FINAL
COMPLETION REPORT

High Flux Beam Reactor
Waste Loading Area
Area of Concern 31
Soil Remediation

Brookhaven National Laboratory
Upton, New York

July 2009

Prepared for:
Brookhaven Science Associates, LLC
Building No. 460
Upton, NY 11973
Prime Contract No. DE-AC02-98CH10886

Prepared By:
P.W. Grosser Consulting, Inc.

Executive Summary

The Waste Loading Area (WLA) was part of the former Hazardous Waste Management Facility (HWMF), Area of Concern (AOC) 1. It is an area (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 Brookhaven Graphite Research Reactor (BGRR) and High Flux Beam Reactor (HFBR) Projects.

The former HWMF was used during the period between 1947 and 1997 as the central receiving facility for storage, processing and limited treatment of waste generated at Brookhaven National Laboratory (BNL). Soil contamination at the former HWMF resulted from spills during past waste handling operations.

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 authorized by the *Action Memorandum, High Flux Beam Reactor, Removal Action for Waste Loading Area*. The cleanup of this area used the same cleanup goals and methodology required for AOC 1 in the Operable Unit (OU) I Record of Decision (ROD).

The soil cleanup objectives for radiological contamination were based on a dose, from remaining concentrations of all radionuclides present, of 15 millirem per year (mrem/year) above background considering 50 years of institutional control for industrial land use, per a Residual Radioactivity Computer Code (RESRAD). The cleanup objective also was based on a 15 millirem per year dose to a future resident after 100 years of institutional control.

Soil remediation activities at the WLA commenced in November, 2007 and were completed in May 2008. The following summarizes the as-left conditions at the WLA and how they satisfy the requirements of the OU I ROD:

- The average Cs-137, Sr-90 and Ra-226 concentrations following remediation are 11.4 picocurie per gram (pCi/g), 0.55 pCi/g and 0.64 pCi/g, respectively. The as-left average concentrations are well below the site cleanup goals (Cs-137=67 pCi/g, Sr-90=15 pCi/g and Ra-226=5pCi/g). The maximum concentrations for any survey unit were as follows: 61.3 pCi/g Cs-137, 4.0 pCi/g Sr-90, and 1.0 pCi/g Ra-226.

- Chemical results for soil samples analyzed for mercury and lead also indicated that residual soil concentrations for these contaminants are within the respective

cleanup goals for these contaminants, i.e., 400 mg/kg for lead and 1.84 mg/kg for mercury.

- The maximum projected dose to an industrial worker after 50 years of institutional controls is 3.8 millirem/yr. The maximum projected dose to a resident (non-farmer) after 100 years of institutional controls is 8.9 millirem/yr. The results of the dose assessment are below the dose objective of 15 millirem/yr established by the OU I ROD and the New York State Department of Environmental Conservation (NYSDEC) Technical and Administrative Guidance Memorandum (TAGM) 4003 guideline of 10 millirem/yr.

- Site restoration was completed at the WLA using materials that met NYSDEC TAGM 4046 guidelines. Restoration included backfilling, re-grading, the placement of topsoil and reseeding the site with Long Island native grasses.

The WLA meets all the completion requirements as specified in Office of Solid Waste and Emergency Response (OSWER) Directive 9320.2-09-A-P, *Closeout Procedures for National Priorities List Sites.* Post remediation operation and maintenance activities at the WLA will be performed by BNL's Groundwater Protection (formerly Long Term Response Action) Group to ensure that land uses remain protective of public health and the environment. These activities will include inspections of site fencing and institutional controls (signs, entry and access restrictions, land-use and real controls, notifications and restrictions, work planning controls such as digging permits, and government ownership). The clean fill and topsoil cover, placed during site restoration, will also be inspected for signs of erosion.

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1.0 INTRODUCTION 1

1.1 PURPOSE 1
1.2 SITE HISTORY AND REGULATORY FRAMEWORK 2
1.3 FORMER HWMF AND WASTE LOADING AREA 3
1.4 REMEDIAL INVESTIGATION/FEASIBILITY STUDY/SUPPLEMENTAL INVESTIGATION 5
1.5 RELATIONSHIP BETWEEN WLA AND THE FORMER HWMF - AOC I 6

2.0 SITE BACKGROUND 8

2.1 SITE CLEANUP CRITERIA 9
2.2 DESIGN CRITERIA 9
2.3 COMMUNITY RELATIONS ACTIVITIES 10

3.0 CONSTRUCTION ACTIVITIES AND CONTROLS 12

INDUSTRIAL HYGIENE OVERSIGHT 13
RADIOLOGICAL MONITORING 13
3.1 SOIL EXCAVATION 15
3.2 FINAL STATUS SURVEY AND SAMPLING 18
3.2.1 Final Status Survey Design 19
3.2.2 Final Status Survey and Sampling Results 19
3.2.3 Post Remediation Dose Assessment 22
3.2.4 Final Status Survey Conclusions 23
3.2.5 Final Status Survey Independent Verification 23
3.3 WASTE MANAGEMENT 23
3.3.1 Waste Characterization and Handling 23
3.3.2 Waste Shipment and Disposal 24
3.3.3 Pollution Prevention and Waste Minimization Opportunities 25
3.5 SITE RESTORATION 25

4.0 PERFORMANCE STANDARDS AND CONSTRUCTION QUALITY CONTROL 27

5.0 FINAL INSPECTION AND CERTIFICATIONS 28

6.0 OPERATION AND MAINTENANCE ACTIVITES 29

7.0 PROTECTIVENESS 30

8.0 FIVE YEAR REVIEW 31

9.0 LESSONS LEARNED 32

10.0 SUMMARY OF PROJECT COSTS 33

FIGURES

Figure 1-1: Location of Brookhaven National Laboratory
Figure 1-2: Former HWMF Location
Figure 3-1: WLA Pre-Remediation Radiological Walkover Survey Results
Figure 3-2: WLA FSS Survey Units and Soil Sample Locations
Figure 3-3: WLA Post-Remediation Radiological Walkover Survey Results

TABLES

Table 3-1: Summary of WLA Soil Sample Results for Radionuclides
Table 3-2: Summary of Post Remediation Dose Assessment Results

PHOTOGRAPHS

Photograph 1: Pre-Excavation Conditions at the WLA
Photograph 2: Soil Removal at the WLA
Photograph 3: Bermed Excavation Area at the WLA
Photograph 4: Loading Debris (construction mat) into Railcar at the WLA
Photograph 5: Site Restoration Activities at the WLA

APPENDICES

Appendix A: Waste Loading Area Final Status Survey Report
Appendix B: Oak Ridge Institute for Science and Education (ORISE) Independent Verification Survey Report for the Waste Loading Area
Appendix C: Summary of Railcar Shipments
Appendix D: ERP Work Procedure ERP-WP-2.18, Revision 5, "Excavate, Load and Ship Soil and Debris from the Waste Loading Area.
Appendix E: RESRAD Dose Assessment Summary Reports
Appendix F: Excerpt from WLA Field Sampling Plan
Appendix G: Waste Loading Area Waste Verification Results

ACRONYM LIST

ALARA	As Low As Reasonably Achievable
AOC	Area of Concern
AOI	Area of Interest
BGRR	Brookhaven Graphite Research Reactor
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CDM	CDM Federal Programs
CPM	Counts Per Minute
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CFR	Code of Federal Regulations
CY	Cubic Yards
DAC-Hr	Derived Air Concentration-Hour
DOE	Department Of Energy
EPA	United States Environmental Protection Agency
ERP	Environmental Restoration Projects
EWMSD	Environmental and Waste Management Services Division
FS	Feasibility Study
FSS	Final Status Survey
GPS	Global Positioning System
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Interagency Agreement
IH	Industrial Hygiene
IT	International Technology Corporation
ISOCS	In Situ Object Counting System
IVS	Independent Verification Survey
JRA	Job Risk Assessment
LUCMP	Land Use Controls Management Plan
M^2	Square Meter
mg/kg	Milligrams per Kilograms
MARSSIM	Multi-Agency Radiological Survey and Site Investigation Manuel
NaI	Sodium Iodide
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
ORISE	Oak Ridge Institute for Science and Education
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PCB	Polychlorinated Biphenyl
pCi/g	Picocuries per Gram
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RCD	Radiological Controls Division
RCT	Radiological Controls Technician

RDIP	Remedial Design Implementation Plan
RESRAD	Residual Radioactivity Computer Code
RI	Remedial Investigation
ROD	Record of Decision
SCDHS	Suffolk County Department of Health Services
SI	Supplemental Investigation
RWP	Radiological Work Permit
SU	Survey Unit
TAGM	Technical and Administrative Guidance Memorandum
TCLP	Toxicity Characteristic Leaching Procedure
TLD	Thermoluminscent Dosimeter
TA	Test America of Earth City, Missouri
UIC	Underground Injection Control
USC	United States Code
UST	Underground Storage Tank
WAC	Waste Acceptance Criteria
WCS	Waste Confirmation Sample
WLA	Waste Loading Area
WP	Work Procedure

1.0 INTRODUCTION

1.1 Purpose

The purpose of this of this completion report is to document the following at the Waste Loading Area (WLA) that was part of the of the former Hazardous Waste Management Facility (HWMF), Area of Concern (AOC) 1 within Operable Unit (OU) 1, Brookhaven National Laboratory (BNL) in accordance with *Closeout Procedures at National Priority List Sites, OSWER Directive 9320.2-09A-P* (EPA, 2000a):

- The excavation of contaminated soil above site cleanup goals;
- The results of the final status survey (FSS) and sampling, including Oak Ridge Institute for Science and Education (ORISE) independent verification survey (IVS) and sampling results;
- The post closure dose assessment in accordance with the Residual Radioactive Materials Computer Code(RESRAD);
- The characterization and disposal of soil and debris at Energy Solutions Disposal Facility of Clive, Utah; and
- Site restoration.

Remedial activities at the WLA were self-performed by BNL's Environmental Restoration Projects (ERP), ERP seconded subcontractors, Brookhaven Science Associates (BSA) Radiological Control Division (RCD) and Environmental and Waste Management Services Division (EWMSD) personnel. Verification sampling was performed by the Oak Ridge Institute for Science and Education (ORISE).

