FINAL STATUS SURVEY PLAN

BUSH RIVER STUDY AREA
RADIOACTIVE WASTE MANAGEMENT FACILITY

Edgewood Area, Aberdeen Proving Ground, MD
Contract No: W91ZLK04-D-0014, DO 0005

October 2007

TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS (CONTINUED)

Section **Page**

LIST OF FIGURES

Figure No. **Page**

LIST OF TABLES

Table No. **Page**

LIST OF ACRONYMS

α	alpha radiation
ALARA	as low as reasonably achievable
APG	Aberdeen Proving Ground
As	arsenic
BEST	Base Environmental Support Team
β	beta radiation
Ba	barium
Be	beryllium
Bi	bismuth
BRSA	Bush River Study Area
C	carbon
CENAB	USACE Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cr	chromium
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
Co	cobalt
cm	centimeter
cm^2	square centimeter
COC	contaminant of concern
CoC	chain-of-custody
cpm	counts per minute
Cs	Cesium
Cu	copper
d’	index of detectability
DCGL	derived concentration guideline level
dpm	disintegrations per minute
DO	delivery order
DOE	U.S. Department of Energy
DQO	data quality objective
DSHE	Directorate of Safety, Health and Environment
ECBC	Edgewood Chemical Biological Center
EE/CA	engineering evaluation/cost analysis
EMC	elevated measurement comparison

LIST OF ACRONYMS (CONTINUED)

EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FPS	feet per second
FSS	Final Status Survey
FSSP	Final Status Survey Plan
ft	foot
ft^2	square feet
GP	General Physics
GPS	global positioning system
H-3	tritium
HAZWOPER	Hazardous Waste Operations and Emergency Response
HHRRA	Human Health Radiological Risk Assessment
ID	identification
IRP	Installation Restoration Program
K	potassium
keV	kiloelectron-volt
Kg	kilogram
LBGR	Lower Bound Gray Region
LUC	land use control
m^2	square meter
MARSSIM	*Multi-Agency Radioactive Survey and Site Investigation Manual*
MDA	Minimum Detectable Activity
MDC	minimum detectable concentration
MDE	Maryland Department of Environment
MDCR	minimum detectable count rate
MDL	minimum detection level
MOU	Memorandum of Understanding
mrem	millirem
mrem/yr	millirem per year
m/s	meters per second
μR/h	microroentgen per hour
NaI	sodium iodide
NAREL	National Air and Radiation Environmental Laboratory
NIST	National Institute of Standards and Technology

LIST OF ACRONYMS (CONTINUED)

NMED	New Mexico Environment Department
NRC	U.S. Nuclear Regulatory Commission
NTCRA	non-time-critical-removal action
OU	operable unit
Pb	lead
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
Pr	praseodymium
PM	Project Manager
PPE	personal protective equipment
QA	Quality Assurance
Ra	Radium
RBA	risk-based activity
RCT	Radiological Control Technician
RDECOM	U.S. Army Research Development and Engineering Command
RI	remedial investigation
SBCCOM	U.S. Army Soldier and Biological Chemical Command
Sr	strontium
SSSHP	Site-Specific Safety and Health Plan
TAL	Target Analyte List
Tc	technectium
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
Th	thorium
U	uranium
U.S.	United States
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound
WESTON	Weston Solutions, Inc.
yd^3	cubic yard

1. EXECUTIVE SUMMARY

Weston Solutions, Inc. (WESTON®) has been contracted to achieve U.S. Nuclear Regulatory Commission (NRC) delisting of the Bush River Rad Yard site in the Edgewood Area of Aberdeen Proving Ground (APG), (MD). This work is being conducted under the Base Environmental Support Team (BEST) Contract (W91ZLK-04-D-0014), Delivery Order (DO) 0005, respectively, for the Directorate of Safety, Health and Environment (DSHE).

In 2003, the NRC determined that the Bush River Rad Yard site (which will be referred to as "the Rad Yard" for the remainder of this report) was controlled under NRC license number 19-10306-01, which is held by the U.S. Army Research Development and Engineering Command (RDECOM), formerly the Edgewood Chemical Biological Center (ECBC), U.S. Army Soldier and Biological Chemical Command (SBCCOM). Activities at the Rad Yard were terminated in 2007 and the licensee decided to remove the site from its license. This Final Status Survey Plan (FSSP) follows guidance in the *Multi-Agency Radioactive Survey and Site Investigation Manual* (MARSSIM) (NRC, 2002) and *Consolidated NMSS Decommissioning Guidance* (NUREG-1757) (NRC, 2003) in describing the pathway by which that license action will be supported. The objective of this FSSP is to have the Rad Yard site removed from NRC control under the RDECOM license by December 2008. Control of other sites and activities under license number 19-10306-01 may continue, and the termination of that license is not part of this project goal. These activities are not intended to address regulatory control of the site by any other state or federal agencies.

This FSSP documents the history and current condition of the site, provides a statistical evaluation of characterization data from the site in accordance with MARSSIM guidance, and describes the procedures and protocols for global positioning system (GPS)-supported instrument surveys, sample collection, and laboratory analyses. The status of the Rad Yard site at the time of this FSSP is as follows: (1) site monitoring data indicate there is no groundwater contamination; (2) contamination is expected only in surface soils; (3) there is no license condition requiring a decommissioning plan for the site; and (4) the residual soil concentrations for cesium (Cs)-137 and cobalt (Co)-60 are well below the NRC screening values and the trigger values listed in a Memorandum of Understanding (MOU) between the NRC and the U.S. Environmental Protection Agency (EPA).

