary of Conversation

Mr. Rapiejko's overall impression of the cleanup is that the Lab has done a good job, it has been successful. He thinks that the specific aspect of the cleanup that should be focused on is the Peconic River and the elevated mercury concentrations. He feels well informed about the cleanup activities and progress and from his perspective thinks that the public is sufficiently informed, at least as much as he can gage.

Mr. Rapiejko believes that the remedies are functioning as expected and he would say there is not any component of the cleanup that poses a higher degree of difficulty in achieving.

He thinks the biggest risk to achieving the groundwater cleanup objectives are any unknowns, anything that wasn't accounted for, although there was diligence in the initial characterization so any unknowns should be minimal. He feels that BNL and DOE are actively managing the long-term cleanup operations and properly maintaining appropriate institutional controls.

Mr. Rapiejko commented that he feels it is important to have the funding and staff to continue the monitoring and assessing of the cleanup activities.

INTERVIEW RECORD

Site Name: Brookhaven National Laboratory	**EPA ID No.:**
Subject: 2016 Five-Year Review	**Time:** 10:30 **Date:** 10/5
Type: X Telephone ☐ Visit ☐ Other **Location of Visit:**	☐ Incoming ☐ Outgoing

Contact Made By:

Name: S. Johnson	**Title:**	**Organization:** BNL Stakeholder Relations

Individual Contacted:

Name: Terri Kneitel	**Title**: Environmental Engineer	**Organization:** DOE

Telephone No.: 631-344-2112 **Fax No.:** **E-Mail Address:** tkneitel@bnl.gov	**Street Address:** Bell Avenue **City, State, Zip:** Upton, NY

Summary of Conversation

Ms. Kneitel's overall impression of the cleanup is that it was done well and done professionally. The specific aspects of the cleanup that she thought should be focused on were the emerging issues of the Peconic River sediment and Strontium-90.

She believes that the public is sufficiently informed about the cleanup and said that BNL does a lot of outreach. She also believes that the remedies are functioning as expected by the RODs.

Regarding the components of the cleanup that may pose a higher degree of difficulty to achieve, she noted that the lack of an exit strategy for monitoring in the Peconic River makes cleanup difficult to achieve.

She does not believe there are current opportunities to optimize operations and maintenance that could result in cost savings because BNL is doing this all the time and does a good job.

Ms. Kneitel thinks BNL is on track to achieve soil and groundwater cleanup objectives. She said the biggest risk would be discovery of a continuing source of Sr-90.

Ms. Kneitel had no comments, suggestions, or recommendations regarding management of the cleanup. She said they are doing a good job.

Attachment 5

Technology and Standards Review Memos
(T. Sullivan to W. Dorsch, dated 10/1/15)

Building XXX
P.O. Box 5000
Upton, NY 11973-5000
Phone 631 344-2840
Fax 631 344-4486
TSullivan@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

date: *October 1, 2015*

to: *Bill Dorsch*

from: *Terry Sullivan*

subject: *Strontium-90 (Sr-90) Five Year Review*

1) Introduction

As part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Environmental Protection Agency (EPA) requires a review of Brookhaven National Laboratory's (BNL) environmental remediation efforts on a five year cycle. BNL has four Sr-90 plumes on site, a) Building 650 plume; b) Brookhaven Graphite Research Reactor (BGRR) and Waste Concentration Facility (WCF) plume; c) Chemical Holes plume, and d) Former Hazardous Waste Management Facility (HWMF). The Building 650 plume and the Former HWMF plumes are small with low concentrations and are being addressed through Monitored Natural Attenuation (MNA). The other two plumes require an active pump and treat system. Initial modeling of the two actively treated plumes suggested that it would require 25 years of active remediation followed by monitoring. The systems have been operating for ten years and the plumes are more persistent than initial modeling suggested. Both plumes require continued active treatment to reach cleanup goals. For this reason, a review of Sr-90 treatment technologies at other sites was conducted to examine if viable options exist to remediate the plume in a shorter time frame without large cost implications. The evaluation criteria are:

- Advancements in cleanup technologies
- Changes in standards and regulations for worker, public, and environmental protection
- Environmental impacts
- Public health impacts
- Economic impacts

If this technical review identifies a remediation method that demonstrates the potential to be implemented that shows substantial improvements to the above criteria, analysis of that potential method will be initiated and possibly implemented.

2) Review of Sr-90 Plumes and Treatment systems

There are two strontium-90 (Sr-90) groundwater contamination plumes associated with Operable Unit III (OU III) that are undergoing active treatment on the BNL site. The first plume is the result of historical leakage from the Brookhaven Graphite Research Reactor (BGRR) and the Waste Concentration Facility (WCF). The second plume originates from the former "Chemical Holes" disposal site, which is the source of the contamination. There are two additional on-site Sr-90 plumes that are being monitored. One is originating from the Building 650 outfall the other is from the former Hazardous Waste Management Facility. The movement of these plumes is conservatively modeled based on existing data to demonstrate that Sr-90 concentrations will not exceed the drinking water standard of 8 pCi/L off-site. If new monitoring data indicate that this may not be true additional monitoring and, if warranted, active treatment will occur.

2.1 BGRR/WCF Plume

Decommissioning of the BGRR began in 1997 with the discovery and subsequent removal of approximately 60,000 gallons of contaminated water that had infiltrated and accumulated in the below ground ducts. Groundwater characterization data after that detected Sr-90 with concentrations above the drinking water standard of 8 pCi/L. A second Sr-90 plume originating from the Waste Concentration Facility and near the BGRR plume was also discovered. The spatial proximity of these plumes allowed them to be treated together.

The 1999 OU III Remedial Investigation and Feasibility Study (RI/FS) considered several remedial alternatives to address this contamination. "Pump and treat" using ion exchange technology was the remedy selected in the OU III ROD. The OU III ROD relies on active "pump and treat" and continued monitoring to reach drinking water standards in 30 years. The selected remedy for the BGRR/WCF plumes relied on two extraction wells operating at high flow rates. This high flow rates caused withdrawal of water that was not originally contaminated resulting but still needed to be treated due to the mixing with the Sr-90 contaminated waters. This generated large amounts of contaminated resins that require disposal as low-level radioactive wastes. The original estimated cost to reach the cleanup goals was 6.5 million dollars. Operating experience and additional characterization indicated that the cost was more likely to be in excess of 55 million dollars (DOE, 2005).

The large operating and maintenance costs prompted DOE to submit an Explanation of Significant Differences (ESD) to the ROD. Several alternatives were evaluated to determine a more efficient method to be protective of the environment. The preferred alternative increased the number of extraction wells from two to five and ran the extraction wells at lower flow rates to reduce the volume of low-level waste. The use of additional wells allowed a more targeted removal action that captured essentially the same amount of radioactivity as the existing high flow wells. The revised approach suggested a ten year active treatment period based on the assumption that there was not a continuing source followed by monitoring until 2076 when the drinking water standards would be met. The estimated cost of this activity was $14 million. In 2005 the regulators agreed with the proposed approach and the ESD was accepted to allow this change. The ESD to the ROD also increased the time to reach drinking water standards from 30 to 70 years.

Waste Concentration Facility

The Waste Concentration Facility (WCF) had operated as a facility for processing and concentrating liquid radioactive wastes received from the Brookhaven Graphite Research

Reactor (BGRR), the Hot Laboratory Complex (Building 801), and the High Flux Beam Reactor (HFBR). Liquid wastes were stored in three 100,000 gallon above-ground storage tanks (known as D Tanks) from 1947 to 1987. Past operations and practices, including three documented leaks from the above-ground tanks, created both surface and deep soil contamination that required remediation. Subsequent characterization found additional leak pathways and contamination beneath the tanks. In 1995, the removal of the three above ground storage tanks was completed. In 2001, the removal of wastes from the six underground storage tanks was completed. Contaminated soil has also been removed from this area.

BGRR/WCF Treatment System
The BGRR/WCF treatment system currently consists of 9 extraction wells and 91 monitoring wells. Two extraction wells SR-1 and SR-2 are located just downgradient of the WCF. Three wells SR-3, SR-4, and SR-5 are located immediately downgradient of the BGRR. The remaining wells were installed in 2010 to capture the WCF plume that has migrated to the vicinity of the High Flux Beam Reactor (HFBR).

Monitoring of the WCF has shown that the concentrations in the source area have shown a significant decline from 2000 to 2010, with a slower decline after that. The highest concentrations still exceed 100 pCi/L in the source area and confirm that a residual source remains in this region. The extraction wells SR-1 and SR-2 appear to be successful in stopping the plume from migrating further south.

However, there is a second part of the plume that was beyond the reach of the extraction wells SR-1 and SR-2. Additional extraction wells were added in 2010 to capture this part of the plume which is near the HFBR. The peak monthly concentration in these wells was always less than 20 pCi/L and often less than 8 pCi/L in the monthly sampling performed in 2015. However, characterization data in temporary wells suggest that Sr-90 continues to be a groundwater issue in this area with many samples above the 8 pCi/L drinking water standards.

The BGRR plume is being treated by three extraction wells operating in pulsed mode. Monitoring data suggests that they are effectively capturing the plume. However, as with the WCF, a portion of the plume had migrated out of the capture zone of these wells prior to their installation. This part of the plume is being monitored and concentrations above the drinking water standard are expected to be contained on site.

2.2 Chemical Holes

The Chemical Holes were located in the south-central portion of the BNL property. The area contained 55 pits that were located east of the former landfill. These pits were filled with chemical waste from laboratory activities. The chemical holes were excavated for off-site disposal in 1997. Excavation went to the bottom of the pits, but not the top of the water table. This left a small contaminated zone between the water table and the bottom of the pits. Strontium-90 in these areas has been detected above the drinking water standard to levels up to 178 pCi/L (well 106-95) in 2015.

A treatment system comprised of three extraction wells has been developed. The extracted water is treated through ion-exchange. The first well was installed in 2003. The second and third wells, which are further from the source zone, were installed in 2007. The three wells are located along the centerline of the plume at different distances from the source area. The average flow rate in these wells was 14 gpm in 2013. Extraction well concentrations are less than 20 pCi/L in 2013 and have been steadily decreasing. A total of slightly less than 5 mCi of Sr has been removed by the extraction system between 2003 and 2015.