Work was performed in accordance with the OU I ROD and the *Remedial Action Work Plan, Operable Unit I, Area of Concern 1, Former Hazardous Waste Management Facility* (BNL, March 2003). The scope of the soil remediation work was outlined in detail in ERP-Work Procedure (WP)-2.18, *Excavate, Load and Ship Soil and Debris from the WLA, Rev. 5* (Appendix D). The final status survey (FSS) was performed in accordance with ERP-WP-2.21, *Final Status Survey WLA* and the *WLA Field Sampling Plan, Rev. 1* (BNL, 2008d). This remedial work is identified throughout this document as the WLA Soils Removal Project.

Previously completed work at the former HWMF is listed in Section 2.0. The scope of work for the WLA Soils Removal Project included the following:

- Remove radiologically and chemically contaminated soils above prescribed cleanup goals;
- Package on-site, transport, and dispose of radiologically and chemically contaminated soils and debris off-site at a permitted facility;
- Collect and analyze endpoint samples to ensure cleanup goals have been achieved;

- Perform Final Status Surveys;
- Perform site restoration per the BNL project specification documents; and
- Prepare a dose assessment and a completion report.

1.2 Site History and Regulatory Framework

BNL site is located in Suffolk County, New York, and is comprised of approximately 5,320 acres. Approximately 900 acres are developed. The U.S. Army occupied the BNL site, formerly Camp Upton, during World Wars I and II. Between the wars, the Civilian Conservation Corps operated the site. It was transferred to the Atomic Energy Commission in 1947, to the Energy Research and Development Administration in 1975, and to the U.S. DOE in 1977. A map illustrating the location of the BNL site is presented as Figure 1-1.

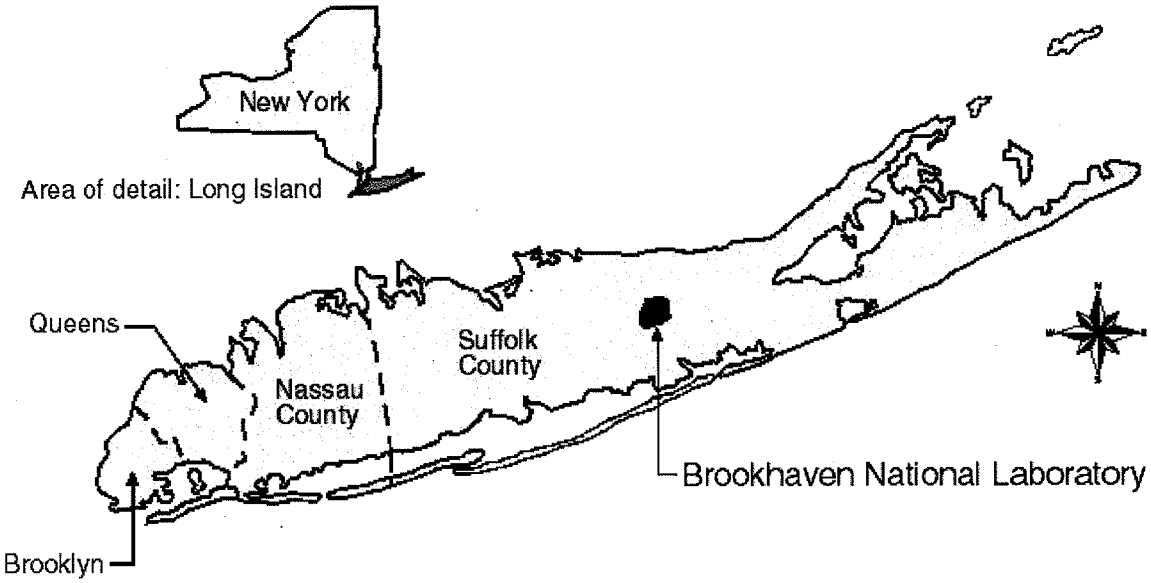


Figure 1-1. Location of Brookhaven National Laboratory

In 1980, the BNL site was placed on New York State's Department of Environmental Conservation (NYSDEC) list of Inactive Hazardous Waste Sites. On December 21, 1989, the BNL site was included on the U.S. Environmental Protection Agency (EPA) National Priorities List because of soil and groundwater contamination that resulted from BNL's past operations. Subsequently, the EPA, NYSDEC, and DOE entered into a Federal Facilities Agreement (herein referred to as the Interagency Agreement; [IAG]) that became effective in May 1992 (Administrative Docket Number: II-CERCLA-FFA-00201) to coordinate the cleanup.

The IAG identified AOCs that were grouped into OUs to be evaluated for response actions. The IAG requires a remedial investigation/feasibility study (RI/FS) for OU I, pursuant to 42 United States Code (USC) 9601 et. seq., to meet Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements. An RI was performed at BNL by CDM Federal Programs (CDM) in 1996 and International

Technology Corp. (IT) in 1999. An FS was prepared by CDM in 1999. These studies are discussed further in Section 1.4.

BNL's *Site Baseline Report* (SAIC, 1992) grouped the identified AOCs into seven OUs; several were subsequently combined. AOC 1 included the remediation of the former HWMF under OU 1. In 2005 two acres of the twelve acre former HWMF were partitioned and designated as the WLA. In February 2009, AOC 31, comprising the HFBR complex and the WLA, was established.

The former HWMF was used from the 1940s to 1997 as the central receiving facility for processing, limited treatment (neutralization), and storage of radioactive waste, hazardous waste, and mixed waste generated at BNL. Several buildings with the former HWMF operated as Resource Conservation and Recovery Act (RCRA) permitted facilities from 1992 until they underwent RCRA closure in 1998.

As a result of several spills of hazardous and radioactive materials during operations at the former HWMF, the soils became contaminated with levels of cesium-137 (Cs-137), strontium-90 (Sr-90), mercury, and lead above cleanup goals established in the OU I ROD. The contaminated soils at the former HWMF were remediated under OU 1.

The cleanup of the WLA was transferred to the HFBR scope of work through a modification to the Remedial Design Implementation Plan (RDIP) for the former HWMF. This transfer was finalized in September 2005, following review and approval/concurrence by the U.S. Environmental Protection Agency (EPA), New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH), and Suffolk County Department of Health Services (SCDHS).

The cleanup of the WLA was performed as a non-time-critical removal action authorized by the *Action Memorandum, High Flux Beam Reactor, Removal Action for Waste Loading Area*. The cleanup of this area used the same cleanup goals and methodology required for AOC 1 in the OU I ROD.

1.3 Former HWMF and Waste Loading Area

The former HWMF was located in the southeastern portion of the BNL site. It comprised about 12 acres, with approximately one-fourth of the FHWMF area being paved. The remaining nine acres was composed of a natural field of grass, weeds and contained buildings. Although not always listed as a separate area, the WLA consisted of 2 acres and was part of the former HWMF, and it contained a rail spur. There is a shallow seasonal ponded wetland, known as the FHWMF wetland, along the fence bordering the western side. This area is designated as a wetland on the National Wetlands Inventory map but is not presently a New York State designated wetland. It was confirmed as a breeding area for the tiger salamander, a New York State endangered species.

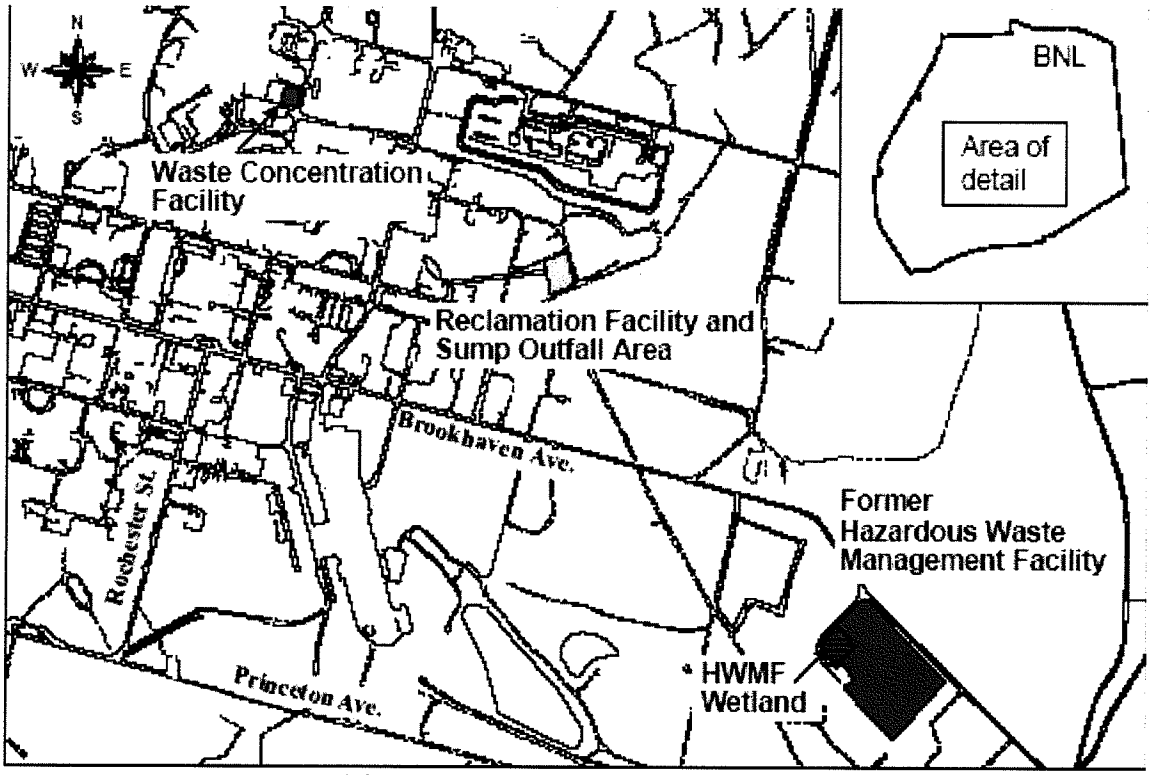


Figure 1-2 Former HWMF Location

There were eight buildings and structures located at the former HWMF that were used for various chemical and/or radioactive operations and storage.