This plan confirms two contaminants of concern (COCs), and cleanup criteria are set at 5.0 picocuries per gram (pCi/g) for Cs-137 and 0.5 pCi/g for Co-60. These criteria are less than the NRC screening values that are applicable for the site, and are demonstrated in this plan to meet as low as reasonably achievable (ALARA) requirements. The plan specifies 13 survey units, each with an area of less than 2,000 square meters (m^2), and a total of 15 samples to be collected from each survey unit. Some of the data from soil samples collected during recent field activities at the site meet the qualifications of the FSSP and a strategy is proposed for using those samples to reduce slightly the number of new samples and analyses required to fulfill the data requirements for the Final Status Survey (FSS). Table 1-1 provides a crosswalk by which each FSSP requirement listed in NUREG-1757 can be compared to the appropriate section in the plan.

Table 1-1
Crosswalk of NUREG-1757 Requirements to FSSP Sections

Requirement as Listed in NUREG-1757, Vol 1, Appendix D, Section D.2	FSSP Section
I. Executive Summary	Section 1 - Executive Summary
II. Facility Operating History	Section 1 - Executive Summary; Section 2 - Site Description; Section 3 - Previous Investigations and Activities
III. Facility Description	Section 2 - Site Description; Section 4.3 Groundwater
IV. Radiological Status of the Facility	Section 1 - Executive Summary; Section 2 - Site Description; Section 3 - Previous Investigations and Activities; Section 4 - Characterization Data Summary for Current Site Conditions
V. Dose Modeling	N/A - see Section 5.1 - Contaminants of Concern and DCGL Determination Process
VI. Environmental Information	Section 1 - Executive Summary; Section 2 - Site Description; Section 3 - Previous Investigations and Activities
VII. ALARA Analysis	Section 5.1.4.3 - ALARA Analysis
VIII. Planned Decommissioning Activities	Section 1 - Executive Summary; Section 2 - Site Description; Section 3 - Previous Investigations and Activities
IX. Project Management and Organization	Section 2.5 - Regulatory Roles, Relationships, and Project Organization
X. Health and Safety Program	Section 2.5 - Regulatory Roles, Relationships, and Project Organization
XI. Environmental Monitoring and Control	Section 2.5 - Regulatory Roles, Relationships, and Project Organization
XII. Radioactive Waste Management Program	Section 2.5 - Regulatory Roles, Relationships, and Project Organization
XIII. Quality Assurance Program	Section 5.2 - Data Quality Objectives for Radiological Data; Section 5.5 - Procedures for Surveys and Sampling
XIV. Facility Radiation Surveys	Section 4 - Characterization Data Summary for Current Site Conditions; Section 5 - FSS Design
XV. Financial Assurance	N/A
XVI. Restricted Use/Alternate Criteria	N/A

2. SITE DESCRIPTION

2.1 SITE LOCATION

The Rad Yard, which covers approximately 5 acres, is located in the Bush River Study Area (BRSA) at the Edgewood Area of APG, MD, as shown in Figure 2-1, Rad Yard Site Map. The Rad Yard is part of Operable Unit (OU) 3 in the BRSA, which includes the Radioactive Material Disposal Facility (the Rad Yard), the 22nd Street Landfill, and the former Adamsite Storage Pit. The Rad Yard includes an open storage yard, two structures (Buildings E2354 and E2371), an abandoned underground storage tank (UST), an abandoned sump at the 22nd Street Landfill, the basement of Building E2364, and three concrete pads, which remain from the removal of Buildings E2366, E2368, and E2356 during the non-time critical removal action (NTCRA).

As depicted in Figure 2-2, Rad Yard Site Boundary, WESTON specifically limits the boundary of the Rad Yard site to the following:

- The area above groundwater.
- The dirt/gravel road to the south and west of the Rad Yard.
- The physical security measure separating the 22nd Street Landfill from the Rad Yard to the north.
- The physical security measure separating the Bush River from the Rad Yard to the east.

2.2 OPERATIONAL HISTORY

The Rad Yard, originally called the Toxic Gas Yard, was used for the consolidation, repackaging, and shipment of waste from the 1930s until 2002 (General Physics Corporation [GP], 2002). The site was built in 1931 as a storage facility for chemical warfare agents and ordnance. The Ton Container Steam-Out Facility (former Buildings E2366 and E2368) was used from the late 1930s to the 1950s or early 1960s for the decontamination of 1-ton containers used for storing chemical agents such as mustard, chloropicrin, and Lewisite. The facility was used for the management of military radioactive waste from the early 1960s until October 2002. During that time, a wide range of radionuclides were potentially processed, packaged, and temporarily stored at the Rad Yard, including tritium (H-3), Cs-137, Co-60, strontium (Sr)-90, and radium (Ra)-226, but site records are not conclusive in identifying all materials that were handled. Before 1985, wastes were received from military installations along the eastern United States for processing. After 1985, only small quantities of radioactive waste produced at APG were stored at the site. Since October 2002, no wastes have been stored at the Rad Yard and the site is currently not in use.