The initial modeling for the ESD to the ROD suggested that it would require about 10 years of active treatment followed by 30 years of monitoring to meet the drinking water standard of 8 pCi/L. However, this has not proven to be the case. The modeling was based on no continuing source of Sr-90 to the aquifer. Concentrations around 100 pCi/L persist in 2015 at the top of the water table near the Chemical Holes suggesting that a continuing source exists. Further evidence that a source remains come from wells 106-94, 106-95, and 106-99. These are the three closest wells in the centerline of the plume with 106-94 being the closest to the source area. All three wells have remained far above the drinking water standard and have had slowly decreasing concentrations over the past 10 years.

Additional characterization data collected in 2013 using temporary wells also showed concentrations around 100 pCi/L at the top of the water table. The area of high concentration is localized as the temporary wells were spaced approximately 20 feet apart and wells adjacent to the high concentration wells showed concentrations of 2 or 3 pCi/L. This small area of contamination suggests that a targeted action may be effective to reduce the source in the vadose zone.

A recent modeling study (P.W. Grosser, 2015) predicted that it would take much more than 25 years for the current plume to have the concentrations fall below 8 pCi/L if the existing treatment system were turned off. This model assumes that there is no further release to the aquifer, which appears to contradict the data, suggesting a longer time may be needed. This is clearly not a viable alternative and the pump and treat system will need to continue operations.

2.3 Building 650 Plume

The Reclamation Facility (Building 650) was used to decontaminate radiologically contaminated clothing and equipment. Liquid effluent was discharged through a pipe to an outfall area approximately 1200 feet to the west of the building. Soils near this facility and the sump-outfall area have become contaminated from these activities. Initially, several radionuclides exceeded the soil cleanup goals. In 2002, the contaminated soil, piping, and decontamination pad was removed. However, a plume of Sr-90 can be traced to the sump outfall area.

Sr-90 groundwater concentrations in the source area near the sump outfall continue to decrease indicating that the source is being depleted. Higher concentrations (up to 130 pCi/L in 2014) have been observed downstream. This is not unanticipated as higher concentrations have been observed in the past. The leading edge of the plume is near Brookhaven Avenue. Modeling performed in 2010 suggests that the 8 pCi/L drinking water standard will be met by 2034 and that the leading edge of the plume will be 250 feet south of Brookhaven Avenue and contained on the BNL site. The current plan for management of this plume is continued monitoring to make sure that the model predictions are valid.

2.4 Former Hazardous Waste Management Plume

The Former Hazardous Waste Management Facility (HWMF) was the site's central RCRA and radioactive waste receiving facility for storing wastes prior to off-site disposal until 1997. Several spills were documented at the former HWMF. A soil remediation program was completed in 2005 to reduce the contamination levels. The VOC plume from this site has been treated, however, there remain residual amounts of Sr-90 that are routinely detected in groundwater above the drinking water standard of 8 pCi/L. A sentinel well, well 108-45 located 700 feet from the site boundary, has shown an increase in Sr-90 from 1 pCi/L to around 5 pCi/L in 2015. The well nearest the source of contamination in the Former HWMF, well 88-26, hovered around 10 pCi/L from 2005 until 2012. After that time, it has decreased to less than 5 pCi/L. However, well 98-30, which is between the well 88-26 and the sentinel well has shown a steady increase in concentration over recent years rising from 8 pCi/L in 2009 to 35 pCi/L in 2015. This suggests that there is a slug of Sr-90 moving through the system.

The increase in Sr-90 concentration in the two wells downstream of the Former HWMF raised concerns and a series of geoprobe wells were installed to further define the plume. Geoprobe samples were collected at four foot intervals to define the vertical location of the plume. Sampling performed at the upstream edge of the Former HWMF showed slight Sr-90 contamination levels (< 8 pCi/L). A row of geoprobe wells spaced approximately 50 feet apart and 300 feet downgradient of the Former HWMF found Sr-90 contamination in five adjacent wells above 8 pCi/L with a maximum concentration of 217 pCi/L (OUI-SR90-GP-40). Most of the contamination was between 8 and 32 pCi/L, however, two wells had Sr-90 levels above 100 pCi/L. The highest concentration occurred at the last sampling location and the transect is being extended to define the plume. An additional row of geoprobe wells is planned approximately 700 feet further south (downgradient) near well 98-30. This will define the width and depth of the plume at this location.

3.0 Review of Advances in Strontium Treatment Technology

The major change in strontium treatment technology is to move away from pump-and-treat systems due to their high costs and limited effectiveness towards permeable reactive barriers. This approach has been used at three DOE sites: Hanford, Savannah River, and West Valley. Table 1 summarizes the treatment system, hydrogeologic system, and contaminant concentrations a these three sites. A more detailed discussion of each site follows.

Table 1 Summary of Sr-90 subsurface barrier treatment systems.

	Hanford	Savannah River	West Valley
Plume Description	0.4 square mile area, 10 to 37 m deep.	2.4 square mile area, 10 to 20 m deep.	430 m long, 200 m wide, 9 m deep.
Plume Origin	Liquid Waste disposal in trenches during the 1950's through 1980's.	Acid Waste disposal in ponds during the 1950's through 1980's.	Facility operations spills and leaks between 1966 and 1972.
Hydrogeology	Vadose Zone: 0 - 23 meters thick. Unconfined Aquifer 6.5 – 14 m thick. Confining aquitard beneath the unconfined aquifer.	Clay layer 20 meters below grade.	Confining till (clay) layer six to nine meters deep.
Remedy	Permeable Reactive Barrier with Apatite	Funnel and Gate Barrier with Base addition to	Permeable Reactive Barrier with Zeolite

		raise pH.	(Clinoptilite).
Barrier Depth	Water table to a depth of 14 meters.	Water table to a depth of 20 meters.	Surface to a depth of 9 meters
Maximum concentrations	15,000 pCi/L (2012)	3200 pCi/L (early 1990's) 213 pCi/L in 2013.	400,000 pCi/L 100,000 pCi/L in 2014.
Concentration after treatment	70 – 210 pCi/L (2012).	Near MCLs (< 80 in treatment zone).	Not available.
Comments	Pump and treat only reduced peak values by a factor of 2 (e.g. > 8000 pCi/L). Apatite PRB reduces concentrations by a factor of 6 to 20. Concerns remain about the length of cleanup.	Base addition works to immobilize Sr in the treatment zone. However, concerns over how long the base additions will be needed still exist.	The site has not addressed long-term cleanup issues. They will review and develop a plan by 2030 after evaluating the effectiveness of the PRB.

3.1) Hanford

The US DOE Hanford site contains several strontium-90 plumes with contamination above the 8 pCi/L drinking water standard. The biggest concern is in the N area adjacent to the Columbia River where peak concentrations are greater than 10,000 pCi/L. The high concentrations of strontium-90 in groundwater near the river required an expedited response action in 1995. A pump-and-treat system was designed and installed to create a hydraulic barrier between the river and the liquid waste disposal facility, such that the rate of strontium-90 movement into the river is reduced. An evaluation of the performance of this system is conducted annually. The remedial action continues to reduce the hydraulic gradient toward the river, reducing the net flux to the river by greater than 90%. However, based on the groundwater monitoring network in 2009, the size, and shape of the strontium-90 plume in groundwater have varied little over the years, Figure 1. The plume has nearly the same areal extent and shape currently as was evidenced in 1996 (prior to startup of 100-N Area pump-and-treat operations.

Strontium-90 is present in the vadose zone beneath the two disposal facilities, having been adsorbed onto sediments. As the water level decreases, strontium‐90 remains in the vadose zone above the water table. When the water table rises strontium‐90 from the periodically re-wetted vadose zone is mobilized and the concentrations in groundwater increase. This creates considerable variability in concentrations observed at some monitoring wells. Levels have been consistent for the last few years, with the increase and decrease of strontium‐90 concentrations mirroring changes in the water table elevation.

While the system removed strontium from the groundwater, the strontium in the soil re-contaminates the groundwater again and again. Based on soil characteristics (strontium distribution coefficient is 15 cm^3/g) it was estimated that less than 1% was in solution with the remainder sorbed to the soil. Thus, to flush the system would take 100's of years. The pump-and-treat removal of 1.8 Ci from 1995 to 2006 was very small compared to the total quantity of Sr-90 discharged to the liquid waste disposal facility, which was estimated to be 1,866 Ci. The amount of Sr-90 discharged to the river in this 11 year period was 1.5 – 2.1 Ci, roughly the same as the amount removed. It was estimated that significantly more Sr-90 decayed in place (~ 400 Ci) during the operational period than was removed. This high energy requirements and operational and maintenance costs required for very little return on investment led the Hanford site to place the system in standby in 2006. In addition to pump-and-treat efforts, DOE tried to insert an underground metal barrier along the shoreline to intercept strontium migration to the river. Hanford scientists also studied the idea of freezing the aquifer and flushing the soil. These efforts did not succeed.

The continued high-level of Sr-90 near the river led to the development of another approach to remediation. In 2008 a permeable reactive barrier (PRB) using Apatite-forming minerals was created by injection into 10 wells along the Columbia River shoreline to create a 90-meter (300-foot) long barrier. Apatite minerals sequester elements into their molecular structures via substitution, whereby elements of similar physical and chemical characteristics replace calcium, phosphate, or hydroxide in the hexagonal crystal structure. Sr-90 replaces calcium and becomes immobilized. The data from this work indicates that apatite sequestration is effective for immobilizing Sr-90 in situ. In 2010 the Record of Decision (ROD) was amended and the selected remedy became the apatite PRB. The PRB was extended to a length of approximately 760 m (2,500 ft.), immediately adjacent and parallel to the Columbia River. This will provide increased protection of the Columbia River by immobilizing, and therefore, removing Sr-90 from the groundwater before it enters the river.