- 444 Building – Old Chemical Building, including incinerator
- 445 Building – Former HWMF Office Building/High Bay Shop
- 446 Building – Radioactive Waste Sorting Barn
- 447 Building – Rigging Shed/Equipment Storage Building
- 448 Building – Chemical Receipt Back Barn (Radioactive/mixed waste storage)
- 483 Building – Chemical Storage Building
- 625 Structure – Detonation Area Viewing Bunker
- Sprung/Tent Structure

Above grades structures and buildings at the former HWMF were removed in 2003. The work is documented in the Former HWMF Decontamination and Decommissioning Closeout Report (BNL, 2003f)

1.4 Remedial Investigation/Feasibility Study/Supplemental Investigation

A Remedial Investigation (RI) was conducted at BNL by CDM in 1996, as documented in *Final Remedial Investigation and Risk Assessment Report for Operable Unit I/VI* (CDM, 1996). A Feasibility Study (FS) was later prepared by CDM, as documented in *Final Feasibility Study Report for Operable Unit I Radiologically Contaminated Soils* (CDM, 1999). The former HWMF (AOC 1) was included in the OU I RI. The RI was performed to evaluate the nature and extent of contamination, as well as the potential risks associated with the AOCs. Several investigative approaches were utilized including radiological surveys, soil/sediment sampling, surface water sampling, and test pits. Baseline chemical and radiological risk assessments were performed as part of the RI Report. A preliminary screening of ecological risks and a focused ecological risk assessment (including an addendum to the focused ecological risks assessment) were also completed.

To further delineate soil, sediment, and asphalt contamination addressed in the RI, BNL also conducted a Supplemental Investigation (SI) at the former HWMF in 2003. Soil, sediment, and asphalt samples were collected based on data gaps and the radiological walkover survey results. Samples were analyzed for gamma emitting isotopes and Sr-90 using a combination of on-site analysis using In Situ Object Counting System (ISOCS) and Beta Scintillation, respectively, and off-site laboratory analysis. In addition, samples were collected and analyzed for Toxicity Characteristic Leaching Procedure (TCLP), alpha isotopes, total lead, and polychlorinated biphenyls (PCBs).

Based on the RI and SI, Cs-137 and Sr-90 were detected in the former HWMF asphalt and soil above the cleanup goals of 67 picocuries per gram (pCi/g) and 15 pCi/g, respectively. Maximum detected concentrations for Cs-137 and Sr-90 were 810,000 pCi/g and 1,300 pCi/g, respectively. Mercury was also detected above the cleanup goal of 1.84 milligrams per kilogram (mg/kg) in soils in the vicinity of an Underground Injection Control (UIC) structure and its associated piping with a maximum concentration of 184 mg/kg. Radionuclides and chemical contaminants that were detected in the former HWMF (but not necessarily in the WLA) are listed in Table 1-1.

Table 1-1 Radionuclides and Chemical Contaminants of Concern in the WLA

Radionuclide or Chemical Contaminant	Preliminary Cleanup Goal	OU I ROD (pCi/g)
Cs-137	67 pCi/g	67
Sr-90	94 pCi/g	**15**
H-3	9.6×10^{15} pCi/g	Not listed
Co-60	3300 pCi/g	Not listed
Ra-226	Not listed	5
Am-241	160 pCi/g	Not listed
Pu-238	274 pCi/g	Not listed
Pu-239	170 pCi/g	Not listed
Pu-240	170 pCi/g	Not listed
U-235	29 pCi/g	Not listed
U-238	36 pCi/g	Not listed
Mercury	1.84 mg/kg	1.84 mg/kg
Lead	400 mg/kg	400 mg/kg

References for Table 1-1 are the FHWMF - OU I/VI RI/RA (BNL, 1996) and the OU I ROD for Radiologically Contaminated Soils (BNL, 1999b). ^{226}Ra is not expected at levels exceeding the cleanup criteria, but it is listed as a radioactive contaminant of concern based on its specific listing in the OU I ROD and guidance from DOE order 5400.5.

The cleanup goals in Table 1-1 are based on future commercial or industrial use of the site, with a period of 50 years of institutional controls

1.5 Relationship between WLA and the Former HWMF - AOC I

The Waste Loading Area was part of the former Hazardous Waste Management Facility, AOC 1 within Operable Unit I.

In 2005, cleanup was performed in the HWMF, and a Final Status Survey was performed in all areas of the HWMF except the WLA. In September of 2005, the cleanup of the WLA was transferred to the HFBR scope of work through a modification to the Remedial Design Implementation Plan (RDIP) for the former HWMF. In November of 2007, the final Action Memorandum was issued for the High Flux Beam Reactor, Removal Action for Waste Loading Area. In February 2009, AOC 31, comprising the HFBR complex and the WLA, was established. The WLA was left in place, so that it could be used as a waste staging and railcar loading area for the BGRR and HFBR

projects. This eliminated the possibility of removing the contaminated soil from this area and potentially re-contaminating it during waste staging and railcar loading operations.

The final remedy for AOC 31 is documented in the HFBR ROD.

2.0 SITE BACKGROUND

The following is a chronology of the main remedial events and the associated plans/reports for the former HWMF and WLA:

- August 1999 - *OU I Record of Decision*
- October 2000 - *Remedial Design and General and Supplemental Specifications for Remedial Action, Operable Unit I Contaminated Soil and Debris*
- 2000-2002 - Aboveground waste in storage removed
- December 2001 - *Decommissioning Plan for the Former Hazardous Waste Management Facility Buildings and Structures*
- July 2002 - *Characterization and Waste Management Plan for the Former Hazardous Waste Management Facility Buildings and Structures*
- 2002 - Characterization field work for the decommissioning of the former HWMF buildings and structures
- March 2003 - *Remedial Action Work Plan, Operable Unit I, Area of Concern 1, Former Hazardous Waste Management Facility*
- April 2003 - *Supplemental Investigation Plan, Former Hazardous Waste Management Facility, Soil, Asphalt, and Debris*
- May 2003 - *Former Hazardous Waste Management Facility Decontamination and Decommissioning Characterization Report*
- June-July 2003 - SI field work
- July-September 2003 - Building decommissioning and decontamination field work, including removal of contaminated asphalt and underground storage tanks (UST)
- September 2003 - *Supplemental Investigation Report, Former Hazardous Waste Management Facility, Soil, Asphalt, and Debris*
- November 2003 - *Former Hazardous Waste Management Facility Decontamination and Decommissioning Closeout Report*
- March 2004 - *Remedial Design Implementation Plan, Operable Unit 1, Area of Concern 1, Former Hazardous Waste Management Facility*
- September 2004–August 2005 - Excavated contaminated soil above cleanup goals, excluding the WLA, and removed contaminated subsurface structures
- March-August 2005 - Performed FSS and IVS in all areas of the former HWMF except for the WLA
- September 2005 - Cleanup of WLA transferred to the HFBR scope of work in through a modification to the Remedial Design Implementation Plan (RDIP) for the former HWMF
- September 2005 – *Former Hazardous Waste Management Facility Soil Remediation Closeout Report*
- November 2007 – Issued final *Action Memorandum, High Flux Beam Reactor, Removal Action for Waste Loading Area*

- November 2007-April 2008 – Excavated contaminated soil above cleanup goals at the WLA
- May 2008 – Performed FSS and IVS of the WLA
- February 2008 - Data Evaluation and Dose Modeling Report for the Former Hazardous Waste Management Facility, Rev.1, Brookhaven National Laboratory, Upton, New York

2.1 Site Cleanup Criteria

The radiological contaminants of concern for the WLA are the same as those at the former HWMF: Cs-137, Ra-226, and Sr-90. The cleanup goals for specific radionuclides were calculated using RESRAD, 15 millirem per year (mrem/yr) above background (*OSWER Directive 9200.4-1., EPA, 1997*), industrial land use with 50 years of institutional control, and residential land use with 100 years of institutional control by the DOE. In addition, the NYSDEC cleanup guideline of 10 mrem/yr, from Technical Administrative Guidance Memorandum (TAGM) 4003, was adopted as an ALARA goal. The primary radiological isotope present at the site was Cs-137; its cleanup goal established in the OU I ROD is 67 pCi/g, and this value was used for the WLA.

The potential for radiologically contaminated soil to impact groundwater also was considered. A soil cleanup goal for Sr-90 was calculated as 15 pCi/g, based on its potential to impact the groundwater. The goal also protects both residential and industrial uses. A 5-pCi/g-cleanup goal was selected for Radium-226 (Ra-226) based on DOE Order 5400.5, *Radiation Protection of the Environment and the Public.*

The chemical contaminants of concern for the WLA are the same as those at the former HWMF: mercury and lead. The cleanup goal established for mercury is 1.84 mg/kg, based on the EPA's soil screening level guidance (*OSWER Directive 9355.4-23*) for protecting groundwater and residential use. A cleanup goal of 400 mg/kg for lead was also chosen based on the EPA's soil screening level guidance; this level is protective of residential use. The cleanup goals for these chemical contaminants were developed for the Former HWMF Soils Removal Project and applied to the WLA Soils Removal Project.

2.2 Design Criteria

Technical specifications and design criteria for the WLA Soils Removal Project were originally established for the Former HWMF Soils Removal Project, which were developed in response to the evaluation of remedial actions described in the OU I ROD. The remedial design, presented in the *Remedial Design and General and Supplemental Specifications for Remedial Action Operable Unit I Contaminated Soil and Debris* (URS, October 2000), the *Remedial Action Work Plan, Operable Unit I, Area of Concern 1, Former Hazardous Waste Management Facility* (BNL, March 2003), and the *Remedial Design Implementation Plan, Operable Unit 1, Area of Concern 1, Former Hazardous*

Waste Management Facility (BNL, March 2004) was developed to satisfy the requirements specified in the OU I ROD. The remedial design was developed in compliance with federal, state, and local regulatory requirements.