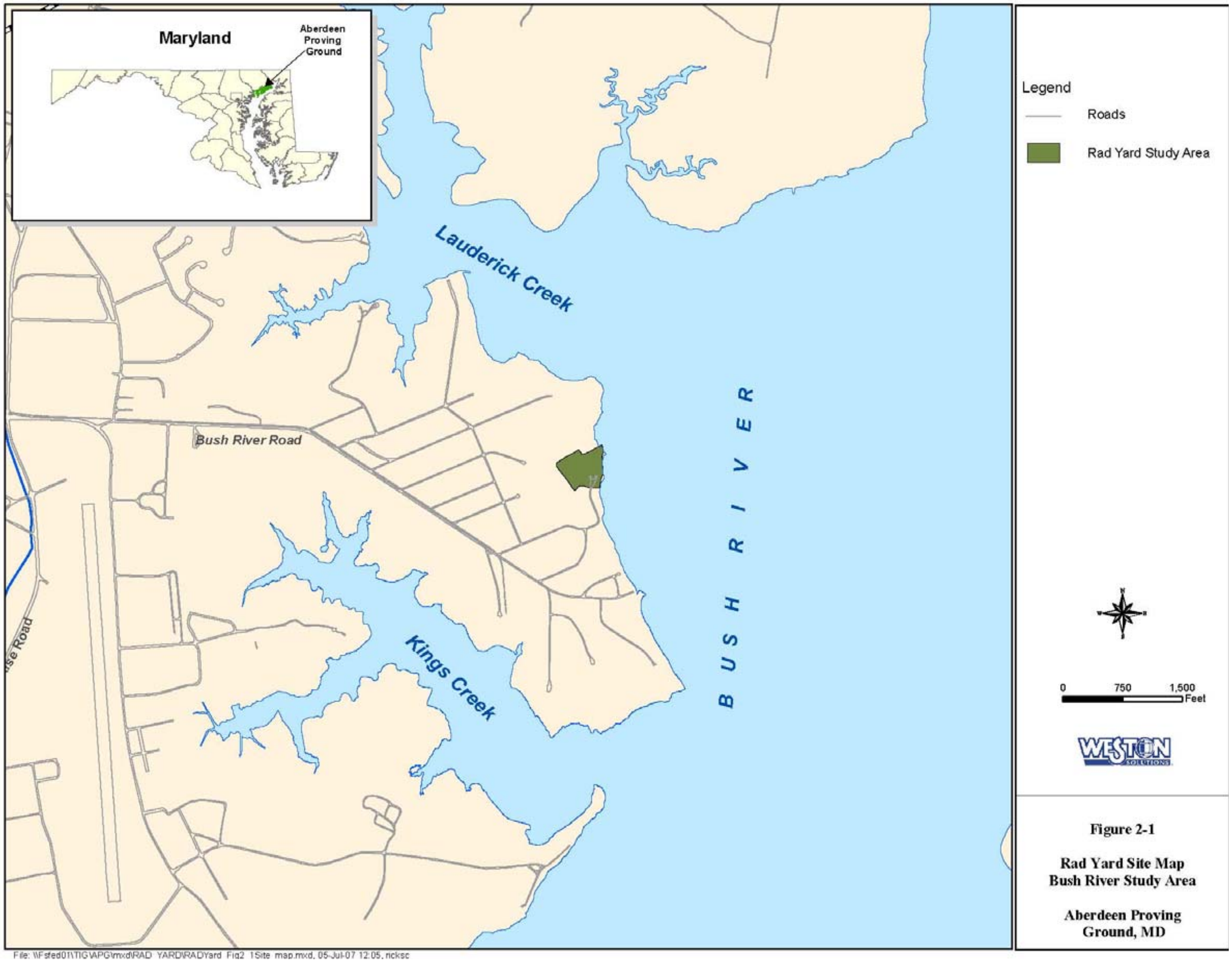


Figure 2-1 RAD Yard Site Map

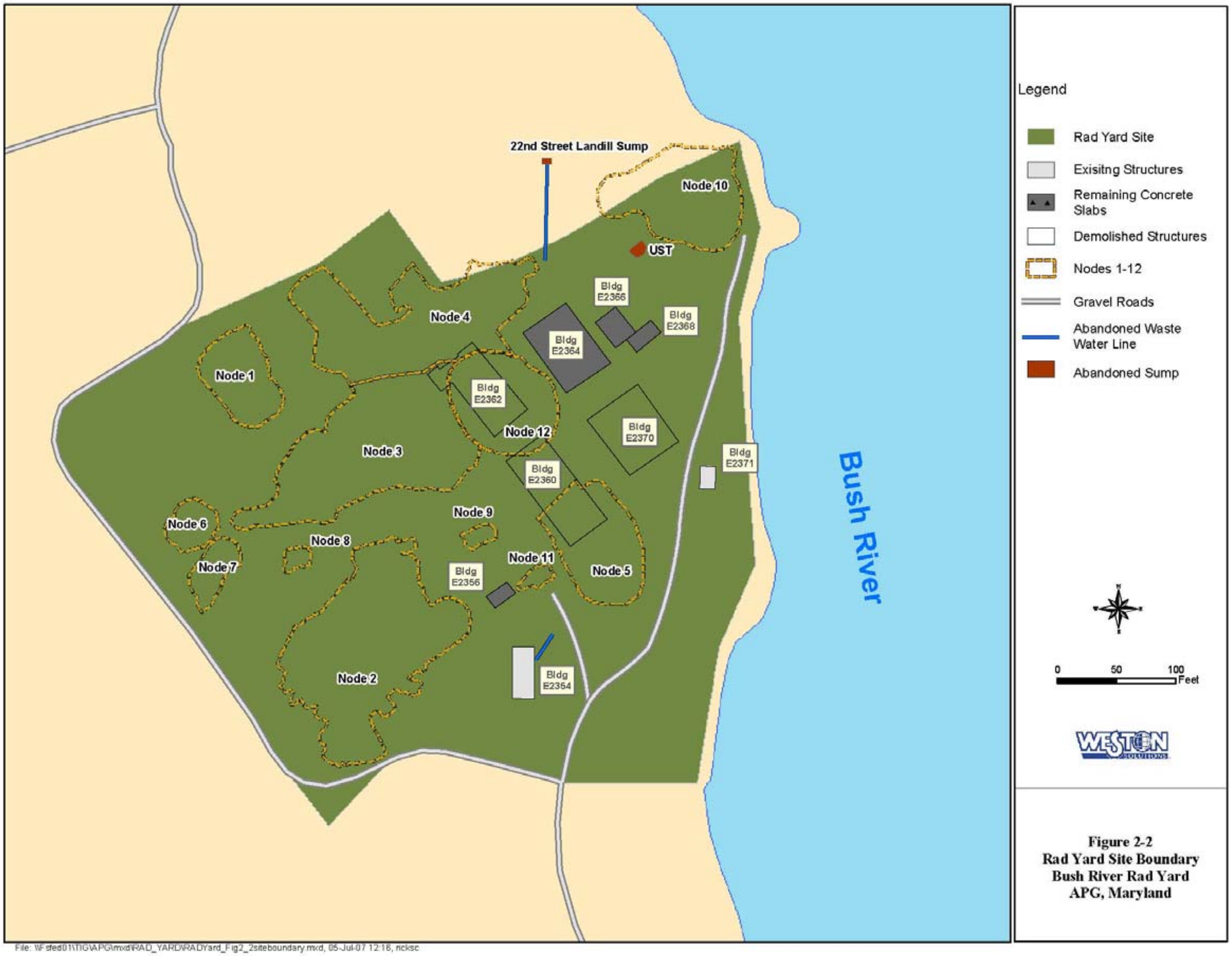


Figure 2-2 RAD Yard Site Boundary

2.3 SITE FEATURES AND NEARBY COMMUNITIES

The Rad Yard is located along the west bank of the Bush River on a small peninsula between Lauderick Creek and Kings Creek. The site elevation is slightly above the level of the Bush River with no significant landmarks, and as a result the depth to groundwater is generally less than 20 feet. The site consists primarily of soil typical for the region with some areas covered by rock that has been laid down on the site to provide a base for vehicle traffic and for storage during past operational activities.

The Rad Yard is part of the Edgewood Arsenal property and is several miles within the arsenal site fence line. The site is expected to always be part of the arsenal and be used for military and research purposes. There are some residences on the arsenal property, but none are near the site. Several small communities are located north of the arsenal and the nearest to the site is Edgewood, MD, less than 5 miles from the northern boundary of the arsenal. Baltimore, MD, is the largest city near the site and is approximately 30 miles to the west.

2.4 POTENTIALLY IMPACTED AREAS

As described in Subsection 2.1 and depicted in Figure 2-2, the boundary of the Rad Yard is specifically limited to the dirt/gravel road on the southern and western boundaries of the Rad Yard, the physical security measure separating the 22nd Street landfill from the Rad Yard on the north, and the Bush River physical security measure on the east. Radioactive materials were handled at the Rad Yard under NRC license number 19-10306-01, which has covered numerous activities conducted over a long time period at a variety of sites at the APG. As a result, all Rad Yard areas are considered to be potentially impacted.

Activities involving radioactive materials that were unrelated to the Rad Yard activities have been documented at areas near the Rad Yard, such as the 26th Street Dump site and the 22nd Street Landfill sites. Prior studies and the recent removal action have focused on conditions clearly related to licensed activities at the Rad Yard. At the same time, measurements such as general gamma spectroscopy and H-3 analyses were performed to detect radioactive contamination that could have resulted from past activities at other nearby sites. In addition, any contamination that started on-site and extended beyond the initial site boundaries was identified and removed during the removal action. In that manner, unexpected contaminants would be detected if present, and contamination caused by site activities that may have migrated off-site would be identified and removed if present. The area defined herein as the Rad Yard comprehensively includes all related impacted areas and is consistent with the areas that were included under the site removal activities. This plan includes no characterization data outside the site perimeter, and makes no representation as to the potential radiological contamination unrelated to Rad Yard activities that might be present outside this footprint.