Prior to treatment with Apatite, two baselines for strontium concentration were developed to represent the annual variability. The upper baseline represents the typical maximum values observed and the lower baseline represents the typical lower annual values. Post-treatment aqueous ^{90}Sr concentrations, based on both direct measurements of ^{90}Sr and ^{90}Sr equivalents (i.e., scaled gross beta particle emissions) have been collected at compliance locations along the river. Short-term increases in the ^{90}Sr concentration at these compliance well locations, which

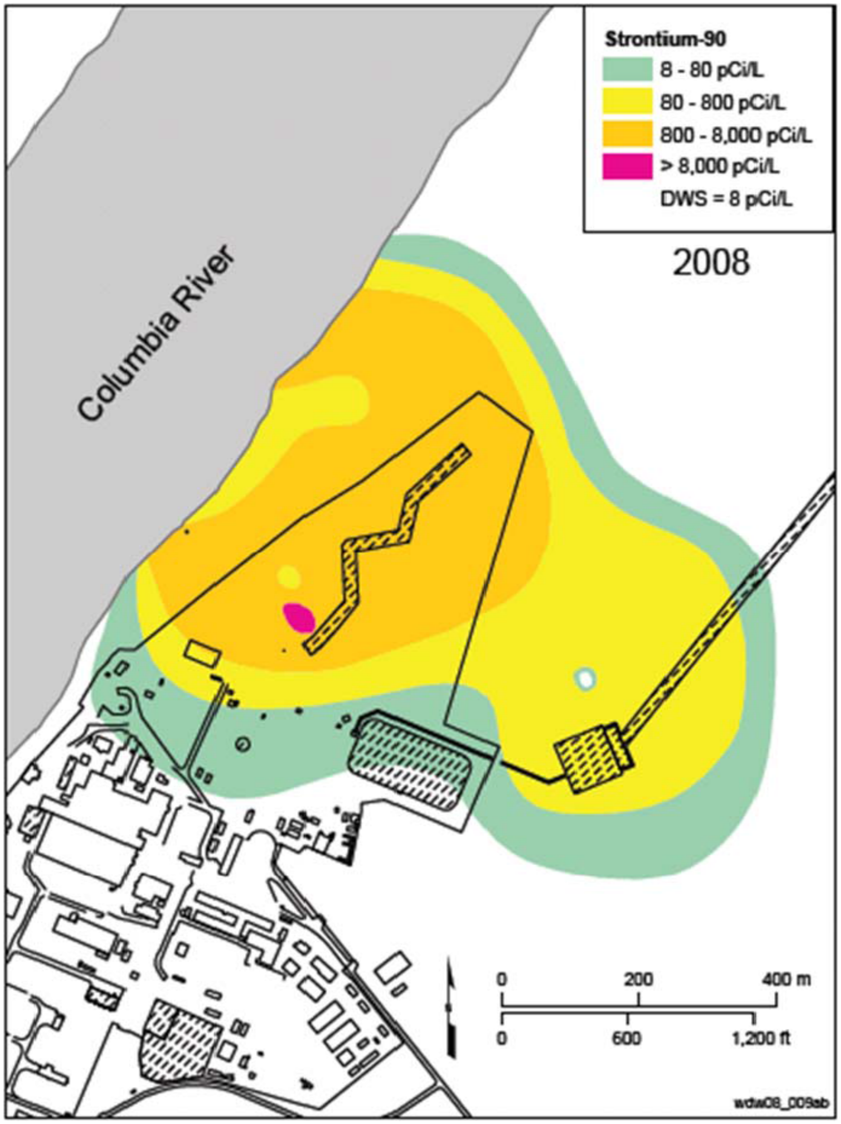


Figure 1 Strontium plume at the Hanford site along the Columbia River in 2008.

are associated with the injection of high-ionic strength apatite amendment solutions during treatment, generally fell near or below the baseline maximum concentration. One well hade short term increases in ^{90}Sr concentration that reached approximately five times the baseline maximum value. Also worth noting is the elevated ^{90}Sr concentration observed in September 2011 at compliance monitoring well. This increase was associated with amendment injections in adjacent wells that were performed in support of PRB expansion activities. Longer-term monitoring results continue to show seasonal variability, with concentrations decreasing during periods of high Columbia River stage when groundwater flows are reversed (i.e., bank storage is occurring) and increasing when river stage drops and groundwater with mobilized ^{90}Sr is migrating toward the discharge boundary at elevated groundwater velocities (September/October time frame). Although this seasonal trend is still present in the post treatment data, observed post treatment ^{90}Sr concentrations fall near or below the baseline. The average reduction in ^{90}Sr concentrations at the four compliance monitoring locations was a factor of 20 relative to the high end of the baseline range and a factor of 6 relative to the low end of the baseline range approximately 1 year after treatment. By the 4th year after treatment, these performance metrics had decreased slightly.

Monitoring well concentrations downstream of the barrier had Sr-90 concentrations between 70 and 200 pCi/L. This is due to incomplete coverage of the apatite zones and water table fluctuations. Given the amount of Sr in the vadose zone there is concern that it will take more than 100 years to meet cleanup goals. In 2014, the Hanford Advisory Board HAB) recommended targeted source removal from the vadose zone, use of apatite in the vadose zone above the existing barrier to reduce the effects of groundwater fluctuation, and mini PRBs in the aquifer near known sources (HAB, 2014). While the HAB, Regulators, and DOE all believe that the PRB is an improvement over pump-and-treat, it has not completely solved Hanford's strontium problems.

3.2) Savannah River

The US DOE site at Savannah River operated unlined F and H Area Seepage Basins from 1955 until 1988 for the disposition of deionized acidic waste water from the F and H Separations Facilities. Additionally, fuel failures, primarily in the 1950's and 1960's led to direct release of tens of curies of Sr-90 directly to the on-site streams (Carlton, 1992). Waste water from nuclear plant operations contained low concentrations of non-radioactive metals, and radionuclides, with the major isotopes being Cs-137, Sr-90, U-235, U-238, Pu-239, Tc-99, I-129, and tritium. The tritium concentration in the waste water was elevated with concentrations in excess of 10,000,000 pCi/L. The acid content of the waste water during the operational period of the basins was equal to 12 billion liters of nitric acid. The seepage basins were closed in 1988 and backfilled and capped by 1991. The high acidic content of these seepage basins mobilized many nuclides leading to a mixed plume. Groundwater discharges of Sr-90 to the Fourmile Branch were consistently around 3200 pCi/L in the early 1990's (Carlton, 1992).

The plumes associated with the F and H basins cover an area of nearly 2.4 square kilometers (600 acres) and discharge along ~2,600 meters of Fourmile Branch. The acidic nature of the plumes and their overall discharge extent along the branch represent a large challenge with respect to reducing contaminant flux to Fourmile Branch. The introduction of nitric acid into the groundwater over a long time effectively reduced the pH of the aquifer and consequently reduced the retardation of metal migration from the basins to the groundwater and in the groundwater to Fourmile Branch. The pH was low enough (< 4) that most negatively charged surfaces on the aquifer materials were filled with hydrogen ion and unavailable for the metal ions.

Two large pump and treat systems were constructed in 1997 and operated until 2003 in an attempt to capture and control the releases to Fourmile Branch. These systems included flocculation tanks, reverse osmosis, and resin beds to remove the metals and contaminants in the groundwater. The operating cost, including waste disposal, for the two systems was ~$1.3M/month. Both systems employed reinjection of tritiated water up gradient of the extraction, and produced large quantities of waste from non-tritium isotopes and metals removal prior to reinjection. Both systems were determined to be ineffective and potentially detrimental with respect to limiting the flux of contaminants to Fourmile Branch.

After it became apparent that there was very little benefit to continued operation of the systems, and the staggering cost of operations was recognized by the SRS and regulators, a new remedy was developed in 2005. The new system uses vertical subsurface barriers to redirect groundwater flow to limit the transport of contaminants to the stream. The barriers were constructed of acid resistant grout using deep soil mixing techniques. The grout mixture used low swelling clay, fly ash, and sodium hydroxide to form a pozzolan material with low permeability and low strength. The SRS and regulators agreed to a series of remedial goals, with the first goal to reduce tritium flux to the stream by 70% and bring constituents other than tritium to groundwater protection standards.

At the F Area Seepage Basins the subsurface barriers extend to 18 meters (60 feet) below the surface, and form a funnel and gate system 1,036 meters (3,400 feet) long. The system contains three gates that have openings set in the upper portion of the water table, which promotes water movement mostly in the top of the stratigraphic section. The gates also contain a base injection system to neutralize nitric acid, raise the pH and cause the precipitation of metals onto aquifer materials. Injection of the alkaline solution establishes treatment zones for uranium and Sr-90 for approximately 30 meters down gradient of the gates. The base neutralizes the acidity of the plume and aquifer mineral surfaces causing sorption of the contaminants and possible precipitation of uranium silicates. For each injection campaign between 5.7 and 13.2 million liters (1.5 to 3.5 million gallons) of alkaline solution are injected per gate. An injection campaign takes about two months to complete. Since 2005, 132 million liters (35 million gallons) have been injected at all three gates. The gate areas comprise about 306 linear meters of the funnel and-gate system.

Treatment at the gates has been effective at reducing aqueous concentrations of most metal and metallic radionuclide contaminants. Due to the large volume of alkaline solution, the effect of diluting the contaminants rather than neutralization was a concern. The effect of dilution was determined using tritium because it is a non-reactive contaminant. The effect of dilution corresponded to a contaminant reduction factor of 1.5. For Sr-90 the reduction in concentration is a factor of 5 from upstream values. Thus, the concentrations are still above the drinking water standard of 8 pCi/L.

At the H Area Seepage Basins the subsurface barriers extend to 27 meters (90 feet) below the surface and have a cumulative length of 1,005 meters (3,300 feet). The barriers are positioned up gradient (length of 610 meters (2,000 feet)) and down gradient (length of 400 meters (1,300 feet)) of the largest seepage basin (H-4). The barriers create a "step-down" configuration from up gradient of the basins to down gradient of the basins adjacent to Fourmile Branch, with a large reduction in groundwater gradient within each of the steps. The reduction in gradient is used to reduce the flux of contaminants to the stream. The peak Sr-90 concentration in this area was 425 pCi/L in 2013.

Construction of the subsurface barriers was completed in 2005; a 70% reduction in tritium flux was achieved by 2011. SRS has implemented several base injection campaigns in the gates and down gradient of the barriers to work toward achieving standards in Fourmile Branch for all constituents other than tritium. It is believed that achieving groundwater protection standards for radioactive metals including Sr-90 will be achieved soon. SRS is currently evaluating a passive reactive treatment for I-129 in one of the gates at the F Area Seepage Basins.

3.3) West Valley

Reprocessing of nuclear fuel occurred at the West Valley site from 1966 to 1972 but was closed down following regulatory reform of the nuclear industry that drove the costs higher than expected. Contamination came from piping leaks within the former irradiated (used) nuclear fuel reprocessing plant during operation. Contaminated liquid moved through expansion joints in the floor of the plant and into the underlying soil. Sampling beneath the plant confirmed the presence of Sr-90 and other isotopes consistent with the documented leaks. Although releases have stopped since the West Valley Facility ceased operations in 1972, a continuing source of Sr-90 from the vadose zone has kept concentrations well above the drinking water standard to this day.