The remedial design included:

- A plan and process for ensuring the total exposure from all radioisotopes does not exceed 15 mrem/yr above background following the 50-year period for institutional control for the site;
- A method for instituting an As Low As Reasonably Achievable (ALARA) analysis to identify cost effective measures for reducing exposure to residual contamination below cleanup goals;
- Methods to reduce waste volumes that require offsite disposal;
- An evaluation of waste acceptance criteria for offsite disposal to determine whether further stabilization of mixed wastes is required;
- An approach for post-remediation sampling to confirm that cleanup goals have been achieved; and
- An evaluation of transport and shipping regulations.

2.3 Community Relations Activities

The community involvement process is an integral part of making cleanup decisions at BNL. A Community Relations Plan was completed in September 1991. In accordance with this plan and CERCLA sections 113 (k)(2)(B)(I-v) and 117, the community relations program focused on distribution of public information and community involvement. Community relations activities include a stakeholders' mailing list, community meetings, availability sessions, site tours, and workshops. An Administrative Record was established to document the basis for selecting the remedial actions at BNL. This record, as well as current site reports, press releases, and fact sheets are maintained at the BNL Research Library, Building 477A, Upton, N.Y., 11973.

The Administrative Record is also kept at the EPA's Region II Administrative Records Room, 290 Broadway, New York, N.Y., 10007-1866.

In accordance with CERCLA guidance and state requirements the project work plan, quality assurance plan, engineering evaluation/cost analysis, risk assessment, remedial investigation, and feasibility study were made available for public review. A full discussion of BNL's community involvement programs is presented in the OU I ROD.

As part of the HFBR scope of work, the cleanup of the WLA was included in the *Feasibility Study, Brookhaven High Flux Beam Reactor, Decommissioning Project* and *the Proposed Remedial Action Plan for the High Flux Beam Reactor.*

The public comment period for the *Proposed Remedial Action Plan for the High Flux Beam Reactor* extended from January 10 through March 17, 2008. Two information sessions were held on March 4, 2008, and a public meeting was held on March 6, 2008. The transcript for the public meeting was placed in the Administrative Record. Comments received during the public comment period and DOE responses are included in the HFBR ROD.

3.0 CONSTRUCTION ACTIVITIES AND CONTROLS

All pre-construction tasks were completed prior to beginning cleanup activities, including equipment mobilization, radiological walkover surveys, site inspections, excavation area mark-outs, silt fence installation, and securing the general work area.

As noted in Section 1.3.1, the WLA was used to stage and load excavated material for transportation to an off-site disposal facility via railcars during remedial activities in 2004 and 2005. This material included contaminated soil and debris from both the Former HWMF Soils Removal Project and the Waste Concentration Facility - Building 811 Underground Tank Removal and Soil Remediation Project. The objective of the WLA Soils Removal Project was to safely characterize, remediate, and dispose of radiologically and chemically contaminated soil in accordance with the OU I ROD, as well as the project specific plans. Following the soil excavation activities, an FSS and dose assessment was performed by BNL ERP. The final status survey was independently verified by ORISE. This work is further discussed in sections 3.4 and 3.5. The FSS was completed using the *Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM)* guidelines.

A Job Risk Assessment (JRA), ERP-JRA-417, *Excavate, Load and Ship Soil and Debris from the WLA,* was developed to address hazards associated with the WLA Soils Removal Project. The information presented in the JRA was reviewed by the site workers prior to initiating the project work activities. A copy of the JRA was available onsite at all times for site workers to thoroughly review.

A BNL Radiological Work Permit (RWP), RWP 2008-ERP-038, *Removal of Radioactive Soil and Debris from the WLA Including Set up and Support Work*, was developed to address radiological hazards associated with the WLA Soils Removal Project. The information presented in the RWP was reviewed by the site workers prior to initiating the project work activities. A copy of the RWP was available onsite at all times for site workers to thoroughly review.

Industrial hygiene (IH) oversight and radiological monitoring were conducted in accordance with ERP-JRA-417, *Excavate, Load and Ship Soil and Debris from the WLA* and RWP 2008-ERP-038, *Removal of Radioactive Soil and Debris from the WLA Including Set up and Support Work.*

Industrial Hygiene Oversight

IH oversight was conducted by ERP personnel in accordance with ERP-JRA-417, *Excavate, Load and Ship Soil and Debris from the WLA.* The JRA identified hazards associated with each of the tasks identified in ERP-WP-2.18, and specified the required controls for each hazard. A designated Site Health and Safety Officer was onsite during cleanup activities to ensure controls were in place as specified in the JRA, including the use of safety equipment and safe work practices.

Radiological Monitoring

Radiological monitoring was conducted by BNL Radiological Control Technicians (RCTs) during cleanup activities. Radiological monitoring was general area air sample collection. General area air samples were collected with SAIC low volume air samplers positioned downwind of cleanup activities and at the soil and debris dumping/railcar loading area. General area air sample results were used to track derived air concentration-hour (DAC-Hr) exposures. All general area air sample results were below 0.5 DAC.

Thermoluminescent dosimeters (TLD)s were worn by each individual entering the work zone. No worker received a measurable dose by TLD while working on the WLA Soils Removal Project.

Workers entering the work zone were also required to have an annual whole body count prior to starting work on the project. In addition workers were required to complete a whole body monitoring using a PCM-1B or equivalent hand held instrument each time they exited the site, in accordance with FS-SOP-4027, *Entry/Egress Requirements For Areas Controlled For Radiological Purposes* (BNL, June 2006).

In addition to personal and general area monitoring, equipment used during cleanup activities was monitored for radiological contamination. All equipment that was released from the work zone was surveyed in accordance with FS-SOP-1005, *Radiological Surveys Required For Release of Materials from Areas Controlled For Radiological Purposes* (BNL, November 2007).

Photograph 1 – Pre-Excavation Conditions at the WLA

In accordance with the *MARSSIM* guidelines for survey unit (SU) classification and size, the 81,000 ft^2 (7,525 square meters (m^2)) WLA was divided into four (4) SUs, designated as SU-1 through SU-4. An SU is a physical area of structure or land area of specified size and shape for which a separate decision will be made on whether or not cleanup goals are met. Soils contaminated above cleanup goals were designated as Class 1 survey units. The maximum suggested area for Class 1 soil area survey units is 2,000 m^2.

A pre-excavation radiological walkover survey of the WLA was performed in 2005. It indicated that the central portion of the WLA required remediation, where gamma survey results ranged from 20,000 to 65,000 counts per minute (cpm). The results of the radiological survey are presented as Figure 3-1. According to the *Former Hazardous Waste Management Facility Soil Remediation Closeout Report* (Envirocon, September 2005), the anticipated excavation volume for the WLA was 900 cubic yards (CY).