2.5 REGULATORY ROLES, RELATIONSHIPS, AND PROJECT ORGANIZATION

2.5.1 Responsible Parties

Past activities involving radioactive materials had been performed for decades by a wide range of site occupants at the Rad Yard. The NRC determined that recent activities were conducted under NRC license number 19-10306-01, which was held by the RDECOM. DSHE is responsible for planning and conducting environmental activities at the Edgewood Area.

WESTON conducts site activities at the Rad Yard under contract to DSHE, and maintains an indirect reporting relationship with the RDECOM radiation safety officer to ensure that site activities are in compliance with license requirements. WESTON maintains Project Manager, Site Engineer, and Certified Health Physicist (CIH) positions for this project. The Project Manager is responsible for the overall project performance. The Site Engineer is responsible for daily site activities, and the Health Physicist provides radiation safety support as well as technical support. WESTON maintains its corporate safety programs and interfaces with existing client safety programs during on-site activities. WESTON also maintains corporate radiation safety programs under its radiological services license granted by the New Mexico Environment Department (NMED) Bureau of Radiation Protection. Project-specific implementation of those corporate programs is ensured through development of a Site-Specific Safety and Health Plan (SSSHP) and compliance with its requirements. The SSSHP that was developed by WESTON, approved by DSHE and RDECOM, and implemented during the removal action will be revised as necessary and used for the FSS activities.

The SSSHP addresses both occupational, environmental, and waste management issues and requirements. Concentrations of COCs are at or very near background levels at the Rad Yard, and effluent controls, monitoring, and waste disposal concerns will be minimal.

2.5.2 License Authority

The NRC identified license number 19-10306-01 as having authority over past activities at the Rad Yard. That license authorized storage and treatment of radioactive material at the site and was held by RDECOM, formerly the ECBC SBCCOM. Therefore, RDECOM was the responsible party for actions associated with the site under the scope of the NRC license and for changes in the license status for this site.