The Department of Energy is responsible for environmental remediation of the site and they set up the West Valley Demonstration Project (WVDP) to address remediation goals. Sr-90 is more mobile in groundwater than the other isotopes involved at West Valley and has been carried with groundwater passing beneath the plant. Strontium concentrations in excess of 400,000 pCi/L have been measured on site. The groundwater moves above a confining layer of glacial clay (till) which varies throughout the deposit from approximately 1.2-9.1 meter (4-30 feet) below the surface. The Sr-90 plume extends primarily northeast from the plant moving downgradient toward the edge of the WVDP site and the edge of the small plateau upon which the facility was built. At or near the edge of the plateau, the groundwater comes to the surface as springs or seeps.

The plume is approximately 430 meters (1,400 feet) long at levels above 10,000 pCi/L. It extends from the reprocessing plant downgradient approximately 275 meters (900 feet), the groundwater follows a fairly narrow path 120 -152 m (400-500 feet) in width. Beyond approximately 275 meters (900 feet) the plume widens to approximately 213 meters (700 feet) and three distinct preferential pathways (lobes) occur.

A pump-and-treat system was installed in 1995 and was still operating in 2013. The system has treated 54.7 million gallons of water and removed 9 curies of Sr-90 by 2010. However, the recovery system does not completely prevent migration of the plume. WVDP is considering the permanent shut down of this system.

In 1999, a 9 meter (30 feet) permeable treatment wall (PTW) was installed as a pilot program. The PTW used one pass trenching to remove existing soil and install clinoptolite. The wall was capable of removing Sr-90 but a number of problems arose during the installation including a decrease in permeability relative to the native soils that led to less flow through the wall than predicted. It was concluded that the wall, while effective, was too small to control the migration of strontium.

Installation of a second PTW, approximately 259 meters (860 feet) long was completed in the fall of 2010. The excavation was approximately 1 meter (39 inches) wide and from 5.8-9.1 meters (19- 30 feet) deep and 2,600 metric tons of zeolite were installed using a one-pass trencher. The excavated soil was placed directly into an aboveground containment structure via a conveyor specifically designed and fabricated for use in this project.

The PTW is intended to contain further expansion of the leading edge of the Sr-90 plume until a long-term management approach is selected for this area of the WVDP site. Planning for the PTW focused on designing and installing a system that could function for up to 20 years. Current agencies' plans call for making a decision on the long-term management of the plume by 2020.

The full-scale PTW, installed in November 2010, has now been monitored for three years. Performance monitoring data collected to date indicate:

- groundwater flow patterns in the PTW area are similar to those observed prior to PTW construction indicating that the PTW installation did not significantly alter groundwater flow conditions on the north plateau;
- strontium-90 activity in groundwater immediately downgradient of the PTW has decreased; and
- strontium-90 activity that had already migrated past the PTW prior to its installation is continuing to migrate downgradient. However, downgradient strontium-90 concentrations are expected to decrease over time as groundwater treated by the PTW flows towards these areas.

Based on the January 2013 and January 2014 annual sampling results, there are no longer strontium-90 concentrations greater than 10,000 pCi/L in the downgradient (e.g. past the PTW) western or central lobes and no detected strontium-90 activities above 1,000 pCi/L in the downgradient eastern lobe of the strontium-90 plume. The PTW has decreased the concentration of the contaminant strontium-90 in the groundwater by 77 percent since the wall began operating in late 2010.

3.4) Discussion

There are several important points to observe from the experiences of these three major Sr-90 contamination sites:

a) All three sites found the standard pump-and-treat option ineffective and moved to some type of permeable barrier system that would allow for decay in place. The permeable barrier systems have a major cost advantage in that there is no water removal and therefore, no need for treatment. All three sites had an underlying layer that they could key into which is not the case at BNL.
b) The sorption of the strontium onto the soil provides a continual source that is difficult to remove quickly. This is evidenced by the fact that the plumes have existed for more than 20 years without a discernable reduction in size and only a slight reduction in concentration due to radioactive decay.
c) The West Valley and Hanford sites have contamination in the vadose zone that acts as a continuing source. The plume at the Hanford site is responsive to variations in the water table with increases in the groundwater concentration after the water table rises and decreases when the water table falls. This implies that effective source control would require removing all of the contaminated soil above the water table to stop the continual replenishment of the strontium to the groundwater.
d) The permeable reactive barrier systems are relatively new (< 5 years) and long-term performance is not guaranteed. The Hanford Advisory Board is suggesting additional treatment zones for the apatite to improve performance. The PRB's at these sites have required multi-million dollar up-front investments for installation.

4) Review of criteria for changing the current strategy.

Advancements in cleanup technologies

Several DOE sites with active treatment of Strontium-90 plumes have moved away from active pump and treat to passive treatment with permeable barriers. This approach has led to a factor of ten or more decrease in strontium concentrations after the groundwater has passed through the barrier. The long term effectiveness of these barriers is not known. While this approach has been successful at all three sites, it is not applicable at BNL. All sites have a near surface layer to key into. This allows flow to be funneled through the barrier wall. At BNL the clay layer is far below the land surface thus it would be cost prohibitive and may not be feasible from an engineering standpoint. A targeted soil amendment to sequester the Sr-90, such as apatite used at Hanford, is unproven and would likely lead to slight decreases in permeability that would cause flow to be diverted around the treatment zone.

Changes in standards and regulations for worker, public, and environmental protection

There has not been a change in the standards for worker, public or environmental protection in the last five years. Although these may change in the future, there is no current activity to change existing limits and regulations.

Environmental impacts

The Sr-90 levels are currently above the drinking water standards. However, the monitoring data collected over the past ten years suggests that the existing pump and treat system will capture the plume. This indicates that further action is not necessary if BNL wishes to continue operating the system for the necessary time to deplete the existing source in the vadose zone

Public health impacts

There are no public health impacts from the Sr-90 plumes. The contamination is contained within the BNL boundaries and the existing systems coupled with modeling indicate that the plumes will not migrate off-site.

Economic impacts

The current Sr-90 treatments systems are effectively controlling the Sr-90 plumes on site. The issue is that this is requiring more time than originally estimated which leads to higher costs. Sr-90 currently in the vadose zone above the water table continues to act as a continuing source to the aquifer. This effect is pronounced when the water table rises and encounters Sr-90 contaminated soils. To reduce the time for active operation requires either: a) removal of the vadose zone source term or b) capping at the surface to reduce the rate of water flow and thereby the flux of water (and Sr-90) to the aquifer. However, finding the exact location of the source would be extremely difficult (particularly beneath the BGRR) and even with a cap, a rising water table will continue to add strontium to the vadose zone until the soil in the zone of water table fluctuation is depleted of Sr-90.

5) Conclusion

The existing treatment systems are successfully capturing the Sr-90 plumes; however the cleanup period is longer than originally anticipated. This is primarily due to the continued release of Sr-90 from the vadose zone to the aquifer, which was not accounted for in the modeling. Efforts to locate the source in the vadose zone and/or reduce infiltration through capping, if successful, will reduce the time required for active pumping to remove strontium. Other DOE sites have turned to permeable reactive barriers. Use of a permeable reactive barrier at BNL is probably not feasible due to the absence of a competent geologic layer to tie into and the high initial cost of barrier installation. This will be reviewed in five years if the duration of cleanup of the strontium plume remains a concern.

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Memo

date: *October 1, 2015*
to: *Bill Dorsch*
from: *Terry Sullivan*
subject: Ethylene Dibromide (EDB) Review

1) Introduction

As part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Environmental Protection Agency (EPA) requires a review of Brookhaven National Laboratory's (BNL) environmental remediation efforts on a five year cycle. Initial modeling of the transport rate of Ethylene Dibromide (EDB) suggested that the system could be turned off in 2015. The current data do no support this and it will take several more years to reach cleanup goals. For this reason, a review of EDB treatment technologies at other sites was conducted to examine if viable options exist to remediate the plume in a shorter time frame without large cost implications. The evaluation criteria are:

- Advancements in cleanup technologies
- Changes in standards and regulations for worker, public, and environmental protection
- Environmental impacts
- Public health impacts
- Economic impacts

If this technical review identifies a remediation method that demonstrates the potential to be implemented that shows substantial improvements to the above criteria, analysis of that potential method will be initiated and possibly implemented.

2) Review of EDB Treatment system

EDB was used as a fumigant in 1970's in the Biology Fields in the southeastern portion of the BNL site. Sampling in 1995 and 1996 detected low-levels of EDB above the drinking water standard of 0.05 µg/L in the groundwater near these fields. Higher concentrations were found near the southern boundary and off site to the south. The depth of the plume decreased as the plume migrates southward.

The OU VI EDB treatment system contains two extraction wells and two recharge wells that have been operational since August, 2004. Extracted groundwater is passed through a granulated activated carbon filter before being used for recharged. All equipment, including the treatment building is located off site near the extraction wells. EDB has not been detected on site since 2009. This is important because it indicates the source has been depleted and when the capture goals are met, it should remain that way.

The monitoring system consists of twenty-five wells. Five wells that are in the main part of the plume are sampled quarterly, while other wells are sampled semi-annually. The trailing edge of the plume is south of North Street and extends approximately 3000 feet to the extraction wells. Peak concentrations in the plume remain above 1 µg/L while the cleanup standard is 0.05 µg/L. The region of highest concentrations in the plume extends back approximately 1500 feet from the extraction wells.

Original model estimates of the time required for remediation suggested that 8 to 10 years would be sufficient (BNL, 2004). The system has been operating for 11 years and will require several more years to reach the cleanup goal. For this reason, a review of other EDB plumes and treatment technologies was conducted to determine if an approach was available to speed up the process.

3) EDB Treatment Systems at Other Sites

EDB was used as a pesticide and as a component of lead based gasoline and aviation fuel that reduced engine knock. Florida stopped the sale of produce contaminated with EDB in 1983 and banned its use after that time. Florida still has EDB groundwater contamination problems more than 30 years after stopping its use. This reflects the persistence of EDB in groundwater system and the low rates of biodegradation in many subsurface environments. A study for the State of South Carolina showed that over ½ of the Underground Storage Tanks with leaks have EDB groundwater concentrations above the drinking water standard of 0.05 µg/L (Falta, 2006). EDB is still used as a gas additive. Several large military complexes including Otis Air Force Base (now known as Joint Base Cape Cod - JBCC), Kirtland Air Force Base in New Mexico, and the Kitsap Naval Base in Washington have had major spills leading to EDB plumes with concentrations above the drinking water standards that are over approximately one mile in length and 2000 feet wide. This represents several billion gallons of contaminated water. These plumes have migrated off site leading to concerns by the general public.