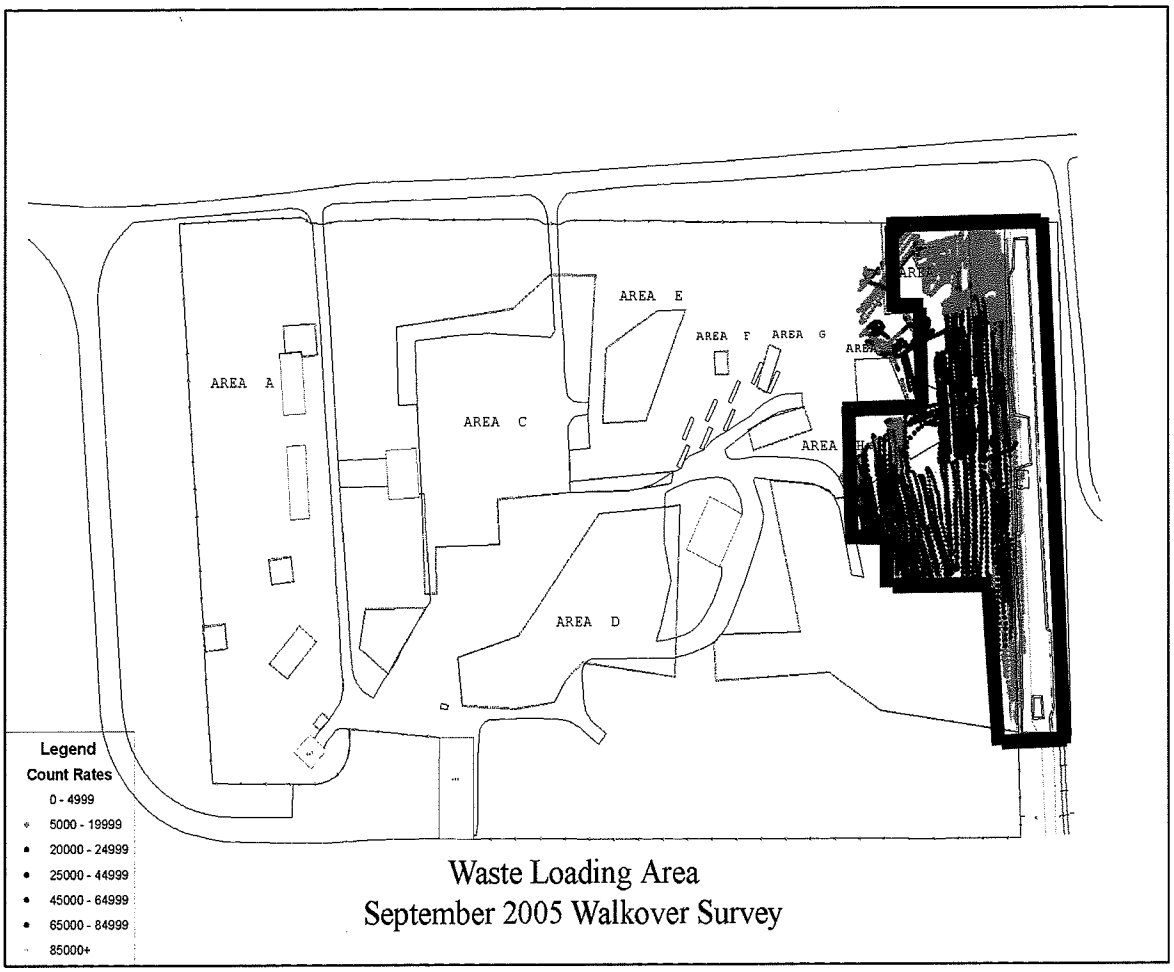


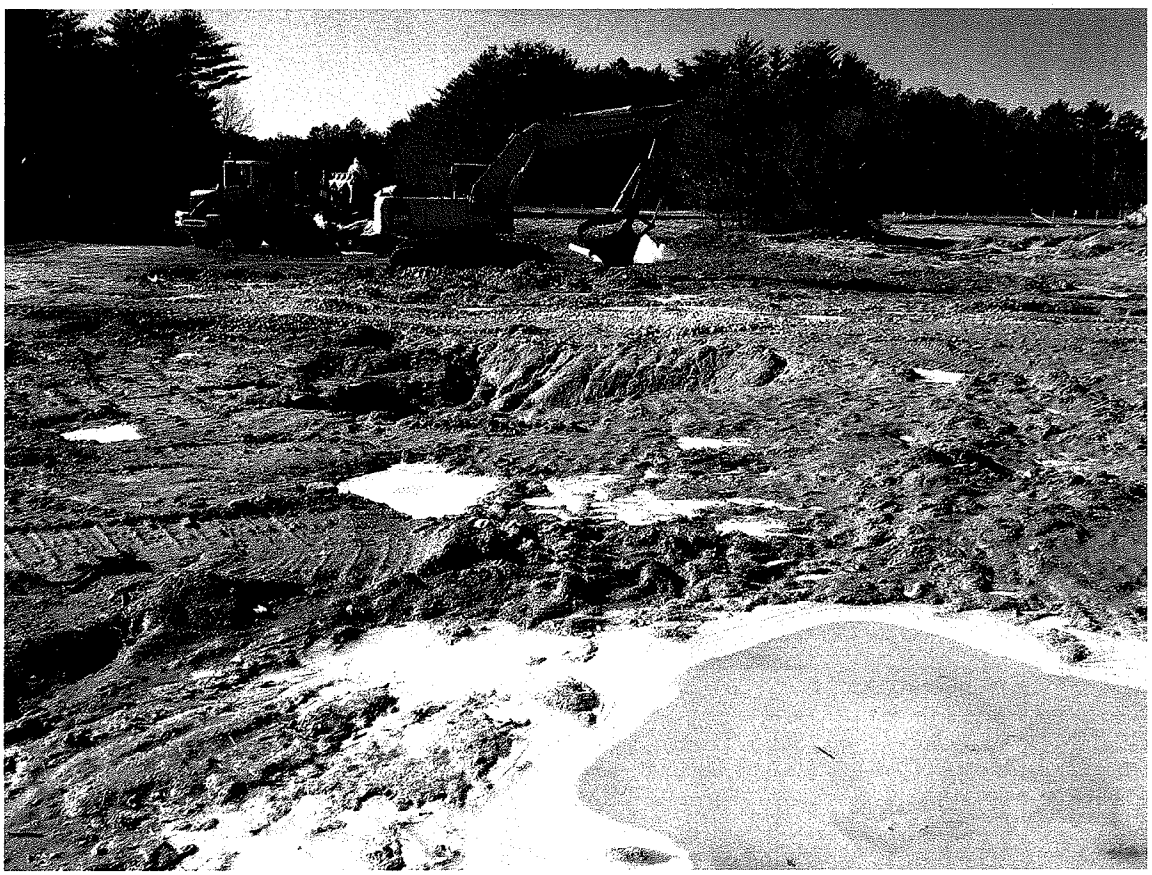
Figure 3-1 – WLA Pre-Remediation Radiological Walkover Survey Results

3.1 Soil Excavation

Prior to the start of cleanup activities, survey unit boundaries were surveyed and marked out in accordance with the *Field Sampling Plan for the Waste Loading Area, Rev. 1* (BNL, April 2008) and ERP-Work Procedure (WP)-2.18, *Excavate, Load and Ship Soil and Debris from the WLA, Rev. 5.* (Appendix D) Contaminated soil was excavated in one-foot lifts starting at the furthest southwest corner of the WLA and continuing north and east. In process field screenings were performed with both shielded and unshielded Sodium Iodide (NaI) gamma scintillation detectors after each lift to determine if additional excavation was required. Soil was removed with an excavator and temporarily placed behind the excavator, on an area that had not yet been remediated. Excavated soil was then transported by a front-end loader and either staged in an onsite soil stockpile or loaded directly into railcars for shipment and final disposal at Energy Solutions Disposal Facility of Clive, Utah, as described further in Section 3.3.

In accordance with ERP-WP-2.18, an initial field screening level was determined and subsequently confirmed by excavating, surveying and sampling a ½-acre test area within

the WLA. This method is described in the WLA Field Sampling Plan (BNL, 2008d) and in Appendix F of this completion report. Cs-137 was the primary radiological contaminant driving the remediation of the site. As a result, gamma count rates using field instruments (NaI gamma scintillation detectors) were used to identify areas requiring excavation to meet the site cleanup goals. Excavation action levels of 49,000 cpm for the unshielded NaI gamma scintillation detectors and 16,000 cpm for shielded NaI gamma scintillation detectors were established as the criterion for determining when excavations were complete. This criterion was determined using a correlation between data from NaI gamma scintillation detector surveys, onsite ISOCS analyses, and offsite gamma spectroscopy analyses at GEL Laboratories, LLC of Charleston, South Carolina. Correlation curves and the associated data used in establishing the excavation action levels are presented and further discussed in ERP-WP-2.21, *Final Status Survey WLA* and the *WLA Field Sampling Plan, Rev. 1*, (BNL, April 2008).



Photograph 2 – Soil removal at the WLA.

Although mercury and lead were also considered contaminants of concern, radiological surveys determined the excavation depth and endpoint samples were collected to ensure cleanup goals were met for chemical contaminants. However, if endpoint sample results were above the project cleanup goals for lead and mercury, additional excavating was performed until endpoint concentrations were below those goals. A map showing the final dimensions of the Class 1 SUs and associated sample locations is presented as Figure 3-2.

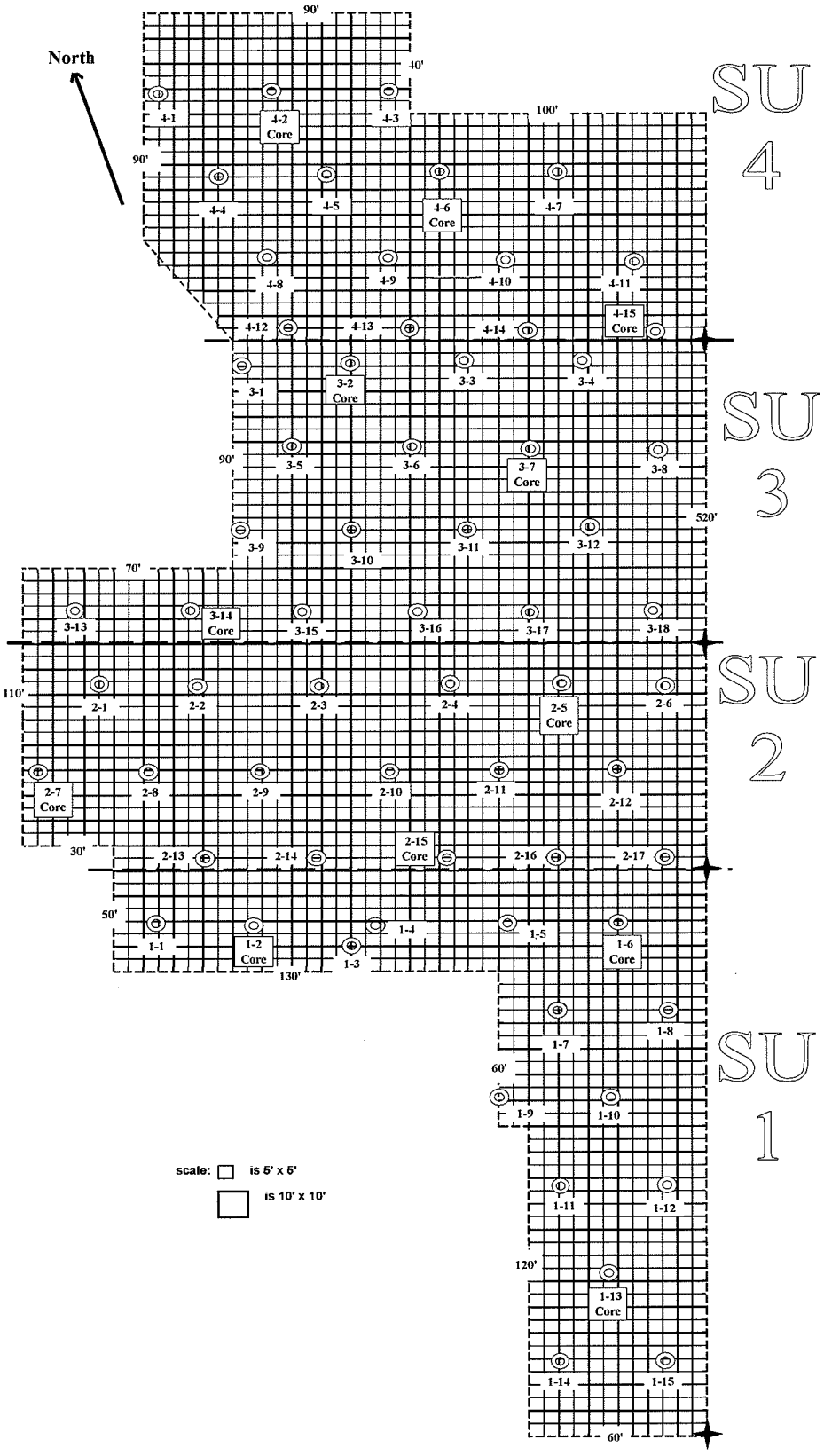


Figure 3-2 – WLA FSS Survey Units and Soil Sample Locations

Photograph 3 – Bermed Excavation Area at the WLA.