2.5.3 Regulatory Agencies

An NTRCRA at the Rad Yard fell under dual regulatory agency oversight because both radioactive (Co-60 and Cs-137) and hazardous arsenic (As) contaminants were present. The NRC provided radiological oversight while EPA and the Maryland Department of the Environment (MDE) provided oversight of hazardous materials. Initial focus was placed on the removal of radioactive materials when it was determined that removal of the radioactive contaminants to the cleanup levels established in the Human Health and Radiological Risk Assessment (HHRRA) (GP, 2002b) could be cost-effectively performed and verified while ensuring that the As contamination levels would be significantly reduced. With concurrence from EPA, NRC assumed a primary oversight role during the removal action to ensure compliance with radiation safety regulations in Title 10 Code of Federal Regulations (CFR)

Chapter 20 (10 CFR 20) and the RDECOM license requirements. With the advent of this FSSP, NRC's role will expand to include partial site decommissioning and removal of the Rad Yard from the RDECOM license.

3. PREVIOUS INVESTIGATIONS AND ACTIVITIES

3.1 ADAMSITE STORAGE VAULT REMOVAL ACTION (FOSTER WHEELER, 1995-1996)

The Adamsite Storage Vault Removal Action was performed between July 1995 and September 1996 under the Installation Restoration Program (IRP). Prior to that removal action, a preliminary site investigation was conducted by the U.S. Army Corps of Engineers (USACE), Baltimore District (CENAB) in 1976, which included the collection of soil borings around the building, which were analyzed for As. The results indicated that As was present at concentrations up to 65 ppm.

In May 1992, GP sampled sediment and water in the northeast vault for Target Analyte List/Target Compound List (TAL/TCL) parameters and gross alpha and gross beta contamination. Several chemicals were present in sediment samples including As, lead (Pb), copper (Cu), chromium (Cr), barium (Ba), and cyanide. Radiological parameters were not reported to be elevated.

In August 1993, WESTON performed a field investigation in and around the Adamsite vaults. Samples were collected from sediment and water remaining in the vaults, soil surrounding the vaults, groundwater under the vaults, and the vault concrete. Samples were analyzed for Toxicity Characteristic Leaching Procedure (TCLP) parameters and surface samples were found to contain polychlorinated biphenyls (PCBs), As, and beryllium (Be). Groundwater samples contained low levels of volatile organic compounds (VOCs) and Be.

In August 1995, Foster Wheeler Environmental conducted an in-depth radiological assessment of the area in order to determine the radiological condition of the soil at the vaults and determine if soil remediation was required. The assessment included establishment of sampling grids at the site, determination of background levels, a walkover gamma survey, and the collection and analysis of soil samples. It was determined that two very small areas of surface soil near the vaults were contaminated slightly above background and would have to be packaged and disposed of as the removal action took place. The total excavated area was about 20 square feet (ft^2) and the total volume was less than 1 cubic yard (yd^3). A detailed discussion of all previous sampling results is included in the *Final Technical Report, Adamsite Storage Vaults Removal Action*, Subsection 1.2, Previous Investigations, dated January 1997 (FW, 1997).

Based on these previous investigations, the removal action at the Adamsite vaults included removal of the contaminated soil identified by Foster Wheeler Environmental, removal of existing water and sediment from the vaults, removal of the existing structure, and backfilling the vaults with stone. The extensive gamma surveys and soil sample analyses described in the Adamsite vaults final report provide reasonable documentation that radioactive contamination was minimal in that area, that it existed only in the surface soil, that the vault surfaces were not contaminated, and that the contaminated soils were properly removed from the site.

3.2 REMEDIAL INVESTIGATION (GP, 2002A)

The *Southern Bush River Remedial Investigation Report* (GP, 2002a) presents the site background, technical approach, environmental field studies and laboratory results, Baseline Risk Assessment, and recommended future actions for several sites found in the Bush River Study Area, including the Cluster 11 Eastern Chemical Depot Area, which contains the Rad Yard. The remedial investigation (RI) served as the mechanism to collect data for site characterization, determine the nature and extent of contamination, evaluate contaminant fate and transport, and assess potential risks to human health and the environment. Work conducted for the RI included geophysical investigations, passive soil gas surveys, groundwater monitoring well installation, removal actions, and sampling of groundwater, surface water, sediment, surface soil, and sludge. Samples were analyzed to evaluate the possible presence of contaminants including radionuclides. Preliminary removal action investigations identified radiological contamination in the soil north and west of the former Adamsite Storage Vault and in water and sediment material associated with two concrete sumps inside of Building E2364.

3.3 ENGINEERING EVALUATION/COST ANALYSIS (GP, 2003)

In February 2003, an engineering evaluation/cost analysis (EE/CA) was conducted by GP to present a comparative analysis and selection of non-time-critical removal options proposed at the Rad Yard. Two alternatives, “no action” and “excavation and disposal,” were evaluated based on the ability to provide an effective interim remedy consistent with the anticipated final remediation goals for the Rad Yard under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The “excavation and disposal” alternative was selected as the preferred alternative because it would be protective of human health and the environment, meet the risk-based remediation goals, satisfy the short- and long-term goals, and reduce the quantity of radioactive wastes on-site. Additionally, the “excavation and disposal” alternative could be implemented with readily available equipment and materials and would not require ongoing land use controls (LUCs) and/or maintenance. The EE/CA defined several specific locations at the Rad Yard where soil contamination existed. Those locations were the focal points of the NTCRA performed in the period from 2004 to 2006.