In 2006, EPA conducted a review of BTEX contaminants including EDB. They found that the treatment technologies used most often for EDB contaminations are air sparging, soil vapor extraction (SVE), and pump and treat (P&T) with granular activated carbon. Air sparging and SVE are frequently used in the source zone and when the contamination is near the surface. Deep groundwater plumes are treated using P&T.

The two largest spills of EDB were at Otis National Guard and Kirtland Air Force Base. At the JBCC (Otis Air Force Base) an aviation fuel pipeline leaked approximately 70,000 gallons. This was identified as Fuel Spill 12. Other large fuel spills occurred at this site as well. Groundwater contamination was discovered in 1990 when the nearby public water district detected hydrocarbon odors in two exploratory wells installed off base. BTEX and EDB were identified in the plume. The source area was 11 acres in size and the resulting plume was 4800 feet long, 2000 feet wide and 60 to 130 feet thick. The depth of this plume is 150 – 250 feet below ground surface. The plume had a maximum EDB concentration of 600 µg/L. Air sparging and SVE were used from 1995 to 1998 to remediate the source zone. During operation 23 air sparging wells and 23 extraction wells were in operation. Approximately 45,000 pounds of BTEX and EDB were removed from the soil.

A P&T system is currently in operation at JBCC. The 1995 interim ROD, which selected P&T as a remedy, set the cleanup goal for EDB in groundwater at 0.02 µg/L based on the state MCL. The initial P&T system includes 25 extraction wells and 23 reinjection wells. The P&T system started operating in September 1997 and treated over 1 million gallons of groundwater per day. Extracted groundwater is treated using granular activated carbon to remove organic contamination and the water is reinjected into the aquifer. As of January, 2015 the Fuel Spill 28 treatment system was down to 2 wells operating at a total of 550 gpm. Two other systems are in place to treat EDB contamination from fuel spills.

The original modeling at the JBCC site suggested that the P&T system would need to be in operation for approximately ten years. However, further characterization showed the plume to be much more widespread than the original estimate. The system has been in operation for 20 years. The longer time required to clean up the plume prompted JBCC to examine in-situ treatment options.

Kirtland Air Force Base in Albuquerque New Mexico also had a large undetected leak of aviation fuel oil. The use of EDB in fuel was stopped in 1975. In 1990 characterization data showed elevated EDB and benzene. Further characterization shows that currently the plume reaches just off base at concentrations in excess of 1000 µg/L. The cleanup level required by the EPA and State of New Mexico is 0.05 µg/L. The plume extends several thousand feet further at this level. EDB has not been detected in the supply wells. In 2003 a soil vapor extraction system was installed to remove contamination from the vadose zone. It has removed 500,000 gallons of fuel since operation started. They have recently decided to install a P&T system with granular activated carbon. The clean water will be recharged to the aquifer. The system will contain up to 8 extraction wells with a total pumping rate of 600 – 800 gpm. The objective of this system is to shrink the size of the EDB plume and prevent the leading edge of the plume from entering the supply wells.

4) Options to Improve Treatment

The long treatment time required for P&T motivated JBCC to search for in-situ treatment techniques. In 2011 attempts to find a method for enhanced biodegradation of EDB at the JBCC were made (McKeever, 2011). In laboratory studies they added a 50 millimole (mM) phosphate buffer to water at pH 7 and 15 ºC. This reduced the half-life of EDB from 22 years to approximately 16 years. A slight improvement, but this was insufficient to justify the costs. In further laboratory studies, the addition of 1mM sulfide to the 50 mM phosphate buffer at 15 ºC further reduced the half-life of EDB to 160 days. Biotic hydrolysis (biodegradation) of EDB is enhanced in the presence of a natural catalyst such as H_2S or the bisulfide ion (HS), with the time required for hydrolysis decreasing from several years to approximately 2 months (Martin, 2011). Ethylene glycol and bromide ions are major products of the hydrolysis reactions. Although this approach showed promise, it was not tried in the field.

CB&I (formerly Shaw Environmental) conducted laboratory and field work to develop a biodegradation technique using indigenous bacteria. The objective of this project was to evaluate options to enhance the aerobic degradation of EDB in groundwater, with a particular focus on possible *in-situ* remediation (CB&I, 2014). Laboratory studies conducted with aquifer solids and groundwater from the FS-12 plume at JBCC revealed that the addition of ethane gas, nutrients, and oxygen resulted in the rapid biodegradation of EDB, and a culture capable of biodegrading EDB (*Mycobacteriumsphagni* ENV482) was subsequently isolated from the site. Based on the laboratory results, a field-scale *in-situ* groundwater treatment system was designed, installed and operated at JBCC. This system captured a side stream of extracted groundwater from the FS-12 plume (~10 GPM from a 120 GPM extraction well), added ethane gas, oxygen and inorganic nutrients into the extracted side stream, and then recharged the groundwater at an upgradient well, creating an active treatment zone. A series of nested monitoring wells were installed to evaluate system performance. After 4 months of active operation (following a 3 month mixing and equilibration period) EDB concentrations declined from ~0.3µg/L to < 0.02 µg/L, the Massachusetts MCL, in six of the pilot monitoring wells. Moreover, complete consumption of ethane and nutrients occurred throughout the treatment plot. The researcher's concluded that the data indicate that aerobic cometabolism using ethane gas can be a viable option to sustainably treat EDB to below regulatory MCLs in the JBCC aquifer.

D) Review of criteria for changing the current plans.

Two potential alternatives exist for increasing the rate of remediation: in-situ treatment as performed at JBCC or adding additional treatment wells.

- ***Advancements in cleanup technologies and transportation methods***

The recent successful EDB biodegradation tests at JBCC indicate that a similar approach may work at BNL. The contaminant depth (150 – 250 feet below ground surface) and aquifer at JBCC is similar to that at BNL which suggests that the potential for a similar approach working at the BNL site is high.

- ***Changes in standards and regulations for worker, public, and environmental protection***

There has not been a change in the standards for worker, public or environmental protection in the last five years. Although these may change in the future, there is no current activity to change existing limits and regulations.

- ***Environmental impacts***

The EDB levels are currently above the drinking water standards. However, the monitoring data collected over the past ten years suggests that the existing pump and treat system will capture the plume and meet the standards within 4 years. This indicates that further action is not necessary if BNL wishes to operate the system for the additional time.

- ***Public health impacts***

There are no public health impacts from the EDB plume. The contamination is not found in any drinking water wells and there is no exposure to the public. The existing system will prevent EDB from reaching any drinking water well.

- ***Economic impacts***

The current O&M costs for the EDB treatments system, comprised of two wells, a granular activated carbon (GAC) treatment building, and discharge wells consists of two components, rent for the land use and the typical O&M including sampling, testing, change out of the carbon filters and routine maintenance. Rental cost for land access to this treatment system is currently split between two projects and is $85,000 per year for the EDB plume. However, one project will end in 2019 and the EDB remediation will pay the entire rental cost of $165,000 in 2019. Thus, there is strong incentive to complete the project as soon as possible. The annual O&M costs are around $160K. This makes the current operating costs around $245,000 per year. Provided that typical O&M costs remain the same, the annual operating cost will increase to $325,000 in 2019.

A reduction in the time required to remediate the plume could be obtained by installing new treatment wells upgradient of the existing wells and near the building that houses the treatment system. Installation of two extraction and three monitoring wells with the associated connections to power and piping to move the extracted water to the treatment system would cost approximately $272,000. The current GAC treatment system is rated at 400 gpm. Thus, the four wells could operate at 100 gpm without upgrading the system. The existing extraction wells averaged a withdrawal rate of 312 gpm in 2013. Thus, their withdrawal rate and capture zone would need to be reduced. An evaluation of whether a flow rate of 100 gpm from four wells would be sufficient would be needed before proceeding without upgrading the treatment system. If the treatment system needs to be expanded, that would cost approximately $100,000. It is anticipated that the O&M costs would increase by $60,000 per year to handle the two additional extraction wells. Therefore, the additional cost in the first year would be $332,000 with an incremental cost of $60,000 per year after that.

The current plans anticipate being able to stop the treatment system in 2019. To get a positive return on investment would require being able to shut down the treatments system at least 2 years earlier than the existing system. Table 1 shows the costs for the current system and the potential new system over time assuming the new system begins in 2016. Examining the table, a positive return on investment is obtained when the total expenditure for the new system is less than the old system. If the new system is started in 2016 this would mean that the system would need to be shut off in 2017. From Table 1, the cost of operating the existing system through 2019 is $980,000 while the cost of operating the new system to 2017 is $882,000. If the project slips such that shutdown occurs after 2019 the results are the same and the new treatment system would need to bring the shut down time to two years earlier than with the current system, however the economic advantage of the new system decreases over time due to the increased O&M costs ($60,000 per year) for the additional wells. Eventually, the new system would have to allow shut down more than 2 years earlier to account for these costs as seen by comparing the costs of the existing system in 2023 ($2,228,000) to those of the new system in 2021 ($2,226,200).

Table 1 Projected costs for existing and new treatment systems for EDB plume

	Total Cost ($1000)	
Year	**Existing**	**2 new wells**
2016	$245	$577
2017	$490	$882
2018	$735	$1,187
2019	$980	$1,492
2020	$1,305	$1,877
2021	$1,630	$2,262
2022	$1,955	$2,647
2023	$2,280	$3,032

A detailed analysis of the potential reduction in the operational period would be needed to verify that the additional wells could lead to a two year reduction. Considering that the expected operational period is only until 2019 and the marginal savings (~$100,000) if everything went as planned and that improvements to the treatment center were not needed, it is hard to justify the addition of two new treatment wells.