3.2 Final Status Survey and Sampling

As indicated in Section 3.1, excavation of radiologically contaminated soils was controlled by conducting excavation surveys with both shielded and unshielded gamma scintillation detectors. Gamma count rates were used to determine when the excavations were complete in each area. During excavation activities walkover surveys were performed and samples were collected and analyzed for Cs-137 using the onsite ISOCS unit. Following completion of the excavation surveys, a complete (100% coverage) Global Position System (GPS)-based walkover survey was conducted using unshielded NaI scintillation detectors coupled with the PRO XR Satellite Receiver Trimble model TSCe Data Logger (Trimble Unit) to document the radiological status of each SU. The walkover survey was performed in accordance with ERP-WP-2.21, Rev. 2, *Final Status Survey WLA*.

Following completion of the walkover survey in each SU, soil sampling was conducted to determine the post-remediation concentrations for the radionuclides of concern and chemical contaminants of concern, as well as to verify that the dose-based criteria established for the site had been met. Soil samples were collected in accordance with BNL EM-SOP-601 Rev. 1, *Collection of Soil Samples,* at locations and depths as specified in ERP-WP-2.21, Rev. 2, *Final Status Survey WLA*.

As discussed in Section 2.1, the primary radionuclides of concern, based on exposure potential, were Sr-90, Cs-137 and Ra-226. Other radionuclides of concern that were monitored include Am-241, Pu-238, Pu-239/240, U-234, U-235, U-238 and tritium. These additional radionuclides were present in the Former HWMF prior to remediation, so it is possible that they would be present in the WLA. The chemical contaminants of concern were mercury and lead, which also were detected in the Former HWMF. Because these contaminants are not anticipated above the cleanup goals, one composite sample, consisting of portions from all 15 – 18 sample sites per survey unit, was specified in the WLA Field Sampling Plan (BNL, 2008d). This in fact results in a split of the four composite samples into multiple samples due to the types of analyses required.

3.2.1 Final Status Survey Design

Based on the size of the WLA, the nature of operations that were conducted there and previous site characterization data, the entire WLA was considered as radiologically impacted. Class 1 survey units were established for soil remediation areas that contained radiological contamination above the cleanup goals prior to cleanup activities. The suggested maximum size area for a Class 1 survey unit is 2000 m^2 for soil areas. The WLA was divided into four Class 1 survey units for the FSS.

A two-step approach to cleanup confirmation for radiological soil contamination was followed using the *MARSSIM* approach at the WLA. The first step consisted of a GPS-based gamma scintillation walkover survey of remediated areas. Gamma walkover surveys were conducted using unshielded two-inch-by-two-inch NaI detectors in conjunction with a Ludlum Model 2221 scaler/ratemeters and a Trimble Unit, in accordance with ERP-WP-2.21, Rev. 2. The second step involved the collection of soil samples for offsite analysis to verify that residual radiological contamination levels were sufficiently low to meet the cleanup goals established for the site. In addition, endpoint soil samples were analyzed for mercury and lead to ensure site cleanup goals for chemical contaminants (Table 1-1) of concern were met.

3.2.2 Final Status Survey and Sampling Results

The results of the final status radiological walkover survey exhibit count rates below 49,000 cpm for all areas within the WLA, with the exception of two stones that were removed and disposed of in accordance with Section 3.3. As specified in the *Waste Loading Area Final Status Survey Report* (BNL, July 2008), the 49,000 cpm count rate was determined to approximate 45 pCi/g Cs-137 in soil, or two-thirds of the cleanup goal for Cs-137 in soil when using the unshielded NaI gamma scintillation detector. Correlations between field survey results, onsite ISOCS soil results and offsite soil analyses are discussed further in Section 3.1 and ERP-WP-2.21. Radiological walkover survey results ranged from less than 15,000 cpm to 30,000 cpm throughout the majority

of the WLA, while some isolated areas exhibited count rates between 30,000 cpm and 40,000 cpm. The results of the final status radiological walkover survey are illustrated in Figure 3-3 and further discussed in *Waste Loading Area Final Status Survey Report,* (BNL, July 2008), provided in Appendix A.

Soil sample results were below the site cleanup goals for Cs-137, Sr-90 and Ra-226, 67 pCi/g, 15 pCi/g and 5 pCi/g, respectively. The average and maximum Cs-137, Sr-90 and Ra-226 concentrations are shown in Table 3-1. The data tables are shown in the Final Status Survey Report (Appendix A, Tables 3, 4, 7, and 8).

Table 3-1 Summary of WLA Soil Sample Results for Radionuclides

	Cs-137 (pCi/g)	Sr-90 (pCi/g)	Ra-226 (pCi/g)
Cleanup Goal	67	15	5
Average	11.4	0.55	0.64
Maximum	61.3	4.0	1.0

Note that Ra-226 background on BNL property had previously been established at approximately 0.56 pCi/g (CDM, 1996), and previous work on the former HWMF indicated an average of 0.49 pCi/g (Envirocon, 2005). Therefore, the average Ra-226 value of 0.64 pCi/g from the WLA is close to background levels. For determination of acceptable levels of cleanup, the value of 0.64 pCi/g was used as a conservative measure, with no subtraction of background Ra-226 in the soil. However, when performing the post-remediation dose assessment, background is subtracted to obtain a more accurate result.

Chemical results for soil samples analyzed for mercury and lead also indicated that residual soil concentrations for these contaminants are within their respective cleanup goals, i.e., 400 mg/kg for lead and 1.84 mg/kg for mercury. Lead results ranged from 3 to 30.2 mg/kg and mercury results ranged from concentrations below detectable limits to 0.24 mg/kg. FSS procedures, results, conclusions, including radiological and chemical results for each sample collected are included in *Waste Loading Area Final Status Survey Report,* (BNL, July 2008), provided in Appendix A.

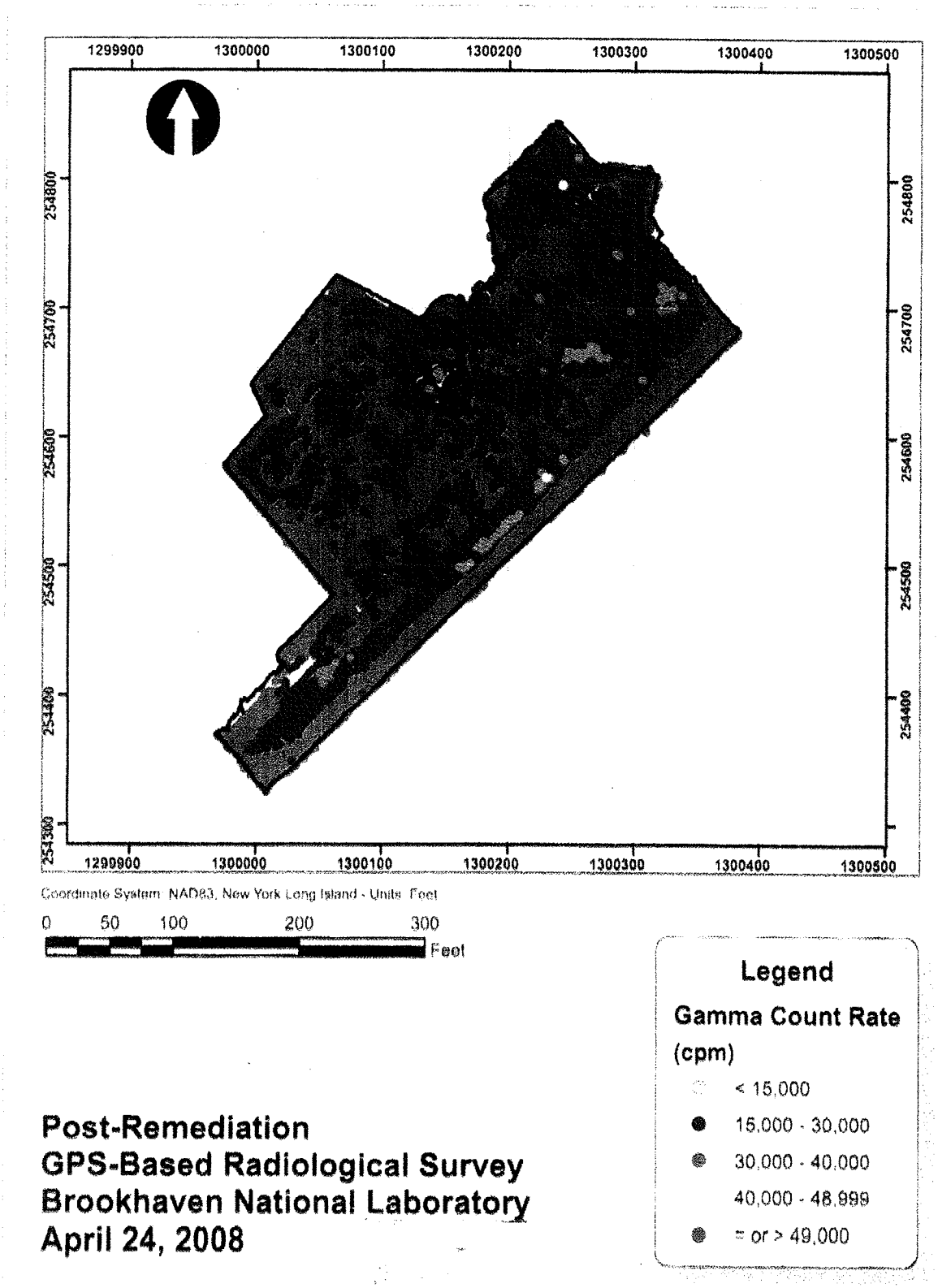


Figure 3-3 – WLA Post-Remediation Radiological Walkover Survey Results.