3.4 FOCUSED FEASIBILITY STUDY (GP, 2004)

In February 2004, GP completed the report, *Southern Bush River Focused Feasibility Study (FFS) Data Report for Operable Unit 3 – Ton-Container Steamout Site, Bush River Radioactive Material Disposal Facility, 22nd Street Landfill, and Northern Groundwater Plume*. This report documents the methodology and analytical results for two phases of FFS field activities associated with the Toxic Gas Yard Ton-Container Steamout Site, the Rad Yard, the 22nd Street Landfill, and the northern VOC plume. Work conducted for the FFS included topographical mapping; geographical surveys; radiological surveys of the Rad Yard; collection of radiological wipe, wastewater, sludge, surface water, sediment, subsurface soil profile, subsurface soil, and groundwater samples; soil vapor surveys; and landfill gas monitoring. This work was conducted in order to address data gaps identified in the FFS Work Plan, Southern Bush River (Earth Tech, 1998), and the Phase II Addendum to the FFS Work Plan for Southern Bush River (GP, 1999).

3.5 HUMAN HEALTH RADIOLOGICAL RISK ASSESSMENT (GP, 2002B)

The *Human Health Radiological Risk Assessment: Radioactive Waste Management Facility* (GP, 2002b) was completed by GP to estimate levels of risk associated with radionuclides at the site and remedial goal options. The remedial goal options were designed for the removal of the Rad Yard from the NRC license and to meet the requirements of CERCLA. COCs were identified and contaminant concentrations were estimated from existing data, and four hypothetical land use scenarios were evaluated using exposure factors consistent with the EPA default factors. Remedial levels for Cs-137 and Co-60 were created to be protective of both human health and ecological health, as well as comply with federal and state requirements. The risk-based remedial goal options were developed in consideration of EPA exposure assumptions for suburban residents and industrial workers. Calculations used the procedures and equations of the EPA documents *Soil Screening Guidance for Radionuclides: User's Guide,* and *Soil Screening Guidance for Radionuclides: Technical Background Document* (EPA, 2000a and 2000b) as presented in Subsection 5.3 of the human health radiological risk assessment (HHRRA). Various remedial goal options and clean-up levels for Cs-137 and Co-60 are evaluated in the HHRRA. The recommended remedial goals for restricted future use were 5.0 pCi/g for Cs-137 and 1.0 pCi/g for Co-60. These levels would be protective of ecological receptors and a total risk to industrial workers exposed to these levels would be 1×10^{-4}.

3.6 NON-TIME CRITICAL REMOVAL ACTION (WESTON, 2006)

Between October 2004 and November 2006, WESTON conducted an NTCRA at the Rad Yard in accordance with the specifications of the EE/CA. The primary objective of this removal action was to demolish contaminated structures and excavate and arrange disposal of radioactive (Cs-137 and Co-60) and hazardous (As) contaminated soils and other associated materials. This removal action was considered an interim remedy to facilitate future remediation at the BRSA under CERCLA, but was not conducted as an NRC decommissioning project. Contaminated structures were demolished and removed; soils and materials were excavated and disposed of; soil verification and characterization samples were collected and analyzed for Cs-137, Co-60 and As; and radiological surveys of remaining concrete foundations and the entire site were conducted. All soil characterization samples and radiological surveys of remaining concrete foundations were below the established action levels. The removal action is described, and results of in situ measurements and sample analyses are provided in the *Bush River Study Area Removal Action Report for Non-Time Critical Removal Action, Radioactive Waste Management Facility, Final,* January 2007 (WESTON, 2007).

All verification samples collected from the excavated areas contained Cs-137 and Co-60 at concentrations less than the cleanup criteria. As will be demonstrated in Subsection 4.1 of this FSSP, if all of the verification measurements, both samples and in situ measurements, were evaluated using MARSSIM-like protocols, the excavated areas would have passed the release criteria.

4. CHARACTERIZATION DATA SUMMARY FOR CURRENT SITE CONDITIONS

The purpose of this section is to present data collected during the previous investigations discussed in Section 3. The data were broken down by media for clarity: soil, concrete structures, and groundwater. The following subsections describe the activities and provide the relevant characterization data collected during the removal action and prior investigations.

4.1 SURFACE SOIL

Soil data were collected and analyzed for Cs-137 and Co-60 during the Southern Bush River RI (GP, 2002a), the Adamsite Storage Vaults Removal Action (FW, 1997), the Southern Bush River FFS in (2004), and the NTCRA (2005). A total of 269 soil samples have been collected at the Rad Yard over the past 13 years. These samples were analyzed for organic, inorganic, and radionuclide contamination, but for the purpose of this plan focus has been placed on Cs-137 and Co-60.

The following subsection describes and interprets the characterization measurements taken during the removal action that represent the current status of the site. This interpretation looks at the data, both soil sample analyses and in situ measurements, and evaluates the data as if a MARSSIM-like FSS had been performed across the excavation nodes. FSS data will be collected from survey units over the entire Rad Yard site, not just the excavated areas. However, the data collected during the FSS and the statistical tests used to evaluate the data will be similar to that described below.

4.1.1 Soil Sample Measurements

As shown in Table 4-1, Characterization Soil Sample Radionuclide Results, the Co-60 and Cs-137 analytical results for all 84 characterization samples collected during the removal action of the Rad Yard are below the derived concentration guideline level ($DCGL_w$). The Co-60 analytical results were below the detection limit for the analysis, and analytical results for Cs-137 ranged from -0.28 (or 0) to 4.71 pCi/g. MARSSIM states that if the largest measurement is below the $DCGL_w$, in this case 5 pCi/g for Cs-137, then application of the Sign test will always show that the survey unit meets the release criterion.

4.1.2 In Situ Measurements

Table 4-2, Characterization Sample and Measurement Data, compares the characterization soil sample results with the surface soil concentrations estimated from stationary and scanning in situ measurements collected over the nodes during the removal action. These two in situ techniques are:

1. Static 1-minute integrated in situ measurements collected at approximately 10 foot (ft) spacing using a 2-inch x 2-inch sodium iodide (2x2 NaI) detector held approximately 6 inches above the soil surface, coupled to a scaler. The instrument was adjusted to detect gamma rays of energy greater than about 50 kiloelectron-volt (keV). Measurement locations were accurately located by a differentially corrected GPS.