The approach at JBCC shows great promise. However, it has not been tested at BNL and there is some uncertainty as to its effectiveness at BNL. The in-situ treatment would require research to identify native bacteria to use for the bioremediation, a test demonstration, and additional wells. Prior to attempting an enhanced biodegradation system, similar to the test at JBCC, the costs of such an approach need to be considered. The pilot test at JBCC cost $560,000. Additional costs would be incurred for the nutrients and additional operation and maintenance (O&M) that would be required for the additional wells. Given the anticipated time frame until the current system is predicted to meet cleanup goals (2019) the costs for proof of principle at BNL and additional risk of the in-situ treatment not performing as desired this approach is not cost-effective for BNL.

Conclusion

The existing treatment system is successfully capturing the EDB plume, however at a slower rate than originally anticipated. Two treatment options, enhanced in-situ biodegradation or adding new treatment wells, could reduce the amount of time required to reduce the EDB concentrations below the drinking water standard of 0.05 μg/L in the aquifer. It appears that that the current approach is the most cost effective in meeting the cleanup goals. This will be reviewed in five years if the EDB plume remains a concern.

References

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Memo

date: *October 1, 2015*
to: *Bill Dorsch*
from: *Terry Sullivan*
subject: *High Flux Beam Reactor (HFBR) Review*

1) Introduction

As part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Environmental Protection Agency (EPA) requires a review of Brookhaven National Laboratory's (BNL) environmental remediation efforts on a five year cycle. As part of this review an evaluation of the remediation of the High Flux Beam Reactor (HFBR) is required (BNL, 2009). The 2007 High Flux Beam Reactor (HFBR) Feasibility Study (FS) provided several options for decontamination and decommissioning (D&D) of the HFBR (BNL, 2007). The cleanup alternative that best balances the National Contingency Plan's remedy selection criteria was Phased Decontamination and Dismantlement with Near-Term Control Rod Blade Removal. This alternative is known as Alternative C in the Proposed Remedial Action Plan. The selected remedy involves land use and institutional controls (LUICs) to protect the site and surveillance and maintenance (S&M) to allow radioactive decay to reduce the dose rates to levels that minimize risk to workers and minimize costs associated with D&D.

The Record of Decision (ROD) states that the Department of Energy will conduct five-year technical reviews of the remedy in accordance with DOE five-year review guidance to determine the feasibility of reducing the safe storage (decay) period and completing the HFBR cleanup earlier taking into consideration the following factors (BNL, 2009):

- Advancements in cleanup technologies and transportation methods
- Availability of waste disposal facilities
- Changes in standards and regulations for worker, public, and environmental protection
- Worker safety impacts
- Environmental impacts
- Public health impacts
- Economic impacts
- Land use
- Existing stabilization and safety of the facility and hazardous materials
- Projected future stability and safety of the facility and hazardous materials

If this technical review identifies a remediation method that demonstrates the potential to be implemented before the selected decay period ends while showing substantial improvements to the above criteria, analysis of that potential method will be initiated and possibly implemented.

2) Review of Remedy Selection

In 2007 the estimated inventory of the HFBR complex was 65,000 Curies and the peak dose rate from the most activated component was close to 1000 Rem/hr at a distance of one foot in air. The most radioactive components were the thermal shield, control rod blades, and reactor internals. The activated components are large and would require cutting to fit into transportation casks. The initially high dose rate would make handling of the activated components difficult and would require cutting operations to be performed under water to provide shielding. The nuclear industry standard to separate a high radiation area from a radiation area is a dose rate 100 mrem/hr at 1 foot in air. For this reason, a dose rate of 100 mrem/hr was chosen as the level to begin dismantlement of the reactor components if a long storage period was selected. Figure 1 shows the predicted dose rate at 1 foot from the major reactor components over time. The dose rate from the highest activity component will decrease below 100 mrem/hr in 2072.

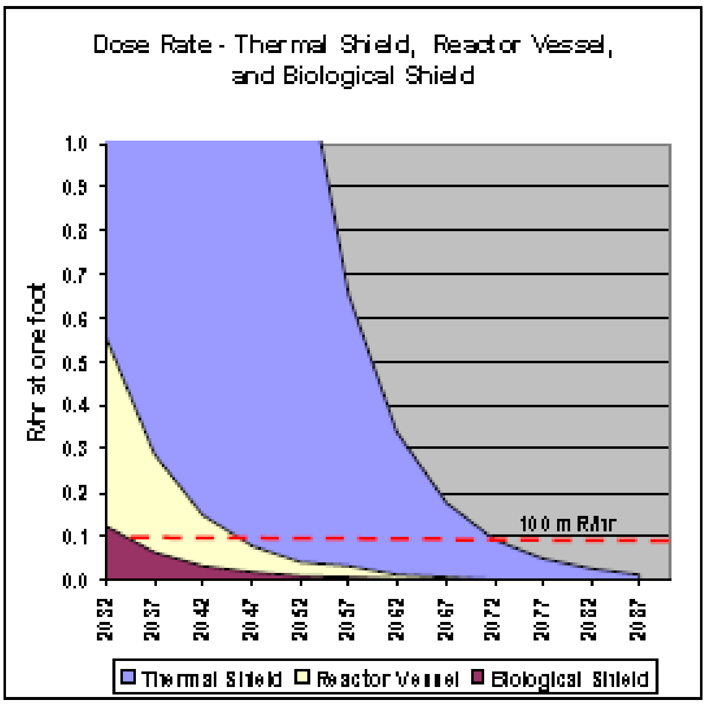

Figure 1 Predicted dose rate in various components in 2032 - 2087.

In the Feasibility Study four potential remediation approaches were considered:

a) ***No Additional Action*** would include those actions already completed. Alternative A would also include the continuation of S&M and the use of LUICs for an indefinite period of time to ensure the protection of human health and the environment.

b) ***Phased Decontamination and Dismantlement*** would include the near-term removal, by Fiscal Year (FY) 2020, of the HFBR ancillary structures as described in Section 1.2, contaminated underground duct and piping systems, and small areas of contaminated soil outside the confinement building footprint. The activated components would remain in place inside the confinement building for a decay period not to exceed 65 years to allow for the natural decay of these high dose rate radioactive components. At the conclusion of this radioactive decay period, the balance of the HFBR complex would be dismantled and removed. This alternative provides for the complete removal of the HFBR complex with the possible exception of the subsurface concrete structures of the confinement building base mat and stack foundation. However, the final decision to leave either of these sub-structures in place will be determined on the basis of radiological sampling and dose assessment. Alternative B would also include the continuation of S&M and the use of LUICs throughout the period of radioactive decay to ensure the protection of human health and the environment. The cleanup, after dismantlement of the confinement building, would satisfy the dose-based cleanup goal of 15 mrem/year and methodology specified in the Operable Unit I (OU I) ROD. After dismantlement, there will be no need for any additional period of LUICs.

c) ***Phased Decontamination and Dismantlement With Near-Term Control Rod Blade Removal,*** consists of the same actions as those included in Alternative B. Alternative C results in the same end state as that of Alternative B, the complete removal of the HFBR complex. The difference is limited to the timing of the decontamination and dismantlement activities. Alternative C would include the near-term removal of the HFBR ancillary structures, contaminated underground duct and piping systems, and small areas of contaminated soil. Alternative C also includes the near-term removal, transportation, and disposal of the CRBs and beam plugs by FY 2020.

d) ***Near-Term Decontamination and Dismantlement,*** includes the complete near-term removal of the HFBR complex by FY 2026.

Alternative C was selected as the Selected Alternative, This plan removes the control rods and beam plugs by 2020, stores the remaining reactor structure and activated components for 65 years (until 2073) and removes the remaining equipment at that time.

3) Actions to Date

After the reactor shutdown in 1998 BNL has made significant efforts to remove and dispose of contaminated components, structures, water, and soil at the HFBR complex. These include:

- The spent fuel was removed and sent to an off-site facility (1998).
- The primary coolant (heavy water) was removed and sent to an off-site facility (2001). Scientific equipment was removed and is being reused or has been sent to an off-site disposal facility (2003).
- Shielding and chemicals were removed and are being reused at BNL and other facilities (2000--2005).
- The cooling tower superstructure was dismantled and disposed of as waste in 1999.
- The confinement structure and spent fuel canal were modified to meet Suffolk County Article 12 requirements (2004).
- Stack monitoring facility (Building 715) was dismantled and removed (2006).
- Cooling tower basin and pump/switchgear house (Buildings 707/707A) were dismantled and removed (2006).
- Water treatment house (Building 707B) was dismantled and removed (2006).

- Cold neutron facility (Building 751) contaminated systems were removed and the clean building has been transferred to another BNL site organization for re-use (2006).
- Guard house (Building 753) was dismantled and removed (2006).
- Cleanup of the Waste Loading Area and removal of Building 801-811 waste transfer lines (A/B waste lines with co-located piping) and associated soil were completed and documented in completion/closeout reports (2009).
- Stabilization activities for the HFBR confinement building (Building 750) were completed (2009 – 2010).
- Control rod blades and beam plugs were removed and disposed (2009).
- The HFBR underground utilities and associated contaminated soils were removed and disposed. (2010).
- Final Status Survey (FSS) and Independent Verification Survey (IVS) were completed for HFBR outside Areas (2010).
- The Fan Houses (Buildings 704 & 802) were dismantled, the associated contaminated soil was removed and project wastes were disposed (2010 – 2011).

In addition to removal actions the HFBR operates with Land Use and Institutional Controls to prevent unintended access to the site and routine surveillance and maintenance (S&M).

HFBR Land Use and Institutional Controls (LUICs)
The HFBR remedy includes the continued implementation of LUICs in accordance with the LUCMP.
These include:

- Measures for controlling future excavation and other actions that could otherwise disturb residual subsurface contamination.
- Land use restrictions and an acceptable method for evaluating potential impact that the remaining contaminants have on future development.

Periodic certification to EPA and NYSDEC stating that the institutional and engineering controls put in place are unchanged from the previous certification, and that nothing has occurred that would impair the ability of the control to protect public health or the environment or constitute a violation or failure to comply with the site management plan.

HFBR System Operations/O&M
Long-term S&M activities are being conducted in accordance with the *Long-Term Surveillance and Maintenance Plan for the HFBR (BNL 2010a*) to ensure effectiveness of the remedy. The BNL LUCMP contains site wide control measures and land-use restrictions to prevent exposure to environmental contamination and to protect the integrity of remedies specified within the ROD.