3.2.3 Post Remediation Dose Assessment

A dose assessment was conducted to evaluate radiological dose impacts from residual radioactive materials remaining following the completion of the WLA Soils Removal Project. The dose assessment for the soil excavation areas was conducted using RESRAD, Version 6.3 (ANL, 2001). The average WLA concentration for each radionuclide was used as input to the model in order to determine the projected dose. As described in section 3.2.2, the Ra-226 concentrations were close to background concentrations (0.64 pCi/g average, compared to 0.56 pCi/g background). In order to improve accuracy, yet maintain a level of conservatism in the dose assessment, 50% of the background value was subtracted prior to performing the RESRAD calculation. That is, a value of (0.5 x 0.56 pCi/g), or 0.28 pCi/g was subtracted as background from the 0.64 pCi/g average Ra-226 concentration. For the RESRAD analysis, the value of 0.64 – 0.28, or 0.36 pCi/g was used as the Ra-226 concentration. The reason for the use of one-half of the background rather than the full background is one of conservatism. The RESRAD model was also run with no background subtract Ra-226 = 0.64 pCi/g) and with full background subtract (Ra-226 = 0.64 – 0.56 = 0.08 pCi/g). This is shown below in Table 3-2, where for the industrial worker at 50 years, the range of results is from 2.7 to 4.1 mrem per year, while for the residential individual at 100 years ranges from 4.0 to 13.8 mrem per year. Since TAGM requires that the dose be calculated without background, the lower values (2.7 mrem for industrial and 4.0 mrem for resident) would be applicable to the TAGM guidelines.

In accordance with the RI/FS and OU I ROD, two potential radiological dose scenarios were evaluated following remediation. The first assessment considered the radiation dose to a hypothetical industrial worker after 50 years of institutional control. The second assessment considered the radiation dose to a future resident (non-farmer), assuming 100 years of institutional control. The parameters and pathways used in the dose assessment for the Former HWMF were used for this dose assessment, and the RESRAD summary reports are included as Appendix E.

The results of the dose assessment are shown in the Table 3-2 below. The maximum projected dose to an industrial worker at Year 50 (3.8 mrem/yr) and the maximum projected dose to a resident (non-farmer) at Year 100 (8.9 mrem/yr) at the WLA would be below the dose objective of 15 mrem/yr established by the OU I ROD. The results also indicate that the NYSDEC TAGM 4003 guideline of 10 mrem/yr would also be met under each of the two scenarios described above

Table 3-2: Summary of Post Remediation Dose Assessment Results

Time to Dose Calculation	Industrial Worker (mrem)	Resident (mrem)
0 years	8.6	31.5
50 years	**3.8 (range 2.7 to 4.1)**	14.5
100 years	1.8	**8.9 (range 4.0 to 13.8)**

3.2.4 Final Status Survey Conclusions

As indicated above, results of the FSS and sampling following the completion of the remediation of the WLA demonstrate conformance to the site cleanup goals established in the OU I ROD and project plans. In addition, the radiological dose objective of 15 mrem/yr and the NYSDEC TAGM cleanup guideline of 10 mrem/yr were met, as discussed above in Section 3.2.3.

3.2.5 Final Status Survey Independent Verification

The Independent Verification Survey (IVS) of the WLA was conducted by an ORISE survey team. The ORISE survey team conducted surveying and sampling during a visit May 19 through 21, 2008.

Radiological walkover surveys identified two isolated areas within SUs 2 and 3 where count rates exceeded the established limit of 49,000 cpm. The areas were marked and reported to BNL for additional remediation. Gamma count rates generally ranged from 8,000 cpm to 50,000 cpm and the mean count rate for the WLA was approximately 17,000 cpm.

The ORISE survey team collected 24 random verification soil samples. All individual soil samples and the corresponding survey unit mean concentration were determined to be below the established guidelines.

The results of the IVS are documented in *Independent Verification Survey Report for the Waste Loading Area, Brookhaven National Laboratory, Upton, New York* (ORISE, August 2008), provided in Appendix B.

3.3 Waste Management

3.3.1 Waste Characterization and Handling

The waste management strategy, waste characterization, packaging, handling, and storage were performed in accordance with ERP-WP-2.18, *Excavate, Load and Ship Soil and Debris from the WLA* (Appendix D) and the *BNL Standard Based Management System.* The removal was accomplished in accordance with the "*Waste Management Plan for Removal of Radioactive Soil and Debris from the Waste Loading Area*" (BNL, 2007c).

Excavated soil contaminated above cleanup goals were either stockpiled or loaded directly into railcars for shipment to Energy Solutions Disposal Facility of Clive, Utah for final disposal. In addition to excavated soil, constructions mats and polyvinyl chloride (PVC) piping formerly used during remedial activities at the former HWMF were size reduced and loaded into railcars for shipment and final disposal.

Photograph 4 – Loading Debris (Construction Mat) into Lined Railcars at the WLA

Waste verification sampling for soil and debris disposal was performed, in accordance with the *EM Waste Management Plan* (BNL, January 2002), at a frequency of 1 sample per five railcars (approximately 1 sample per 340 CY of soil). Samples were analyzed for comparison to Energy Solution's Waste Acceptance Criteria (WAC), which includes complete TCLP, gamma spectroscopy, Strontium-90 analysis, alpha spectroscopy, gross beta, PCBs/Pesticides, and physical parameters (pH, Reactivity, flashpoint). Since 67 railcars were shipped from the WLA, a total of 14 waste verification samples were collected by ERP personnel and analyzed by GEL Laboratories, LLC of Charleston, South Carolina. According to these sample results, the soil and debris shipped met the Energy Solutions WAC. In addition to the waste verification samples, moisture content and pH of was measured at a rate of one sample per approximately 60 yards of waste soil. Waste verification results were submitted to BNL's Waste Management Division and are shown in Appendix G.

3.3.2 Waste Shipment and Disposal

Environmental Rail Solutions provided railcars for transportation of the waste soil and debris to Energy Solutions Disposal Facility of Clive, Utah. After the railcars arrived on site, they were inspected and released for loading. The bottom of the inside of each railcar was covered with a geotextile liner and a Railpac railcar liner was placed within each railcar prior to loading. Approximately 95-100 tons of waste was placed into each rail car. The weights of the soil and debris were determined utilizing a bucket scale on the front-end loader. After the waste was loaded into the railcar, the liner was closed/secured using the Railpac liner zipper and straps, in accordance with instructions provided by

PacTec, Inc. In addition, either a hard or soft tarp cover was secured over each railcar for shipment.

Waste loading and shipping was initiated on November 14, 2007 and was completed on February 8, 2008. A total of 67 railcars were loaded and transported to Energy Solutions Disposal Facility of Clive, Utah for final disposal, which equates to approximately 6,500 tons (4,560 CY) of soil and debris. The volume of waste was higher than originally anticipated because a conservative action level for excavation was selected to address lessons learned from previous remediation activities. The lesson learned occurred at the former HWMF that identified the need to set action levels with a sufficient margin to confidently remediate an area to meet clean-up goals and not repeat excavation activities because clean-up goals were not achieved. All waste shipped as part of the WLA Soils Removal Project was accepted by Energy Solutions. Waste soil and debris shipments summarized in a table included in Appendix C.

3.3.3 Pollution Prevention and Waste Minimization Opportunities

Waste minimization and pollution prevention methods employed during remedial activities at the FHWMF include:

- Operating equipment outside of the controlled areas as much as possible to minimize contact with contaminated areas;
- Lining loader buckets with spill sheets to reduce the spread of contamination;
- Constructing run-on berms around excavations and the entire WLA to prevent the spread of surface contamination;
- Maintaining a berm and raised fence at the north side of the railcar loading area to contain storm water inside the work site;
- Size reducing waste to meet the Energy Solutions WAC; and
- Judicious use of consumables (PPE).

3.5 Site Restoration

Site restoration was completed in accordance with ERP-WP-2.18. The WLA was backfilled and re-graded with material from BNL's "Borrow Pit", which contains material that has been pre-tested to ensure compliance with NYSDEC TAGM 4046 guidelines. BNL has an authorization from the New York Department of Environmental Conservation to operate what's known as the "Borrow Pit". The Borrow Pit is an area where sand was mined for a Laboratory project, leaving a large void space in the firebreak area south of the Laboratory. The authorization allows BNL to fill the void space with construction & demolition debris.

The finished grade was approved by BNL's Long Term Response Action Group (LTRA) and drainage was determined to be acceptable. Topsoil was placed following the placement of backfill material. The topsoil was created from mulch taken from BNL's

stump dump, which was pre-tested to ensure it complied with the NYSDEC TAGM 4046 guidelines. Six inches of topsoil was placed at the WLA and the area was reseeded with native Long Island grasses. Site restoration activities were completed on November 4th, 2008. Future site controls are discussed in Section 6.0.

Photograph 5 – Site restoration activities at the WLA.

4.0 PERFORMANCE STANDARDS AND CONSTRUCTION QUALITY CONTROL

As discussed in Section 3.2.2, the concentrations for Cs-137, Sr-90, and Ra-226 in soil were below the cleanup goals of 67 pCi/g, 15 pCi/g and 5 pCi/g, respectively. The calculated radiological doses from all radioisotopes were also below the levels stipulated in the OU I ROD. In addition, concentrations of mercury and lead in soil were below the cleanup goals of 1.84 mg/kg and 400 mg/kg, respectively.

Physical and radiological inspections were conducted on both incoming and outgoing railcars. Inspections were also conducted on stormwater control measures as well as excavation operations. Excavation monitoring and field sampling procedures were also reviewed periodically.

Quality control/quality assurance (QA/QC) samples were collected in accordance with ERP-WP-2.21, *Final Status Survey WLA*. Field duplicates were collected at a frequency of one per twenty soil samples and analyzed for Cs-137, Sr-90 and Ra-226. QA/QC results are summarized in the *Waste Loading Area Final Status Survey Report,* (BNL, July 2008), provided in Appendix A.

5.0 FINAL INSPECTION AND CERTIFICATIONS

As described in Section 3.2.5, the IVS was performed by ORISE upon the completion of FSS performed by ERP.

The Final Status Survey Report (Appendix A) describes the details of the surveys performed and samples analyzed. Based on the results of the FSS, an evaluation of the dose from the remaining activity was performed using RESRAD, and results were within the design criteria described in Section 2.2.