Table 4-1
Characterization Soil Sample Radionuclide Results

Sample Identification (ID)	Sample Results							
	Co-60			Minimum Detectable Activity (MDA)	Cs-137			MDA
	(pCi/g)							
Removal Action Report, January 2007								
EC-N1-001-F-1-1-0	-0.0190	±	0.0278	0.0456	-0.00202	±	0.0270	0.0475
EC-N1-002-F-1-1-0	0.0151	±	0.0709	0.134	0.183	±	0.0841	0.111
EC-N1-003-F-1-1-0	0.0191	±	0.0657	0.126	0.432	±	0.137	0.119
EC-N1-004-W-1-1-0	-.0111	±	0.0560	0.102	0.372	±	0.0991	0.0957
EC-N1-005-W-1-1-0	0.0179	±	0.0524	0.104	0.595	±	0.1120	0.0994
EC-N1-006-W-1-1-0	-0.0203	±	0.0443	0.0755	0.463	±	0.1110	0.0724
EC-N1-007-W-1-1-0	-0.0186	±	0.0589	0.104	0.155	±	0.0845	0.1010
EC-N2-001-1T-1-1-0	0.0184	±	0.0295	0.0570	0.240	±	0.0658	0.0473
EC-N2-009-F-1-0-0	0.000528	±	0.0378	0.0669	0.418	±	0.0883	0.0644
EC-N2-012-F-1-0-0	0.0211	±	0.0250	0.0480	0.347	±	0.0694	0.0468
EC-N2-014-F-1-0-0	-0.0154	±	0.0463	0.0832	0.421	±	0.104	0.0763
EC-N2-017-F-1-0-0	-0.0630	±	0.0514	0.0815	0.438	±	0.111	0.0837
EC-N2-018-F-1-1-0	0.0220	±	0.0759	0.1430	0.154	±	0.0890	0.106
EC-N2-019-F-1-1-0	-0.0298	±	0.0361	0.0582	0.0798	±	0.0490	0.0567
EC-N2-020-F-1-1-0	-0.00948	±	0.0508	0.0908	1.370	±	0.219	0.0948
EC-N2-021-F-1-1-0	0.0288	±	0.0662	0.1280	0.785	±	0.1340	0.1080
EC-N2-022-F-1-1-0	-0.0124	±	0.0361	0.0624	3.90	±	0.397	0.0737
EC-N2-023-F-1-1-0	0.00250	±	0.0211	0.0393	0.231	±	0.0622	0.0386
EC-N2-024-F-1-1-0	0.0235	±	0.0632	0.1250	0.0504	±	0.0614	0.122
EC-N2-025-F-1-1-0	0.0331	±	0.0356	0.0623	7.65	±	0.7230	0.0532
EC-N2-026-F-1-1-0	-0.0152	±	0.0449	0.0783	0.266	±	0.101	0.0744
EC-N2-027-W-1-1-0	0.0522	±	0.0502	0.113	0.663	±	0.138	0.112
EC-N2-028-W-1-1-0	-0.00917	±	0.0348	0.0612	0.980	±	0.135	0.0568
EC-N2-029-W-1-1-0	0.00582	±	0.0267	0.0529	0.524	±	0.0942	0.0493
EC-N2-030-W-1-1-0	0.00212	±	0.0609	0.102	1.610	±	0.2130	0.0874
EC-N2-031-W-1-1-0	0.00318	±	0.0235	0.0435	0.460	±	0.0704	0.0357
EC-N2-HAS-F-4-1-1	.o288	±	0.0588	0.1130	0.200	±	0.0860	0.1040
EC-N3-001-F-1-1-0	0.0148	±	0.0762	0.1430	0.00896	±	0.0657	0.1230
EC-N3-002-F-1-1-0	-0.00469	±	0.0276	0.0485	1.75	±	0.217	0.0502
EC-N3-003-W-1-1-0	0.0211	±	0.0360	0.0658	0.109	±	0.0751	0.0532
EC-N3-004-W-1-1-0	0.0120	±	0.0370	0.0710	4.80	±	0.5530	0.0767
EC-N3-006-W-1-1-0	-0.0228	±	0.0506	0.0885	1.66	±	0.217	0.0933
EC-N3-007-W-1-1-0	0.0127	±	0.0236	0.0453	3.21	±	0.3640	0.0453
EC-N3-008-W-1-1-1	0.00166	±	0.0450	0.0698	0.129	±	0.0634	0.0651
EC-N3-009-F-1-1-0	0.00149	±	0.0552	0.1070	1.55	±	0.212	0.116
EC-N3-010-F-1-1-0	0.00285	±	0.0395	0.0702	-0.00344	±	0.0350	0.0623
EC-N3-011-F-1-1-0	-0.0225	±	0.0485	0.0845	0.0217	±	0.0621	0.1150
EC-N3-012-F-1-1-0	0.0476	±	0.0504	0.102	3.820	±	0.4580	0.0957
EC-N3-013-W-1-1-0	0.00327	±	0.0392	0.0689	1.62	±	0.220	0.0571
EC-N3-017-F-1-1-0	0.0323	±	0.0563	0.102	-0.0266	±	0.0481	0.0799
EC-N4-001-F-1-1-0	-0.00430	±	0.0631	0.115	0.358	±	0.120	0.0957
EC-N4-002-F-1-1-0	0.00954	±	0.0443	0.0788	-0.280	±	0.0756	0.0731
EC-N4-003-W-2-2-0	-0.0235	±	0.0425	0.0695	0.139	±	0.0611	0.0744
EC-N4-004-F-1-1-0	0.000	±	0.0325	0.0611	0.710	±	0.1200	0.0558
EC-N4-006-F-1-1-0	0.0000650	±	0.0195	0.0338	1.14	±	0.149	0.0349
EC-N4-007-W-1-1-0	0.0339	±	0.0492	0.0934	0.0823	±	0.0628	0.0820
EC-N4-008-F-1-1-0	0.0653	±	0.0624	0.0789	-.141	±	0.0736	0.0969
EC-N4-009-W-1-1-0	0.0261	±	0.0625	0.1180	2.99	±	0.370	0.0898