4) Review of Improvements in Decontamination Techniques and Decommissioning Activity

Decommissioning of nuclear reactors is primarily a deconstruction project. As such the field is mature and the technologies for cutting, scabbling, and other surface removal processes have been used for many years. In communications with Larry Boing, Decommissioning Subject Matter Expert at Argonne National Laboratory, he said the major advances have been in cutting and scabbling tools using pressurized liquid nitrogen. The advantages of these tools are that they can be remote operated, have a high efficiency (>95%) waste collection, they do not use chemicals, do not produce a secondary waste stream, and do minimal damage to the surface. The operating speed for cutting or scabbling is better than conventional techniques. The equipment has been hardened to allow use in a nuclear facility. The main disadvantage of the system is expense. For large jobs, the increased operating rates can lead to cost savings. While this tool is an improvement over existing tools, it cannot be used underwater as would be required for the activated components of the HFBR. Mr Boing stated that there has not been any major improvement in underwater cutting techniques in the last five years.

Long term storage of nuclear facilities prior to dismantlement and decommissioning is a common practice in the U.S. commercial sector. Currently three power plants are undergoing decommissioning while twelve plants are in long-term storage. A major concern with commercial power plants is that there is no disposal pathway for spent fuel. This causes all of the power plants to develop an Independent Spent Fuel Storage Installation (ISFSI). The ISFSI are often a cause for public concern as the facility becomes a defacto spent fuel storage facility. Vermont Yankee Nuclear power plant stopped operations in December 2014 planning for long term storage before decommissioning. The potential presence of the ISFSI has led to major public concerns and the local community is trying to find a way to make the site owners remove the fuel from the site.

Savannah River has used an entombment process for decommissioning their nuclear reactors. In this approach, all below grade piping is filled with concrete and left in place. The reactor fuel is removed and the remaining core structure is also filled with concrete. Above grade equipment is removed from the building. This technique reduces the decommissioning costs by a factor of about 4. However, the entombed reactors are effectively low-level waste disposal sites, which are not allowed in New York State.

At the DOE Hanford site they have used the process of “cocooning” for interim safe storage (ISS) before decommissioning. Cocooning is the process of demolishing all but the shield walls surrounding the reactor core, removing or stabilizing all loose contamination within the facility, and placing a new roof on the remaining structure. A single doorway in the structure is installed to provide access for surveillance and maintenance work. This doorway is welded shut, and all other openings in the shield walls are sealed to prevent intrusions and the release of radioactive materials. The facility is inspected every five years and remotely monitored at all times for changes in moisture and temperature. Cocooning was chosen at Hanford to reduce the foot print and remove any concerns with the concrete buildings built in the 1940’s and early 1950’s. The structural stability of the HFBR hemispherical dome is sound and removal of the dome is problematic as compared to the rectangular walls for the Hanford Reactors. The eight reactors at the Hanford site were originally supposed to undergo safe storage for 75 years prior to a one-piece removal action and disposal at the Hanford site. The original cost estimates for this approach were much less than for dismantlement and disposal. Experience in the one-piece removal of two other reactors showed that the costs were more expensive than originally estimated and costs are comparable to the dismantlement and disposal approach. Therefore, the Hanford site has received agreement to consider dismantlement and disposal within 20 years. At this time, it is still planned to store the reactors for 75 years.

D) Review of DOE requirements for changing the current plans.

- ***Advancements in cleanup technologies and transportation methods***

Removal of the reactor and its components would require underwater cutting for size reduction to fit into shipping containers. There have been no major advances in this field in the past several years. However, operating experience has improved and the process has become more efficient in minimizing cloudiness in the water due to cutting debris.

- ***Availability of waste disposal facilities***

The availability of waste disposal facilities has not changed. This option is likely to remain available in the future. The larger more radioactive pieces of waste will be disposed of at a DOE facility. Smaller less radioactive waste may be disposed of at a commercial facility. The country needs at least one commercial facility to handle medical wastes and wastes from nuclear power plants. Therefore, commercial capacity is likely to be available in the future.

- ***Changes in standards and regulations for worker, public, and environmental protection***

There has not been a change in the standards for worker, public or environmental protection in the last five years. Although these may change in the future, there is no current activity to change existing limits and regulations. There has been activity to revise 10 CFR part 61, the Nuclear Regulatory Commission's, regulations for low-level waste disposal. The proposed changes primarily address waste acceptance criteria and the time period for performance assessment. Protective limits in the proposed revised standard are unchanged.

- ***Worker safety impacts***

The current concept for storage until 2073 is more protective of the worker than removal at an earlier time. Earlier removal will cause higher worker dose and risk.

- ***Environmental impacts***

The activated materials are contained within the HFBR structure and do not provide an immediate environmental risk. To confirm that the storage process does not degrade the environment, an active Surveillance and Maintenance (S&M) program monitors for groundwater contamination from the building. Periodic inspections of the building interior are performed to confirm there is no water intrusion and that major degradation of the reactor structure is not occurring.

- ***Public health impacts***

There are no public health impacts from the long-term storage of the HFBR. Over 99% of the radioactivity is in the activated components of the reactor. These components are encased in the biological shield which is made of eight feet of steel reinforced concrete. There are several physical barriers to the site that prevent access of the public to the areas of contamination. The S&M program monitors the air, soil, and groundwater around the HFBR to confirm that release is not occurring and that the public is not impacted.

- ***Economic impacts***

The FS examined costs for each remedial option. The option to remove all of the components by the year 2025 was $205M, while the cost for the selected alternative was $144 M. The selected alternative involved removing the beam plugs and storing the reactor for 65 years. This storage time allows for substantial radioactive decay that leads to reductions in worker dose, shipping costs, and disposal costs.

- ***Land use***

The HFBR is located within BNL boundaries. BNL is a DOE research facility and is expected to remain so for the foreseeable future. Access to the BNL site is restricted and controlled. The use of this land for safe storage does not impact other operations at BNL. BNL has adequate land to expand as research and operational needs dictate and the long-term storage at the HFBR facility is not an issue.

- ***Existing stabilization and safety of the facility and hazardous materials***

The existing facility is stable and undergoes a routine surveillance and maintenance plan. The air, soil, and groundwater around the facility are monitored to make sure that releases of hazardous or radioactive materials are not occurring.

- ***Projected future stability and safety of the facility and hazardous materials***

Access to the site is controlled. The facility will be maintained following the agreed upon Surveillance and Maintenance Plan. If conditions change in the future actions will be taken to ensure the stability of the facility.

Additional reasons that could lead to a reduction in the storage time include:

a) The desire by DOE to reduce institutional risks at an earlier time
b) Concerns over the stability of the HFBR facility, and
c) Discovering that the initial estimates of radioactivity remaining in the structure are biased high. The original estimates were based on calculations that require a detailed operational history and knowledge of the exact composition of the radiological components. The calculated estimates are then compared with the measured radiation field and refined if there is not good agreement.

The original determination by DOE was that the additional cost (>$50 million) for earlier removal was not sufficient to select to remove the equipment sooner to reduce institutional risks at an earlier date. Additionally, worker risks would increase with earlier removal and this is not desireable.

At the current time, there is little public pressure to remove the reactor components at an earlier time. The facility has controlled access and is monitored for releases of radioactive material and undergoes an active surveillance and maintenance program. Any issues must be reported to federal and state regulators.

As part of the surveillance plan, measurements of the radioactivity level in the reactor core are made every five years (BNL, 2012). Dose rate measurements were made in 2009 during the Control Rod Blade removal process (BNL, 2010). The measured values were within the expected range based on calculations. Additionally, radiation measurements were made of the control rod blades and end plugs when they were removed in 2009. The control rod blades contained two parts, the main control rod blade and the auxiliary control rod blade. Predicted dose rates were within 1% on the main control rod blade and 8% on the auxiliary control rod blade. This agreement suggests that the selected decay period is appropriate.

Radiation measurements of the V-14 port were conducted in 2010 and 2015 as a means to confirm that radioactive decay is occurring at the modeled rate. The V-14 port is at the top of the reactor vessel. An AMP-100 probe is lowered into the port to depths of 2, 4, and 10 feet. The measured radiation dose is recorded at each level and provided in Table 1.

Table 1 Measured radiation doses at the V-14 port.

Depth (ft)	Dose (mr/hr) Sample Date (6/29/2010)	Dose (mr/hr) Sample Date (6/3/15)
2	0	0
4	2	3
10	12	6

Characterization and modeling suggest that the gamma dose measured by the probe is primarily from Co-60 with a 5.27 year half-life. Thus, it is expected that the dose will decrease by approximately a factor of 2 in the five years between measurements. The reading at 10 feet does show a factor of two decrease as expected. The reading at 4 feet shows an increase in dose between 2010 and 2015. This is likely due to measurement error as the inventory of radioactivity could not have increased over this time period. Attention should be paid to this reading in subsequent measurements. Additionally, it would be beneficial to report the dose rate to tenths of mr/hr to aid future evaluations of the decay rate. To summarize, the data at ten feet down the V-14 port suggest that decay is occurring as expected and the selected decay period (until 2073) is justified.

Conclusions

Based on the evaluation criteria specified in the ROD (BNL, 2009) and the match between the predicted and measured dose rates there is no reason to alter the current remedial action plan. This will be reviewed in five years.

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Memo

date: *October 1, 2015*

to: *Bill Dorsch*

from: *Terry Sullivan*

subject: *Review of Changes in the Soil Cleanup and Drinking Standards*

Background

Brookhaven National Laboratory as part of its remediation strategy sets cleanup goals based on New York State and the U.S. Environmental Protection Agency (EPA) guidance for soil and groundwater contamination. Nationally, the relevant law is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Regulations establishing ground water quality standards in New York State (NYS) were first passed in 1967. These regulations continue under authority of NYS Environmental Conservation Law and are enforced by DEC. Under NYS law DEC maintains these standards as part of its charge to protect the waters of the state. The NYS water quality standards program is a state program with federal (U.S. EPA) oversight. New York's longstanding water quality standards program predates the federal Clean Water Act and protects both surface waters and groundwaters.

The CERCLA framework includes the expectation that contaminated ground waters will be returned to beneficial uses whenever practicable. Section 121(d) of CERCLA requires on-site remedial actions to attain Maximum Contamination Level Goals (MCLGs) and water quality standards under the Clean Water Act when relevant and appropriate. The National Oil and Hazardous Substances Pollution Contingency Plan clarify that Maximum Concentration Level (MCLs) or non-zero MCLGs established under Safe Drinking Water Act will typically be considered relevant and appropriate cleanup levels for ground waters that are a current or potential source of drinking water. In most cases, the MCLs in the State and Federal laws are identical.