The WLA meets all the completion requirements as specified in OSWER Directive 9320.2-09-A-P, Closeout Procedures for National Priorities List Sites. The affected areas were remediated in accordance with the decommissioning criteria of 10 CFR Part 834, Radiation Protection for the public and environment.

There was strict adherence to industrial safety and radiological safety precautions during the remediation. Work was performed under a written and approved procedure, and any potentially hazardous steps were highlighted in the procedure to ensure understanding and compliance. A Job Risk Analysis was performed and approved for the remediation work. Radiological safety was accomplished by the presence of Radiation Control Technicians and performance of all work under a Radiological Work Permit.

6.0 OPERATION AND MAINTENANCE ACTIVITES

Post remediation operation and maintenance activities at the former HWMF, including the WLA, will be performed in accordance with the *Operable Unit 1 Soils and Operable Unit V Long-Term Monitoring and Maintenance Plan* (BNL, May 2006) to ensure that land uses remain protective of public health and the environment. These activities will include inspections of site fencing, Tiger Salamander habitat monitoring and surveys, and institutional controls (signs, entry and access restrictions, land use controls, notifications and restrictions, work planning controls such as digging permits, and government ownership). The clean fill and topsoil cover, placed during site restoration, will also be inspected for signs of erosion. Land use and institutional control information for the WLA will be included in BNL *Factsheet: Former Hazardous Waste Management Facility.* In addition, the BNL LUCMP was revised to include the HFBR complex and WLA.

BNL's Groundwater Protection Group will perform operation and maintenance activities, in addition to maintaining institutional controls. This group will ensure that the controls listed above are in place and routine monitoring/inspections are performed. The DOE will ensure enforcement of all institutional controls.

7.0 PROTECTIVENESS

The removal of contaminated soils at the WLA, as well as the implementation of monitoring and institutional controls will protect human health and the environment. The removal of these wastes has minimized both the risk of exposure to on-site workers and the risks associated with future-use scenarios by decreasing radiation dose levels at the site. These actions have also minimized the potential for the migration of contaminants into the underlying groundwater.

8.0 FIVE YEAR REVIEW

Five-year reviews will be conducted to determine whether the remedy implemented continues to be protective of human health and the environment. These reviews will be performed in accordance with the *Comprehensive Five-Year Review Guidance, OSWER No. 9355.7-03B-P* (EPA, June 2001). The former HWMF, including the WLA, will be included in the second sitewide Five-Year Review in 2011.

9.0 LESSONS LEARNED

The following is a summary of the lessons learned from this project and the corrective actions for future projects:

- Three of the gondola railcars carrying project waste exhibited soft top failure and/or supper load rapper damage upon arrival at Energy Solutions. An analysis team determined that the failure/damage was likely due to extreme weather conditions during transport, such as high winds and snow. Corrective actions taken included: reviewing the manufacturer's installation procedures for both the super load wrapper and soft top; conducting an investigation to determine the availability of a higher quality soft top; using cable ties to bind the zipper ends together on the super load wrappers; and contracting the rail service provider to inspect railcars during transit so that repairs can be made when soft top breaches occur.

10.0 SUMMARY OF PROJECT COSTS

The cleanup of the WLA was performed as a non-time-critical removal action authorized by the *Action Memorandum, High Flux Beam Reactor, Removal Action for Waste Loading Area*. The estimated cost for WLA remediation presented in the Action Memorandum was $1,900,000. The actual cost for remediation was approximately $2,800,000 to complete. The cost for the remediation of WLA is included in the total estimated cost of $144,000,000 presented in HFBR ROD.

The difference in estimated versus final actual can be contributed to the extra soil that was excavated (900 CY vs. 4,560 CY). The volume of waste originally anticipated was based on a planned action level for soil remediation. During the remediation, BSA used a more conservative action level, based on a lesson learned from remediation of the former HWMF, and this resulted in higher than anticipated waste volumes. The lesson learned occurred at the former HWMF that identified the need to set action levels with a sufficient margin to confidently remediate an area to meet clean-up goals and not repeat excavation activities because clean-up goals were not achieved.

The clean-up costs of the WLA included the following details:

Engineering and planning	$ 112,000
Remediation & Restoration	$ 767,000
Waste Transportation & Disposal	$1,942,000
Total Cost	$2,821,000

REFERENCES

ANL, 2001. *User's Manual for RESRAD Version 6*, Environmental Assessment Division, Argonne National Laboratory, ANL/EAD-4, July 2001.

BNL, Factsheet: *Former Hazardous Waste Management Facility*

BNL, 1992. Interagency Agreement, May 1992.

BNL, 1996. BNL Final Remedial Investigation/Risk Assessment – Final Report, Operable Unit I/VI, CDM Federal Programs Corp., June 1996.

BNL, 1999a. *Proposed Plan for Operable Unit I and Radiologically Contaminated Soils*, 1999.

BNL, 1999b. *Record of Decision, Operable Unit I and Radiologically Contaminated Soils*, August 1999.

BNL, 2001. FS-SOP-1040, *Airborne Radioactivity Sampling and Analysis*, December 2001.

BNL, 2002a. *EM Waste Management Plan,* January 2002.

BNL, 2002b. *Characterization and Waste Management Plan for the Former Hazardous Waste Management Facility Buildings and Structures,* July 2002.

BNL, 2003a. EM-SOP-601, *Collection of Soil Samples, Rev. 1*, March 2003.

BNL, 2003b. *Remedial Action Work Plan, Operable Unit I, Area of Concern I, Former Hazardous Waste Management Facility*, March 2003.

BNL, 2003c. EM-SOP-200, *Collection and Frequency of Field Quality Control Samples,* March 2003.

BNL, 2003d. *Former Hazardous Waste Management Facility Decontamination & Decommissioning Characterization Report*, May 2003.

BNL, 2003e. *Supplemental Investigation Report, Former Hazardous Waste Management Facility, Soil, Asphalt, and Debris*, September 22, 2003.

BNL, 2003f. *Former Hazardous Waste Management Facility Decontamination & Decommissioning Closeout Report,* November 2003.

BNL, 2004. *Remedial Design Implementation Plan, Operable Unit I, Area of Concern 1, Former Hazardous Waste Management Facility Remedial Action Work Plan,* March 2004.

BNL, 2005. *Operable Unit 1 Soils and Operable Unit V Long-Term Monitoring and Maintenance Plan,* May 2006.

BNL, 2006. FS-SOP-4027, *Entry/Egress Requirements for Areas Controlled for Radiological Purposes,* June 2006.

BNL, 2007a, *Land Use Controls Management Plan, Revision 3*, prepared by Brookhaven Science Associates for the U.S. Department of Energy, July 2007.

BNL, 2007b. *Feasibility Study, Brookhaven High Flux Beam Reactor, Decommissioning Project*, prepared by Brookhaven Science Associates for the U.S. Department of Energy, September 2007.

BNL, 2007c. *Waste Management Plan for Removal of Radioactive Soil and Debris from the Waste Loading Area (WLA)*, September 2007.

BNL, 2007d. *Action Memorandum, High Flux Beam Reactor, Removal Action for Waste Loading Area*, prepared by Brookhaven Science Associates for the U.S. Department of Energy, October 26, 2007.

BNL, 2007e. FS-SOP-1005, *Radiological Surveys Required for Release of Materials from Areas Controlled for Radiological Purposes,* November 2007.

BNL, 2008a. *The Proposed Remedial Action Plan for the High Flux Beam Reactor at Brookhaven National Laboratory,* prepared by Brookhaven Science Associates for the U.S. Department of Energy, January 2008.

BNL, 2008b. ERP-WP-2.18, *Excavate, Load and Ship Soil and Debris from the WLA, Rev. 5,* February 2008.

BNL, 2008c. ERP-WP-2.21, *Final Status Survey WLA* and the *WLA Field Sampling Plan, Rev. 1*, April 2008.

BNL, 2008d. *Field Sampling Plan, Waste Loading Area, Rev. 1*, April 2008.

BNL, 2009 *Final Record Of Decision For Area Of Concern 31, High Flux Beam Reactor*, prepared by Brookhaven Science Associates for the U.S. Department of Energy, February 2009.

CDM, 1996. *Final Remedial Investigation and Risk Assessment Report for Operable Unit I/VI*, 1996.

CDM, 1999. *Final Feasibility Study Report for Operable Unit I Radiologically Contaminated Soils,* 1999.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Title 42, U.S. Code, Sec. 9620 et seq.

Department of Energy, DOE Order 5400.5, *Radiation Protection of the Environment and the Public,* as amended.

Department of Energy, 2005, *Letter from R. Rimando (DOE) to J. Lister (NYSDEC) and D. Pocze (EPA), Subject: Remedial Design Implementation Plan (RDIP), Operable Unit I, Area of Concern 1, Former Hazardous Waste Management Facility (FHWMF),* September 30, 2005.

Envirocon, 2005. *Former Hazardous Waste Management Facility Soil Remediation Closeout Report,* September 2005.

EPA, 1997. *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* (OSWER Directive 9200.14-18), 1997.

EPA, 2000a. *Close Out Procedures for National Priorities List Sites* (OSWER Directive 9320.2-09A-P), January 2000.

EPA, 2000b. *Multi-Agency Radiological Survey and Site Investigation Manual, Revision 1,* August 2000.

EPA, 2001. *Comprehensive Five-Year Review Guidance* (OSWER Directive 9355.7-03B-P), June 2001.

NYSDEC, 1993. *New York State Department of Environmental Conservation TAGM 4003: Cleanup Guideline for Soils Contaminated with Radioactive Materials,* September, 1993.

NYSDEC, 1994. *New York State Department of Environmental Conservation TAGM 4046: Determination of Soil Cleanup Objectives and Cleanup Levels,* January, 1994.

ORISE, 2008. *Independent Verification Survey Report for the Waste Loading Area, Brookhaven National Laboratory, Upton, New York,* August, 2008.

RESRAD, Residual Radioactive Material Guideline Computer Code

SAIC, 1992. *Brookhaven National Laboratory Site Baseline Report,* 1992.

URS, 2000. *Remedial Design and General Supplemental Specifications for Remedial Action, Operable Unit I Contaminated Soil and Debris,* October 2000.