The risk from soil contamination depends strongly on many site-specific parameters such as the exposure pathways and time of exposure. For this reason, soil cleanup levels are determined on a site-specific basis. Guidance on how to calculate site-specific soil cleanup levels is provided by both EPA and NYS.

Groundwater

EPA specifies the MCLs for groundwater contamination in their National Primary Drinking Water Regulations. MCLG and MCL values are provided for microorganisms, disinfectants, disinfectant byproducts, inorganic chemicals, organic chemicals, and radionuclides (http://water.epa.gov/drink/contaminants/index.cfm#List). These primary standards were last updated in May, 2009.

The NYSDEC filed a Notice of Adoption for amendments to the water quality standards regulations (6 NYCRR Parts 700-704) with the New York State Department of State on January 17, 2008. The regulations became effective on February 16, 2008 (30 days after filing). The latest amendment to the NYS water quality standards regulations (6 NYCRR Parts 700-706) (http://www.dec.ny.gov/chemical/23853.html) includes new Health (Water Source) standards for metolachlor, acetaldehyde, formaldehyde, and carbon disulfide; a new aquatic life standard for ammonia (marine waters); a revised standard for dissolved oxygen for most marine waters; new or revised groundwater effluent limitations; and a new narrative standard for flow for all fresh waters (http://www.dec.ny.gov/chemical/27985.html). The MCLs are covered in Section 703.5, Table 1 of the standard and can be found at: https://govt.westlaw.com/nycrr/Document/I4ed90418cd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).

New York State water quality standards regulations are currently being revised. The key components being considered for revision can be found at (**http://www.dec.ny.gov/chemical/86605.html**) and include potential revisions to the MCL values found in Table 1 of Section 703.5.

There are differences in the treatment of radionuclides between EPA and NYS. EPA Guidance on radionuclide limits are based on a total effective dose equivalent of 15 mrem/yr (EPA, 1997) with a maximum of 4 mrem/yr from groundwater. New York State uses the maximum dose to any organ to set MCLs for radionuclides. This leads to a more stringent value than in the EPA approach for Sr-90 due to the affinity for strontium to enter the bones.

Table 1 Comparison of EPA and NYS MCL values for radionuclides.

Radionuclide	EPA MCL	NYS MCL	Comments
Gross Beta emitters*	4 mrem/yr	1000 pCi/L	NYS excludes Strontium and alpha emitters.
Gross alpha	15 pCi/L	15 pCi/L	Excludes Uranium and Radium/Radon
Gross photon* emitters	4 mrem/yr		
Uranium	30 µg/L	5000 µg/L	NYS applies only to Uranyl ion.
Sr-90	N/A	8 pCi/L	EPA regulated under the gross beta emitter category.
H-3	N/A	20,000 pCi/L	EPA regulated under the gross beta emitter category.

* The total dose from all Beta/photon emitters must be less than 4 mrem/yr. A total of 168 individual beta particle and photon emitters may be used to calculate compliance with the MCL.
Gross alpha 15 pCi/L, excluding Radon and Uranium
Gross Beta 1000 pCi/L, excluding Sr-90 and alpha emitters
Strontium 8 pCi/L. If two or more radionuclides are present, the sum of their doses shall not exceed an annual potential dose of 4 mrem/yr.

Soils

Soil cleanup levels are determined on a site-specific risk based analysis. EPA provides guidance on how to calculate soil cleanup levels (U.S. EPA, 1996a; 1996 b). NYS updated their cleanup guidance in 2010 with a DEC policy, CP-51, Soil Cleanup Guidance (http://www.dec.ny.gov/docs/remediation_hudson_pdf/cpsoil.pdf) . Both approaches provide a uniform and consistent process to determine soil cleanup levels. Tables 1 - 3 of CP-51 provide generic cleanup levels for different types of contamination. Table 1 provides Supplemental Soil Cleanup Objectives for metals, pesticides, semi-volatile organic compounds, and volatile organic compounds. Tables 2 and 3 provide Soil cleanup Levels for Gasoline (Table 2) and Fuel Oil (Table 3) contaminated soils.

New York State guidance for radioactively contaminated soils can be found in Cleanup Guidelines for Soils Contaminated with Radioactive Materials (DER-38) (http://www.dec.ny.gov/regulations/23472.html). The NYS policy, last updated in April 2013, limits the total effective dose equivalent to the maximally exposed individual of the general public, from radioactive material remaining at a site after cleanup, shall be as low as reasonably achievable and less than 10 mrem above that received from background levels of radiation in any one year. The 10 mrem standard has not been changed from previous guidance.

The radiation dose received from an exposure to soils contaminated by radionuclides will strongly depend on the time of exposure and pathways by which the radionuclides or their decay products can come in contact with an individual. For this reason, the estimated annual dose resulting from exposure to any residual radionuclides in the contaminated area is the basis for establishing site-specific cleanup criteria.

Summary

There have been no substantial changes to the regulations since 2010. Groundwater MCL values were last updated in 2008 (NYS) and 2009 (EPA). Guidance for radioactively contaminated soils has been issued in 2013 (NYS) but the dose limit that was used to set BNL cleanup levels has not changed.

References

U.S. EPA. 1996a. *Soil Screening Guidance: User's Guide*, Office of Emergency and Remedial Response, Washington, DC. EPA/540/R-96/018. NTIS PB96-963505.

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U.S. EPA. 1997, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, Office of Emergency and Remedial Response, Offic of Radiation and Indoor Air, Washington, D.C., OSWER No 9200.4-18.

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Attachment 6

Operable Unit Cleanup Levels Matrix

Attachment 6
Operable Unit Cleanup Levels Matrix

OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
		Residential	Industrial			
I	Cesium-137	23 pCi/g	67 pCi/g			Prevent or minimize: 1. Leaching of contaminants from soil into groundwater, 2. Human exposure from surface and subsurface soil, 3. Uptake to ecological receptors. Rad soil cleanup levels are based on 15 mRem/year above background. The State ALARA goal is 10 mRem/year above background.
	Strontium-90	15 pCi/g	15 pCi/g	8 pCi/L		
	Radium-226	5 pCi/g	5 pCi/g			
	Lead	400 mg/kg				
	Mercury	1.84 mg/kg				
	1,2-Dichloroethane			5 µg/L		
	Chloroethane			5 µg/L		
II	Cesium-137	23 pCi/g	67 pCi/g			Documented in the OU I and III RODs.
	Tritium			20,000 pCi/L		
	Sodium-22			400 pCi/L		
III	1,1,1-Trichloroethane			5 µg/L		1. Meet MCLs for VOCs and tritium in Upper Glacial aquifer within 30 years, 2. Meet MCLs for VOCs in Magothy aquifer within 65 years, 3. Meet MCLs for Sr-90 in Upper Glacial aquifer within 40 years and 70 years at Chemical Holes and BGRR/WCF plumes, respectively.
	Tetrachloroethylene			5 µg/L		
	Carbon tetrachloride			5 µg/L		
	Tritium			20,000 pCi/L		
	Strontium-90			8 pCi/L		
	PCBs	1 mg/kg - Surface NYSDEC TAGM	10 mg/kg - Subsurf. NYSDEC TAGM			
IV	Ethylbenzene			5 µg/L		Restore groundwater quality to MCLs or background, and prevent or minimize: 1. Leaching of contaminants from soil into groundwater, 2. Human exposure from surface and subsurface soil, 3, Uptake of contaminants in soil by plants and animals.
	Toluene			5 µg/L		
	Strontium-90			8 pCi/L		

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OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
V	Mercury	2 mg/kg				Protect public health and the sole-source aquifer, monitor the groundwater, and prevent or minimize: 1. Migration of contaminants present in surface soil via surface runoff, 2. Human and environmental exposure from surface and subsurface soil, 3. Reduce site-related contaminants (e.g., mercury) in sediment to levels that are protective of human health, 4. Reduce or mitigate, to the extent practicable, existing and potential adverse ecological effects of contaminants in the Peconic River, 5. Prevent or reduce the migration of contaminants off BNL property.
	Cesium-137	23 pCi/g				
	Trichloroethene			5 µg/L		
VI	Ethylene dibromide			0.05 µg/L		1. Meet MCL for EDB in the Upper Glacial aquifer within 30 years, 2. Prevent or minimize further migration of EDB in groundwater vertically and horizontally.
g-2/BLIP	Tritium			20,000 pCi/L		1. Prevent additional rainwater infiltration into activated soil shielding, 2. Inspect and maintain the caps and other stormwater controls at the source areas, 3. Conduct groundwater monitoring to verify the effectiveness of the stormwater controls, and monitor the downgradient portion of the g-2 plume until tritium concentrations decrease to below the MCL.

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Operable Unit Cleanup Levels Matrix

OU	Contaminants of Concern	Cleanup Levels			Note any Changes to Cleanup Levels	Remedial Action Objectives
		Soil		Groundwater		
BGRR	Strontium-90	ALARA (1)	ALARA	8 pCi/L		1. Ensure protection of human health and the environment from the potential hazards posed by the radiological inventory that resides in the BGRR complex, 2. Use ALARA while implementing the remedial action, 3. Implement long-term monitoring, maintenance, and institutional controls to manage potential hazards.
	Cesium-137	ALARA	ALARA			
HFBR	Strontium-90	15 pCi/g	15 pCi/g	8 pCi/L		1. Control, minimize, or eliminate:1. All routes of future human and/or environmental exposure to radiologically contaminated facilities or materials, 2. The potential for future release of non-fixed radiological or chemical contamination to the environmen, 3. All routes of future human and/or environmental exposure to contaminated soils, and 4. The future potential for contaminated soils to impact groundwater.
	Cesium-137	23 pCi/g	67 pCi/g for WLA			

Notes:
pCi/g = picocuries per gram
pCi/L = picocuries per liter
mg/kg = milligrams per kilogram
µg/L = micrograms per liter
TAGM = Technical and Administrative Guidance Memorandum
BLIP = Brookhaven Linac Isotope Producer
BGRR = Brookhaven Graphite Research Reactor
HFBR = High Flux Beam Reactor
ALARA = As Low as Reasonably Achievable
OU = Operable Unit
WLA = Waste Loading Area
MCL = Maximum Contaminant Level
EDB = Ethylene dibromide
VOC = Volatile Organic Compound
ROD = Record of Decision
WCF = Waste Concentration Facility