Table 4-1
Characterization Soil Sample Radionuclide Results
(Continued)

Sample Identification (ID)	Sample Results							
	Co-60			Minimum Detectable Activity (MDA)	Cs-137			MDA
	(pCi/g)							
EC-N4-010-W-2-2-0	0.005	±	0.0444	0.0771	1.99	±	0.217	0.0709
EC-N4-011-F-1-1-0	-000620	±	0.0385	0.0669	-0.171	±	0.0656	0.0777
EC-N4-012-W-2-2-0	0.0102	±	0.0411	0.0744	2.52	±	0.310	0.0722
EC-N5-001-F-1-1-0	0.00867	±	0.0254	0.0475	0.323	±	0.0650	0.0424
EC-N5-002-F-1-1-0	0.00940	±	0.0524	0.0957	0.06380	±	0.0513	0.0986
EC-N5-003-F-1-1-0	0.0000964	±	0.0326	0.0602	0.00913	±	0.0381	0.0660
EC-N5-004-F-1-1-0	0.00933	±	0.0514	0.0941	0.146	±	0.0674	0.0798
EC-N5-005-F-1-1-0	0.00420	±	0.0308	0.0579	0.0354	±	0.0359	0.0658
EC-N5-006-F-1-1-0	-0.0233	±	0.0427	0.0711	0.556	±	0.106	0.0657
EC-N5-007-F-1-1-0	0.0120	±	0.0486	0.0899	0.509	±	0.113	0.0784
EC-N5-008-F-1-1-0	-0.00173	±	0.0362	0.0659	0.0338	±	0.0355	0.0648
EC-N6-001-W-1-1-0	0.0156	±	0.0442	0.0844	0.728	±	0.132	0.0745
EC-N6-002-W-1-1-0	0.00857	±	0.0528	0.102	0.594	±	0.111	0.0928
EC-N6-003-F-1-1-0	0.0291	±	0.0465	0.0912	0.0318	±	0.0446	0.0863
EC-N6-004-F-1-1-0	0.0478	±	0.0622	0.128	0.0146	±	0.0647	0.120
EC-N7-001-F-1-1-0	0.0103	±	0.0241	0.0471	0.251	±	0.0500	0.0438
EC-N7-002-F-1-1-0	-0.00477	±	0.0494	0.0884	0.0894	±	0.0646	0.0931
EC-N7-003-W-1-1-0	0.0101	±	0.0359	0.0749	0.774	±	0.123	0.0716
EC-N7-004-W-1-1-0	0.0153	±	0.0258	0.0545	2.77	±	0.321	0.0471
EC-N8-001-F-1-1-0	-0.0219	±	0.0321	0.0529	0.160	±	0.0710	0.0611
EC-N8-002-W-1-1-0	0.00291	±	0.0490	0.0933	0.315	±	0.108	0.0800
EC-N9-001-F-1-1-0	0.031	±	0.0468	0.0889	-0.0299	±	0.0464	0.0774
EC-N9-003-W-2-1-0	0.00287	±	0.0242	0.0433	0.154	±	0.0371	0.0422
EC-N0-001-F-1-1-0	-0.0454	±	0.0511	0.0818	0.101	±	0.0626	0.0888
EC-N0-002-F-1-1-0	0.00982	±	0.0201	0.0382	2.59	±	0.2720	0.0401
EC-N0-003-F-1-1-1	-0.00153	±	0.0304	0.0536	0.534	±	0.0923	0.0449
EC-N0-004-F-1-1-0	-0.00556	±	0.0221	0.0392	1.58	±	0.1860	0.0377
EC-N11-001-F-1-1-0	0.00738	±	0.0250	0.0442	0.119	±	0.0505	0.0407
EC-N11-002-W-1-1-0	0.0191	±	0.0410	0.0752	0.141	±	0.0561	0.0684
EC-N11-005-F-2-1-0	-0.000332	±	0.0274	0.0479	0.0600	±	0.0322	0.0606
EC-N11-006-F-2-1-0	0.0158	±	0.0265	0.0484	3.50	±	0.390	0.0431
EC-N12-001-F-1-1-0	0.0123	±	0.0384	0.0694	0.555	±	0.100	0.0675
EC-N12-002-F-1-1-0	0.0103	±	0.0380	0.0616	0.953	±	0.119	0.0524
EC-N12-003-F-1-1-0	-0.0229	±	0.0710	0.121	1.07	±	0.182	0.106
EC-N12-004-W-1-1-0	-0.000544	±	0.0322	0.0398	4.34	±	0.358	0.0410
EC-N12-005-W-1-1-0	-0.0326	±	0.0415	0.0666	4.71	±	0.407	0.0702

Table 4-2Characterization Sample and Measurement Data

Node	Soil Samples (pCi/g)					1-Minute Stationary Counts (pCi/g)				Scanning Survey (pCi/g)			
	No. Samples Analyzed	Co-60 Range	Cs-137 Range	Average	σ	No. Measurements	Range	Average	σ	No. Records	Range	Average	σ
1	7	0	0-0.6	0.3	0.2	51	0-3.6	0.5	0.6	1,061	0-5.6	0.6	0.9
2	20	0	0-3.9	0.7	0.9	210	0-4.1	0.6	0.9	12,799	0-6.3	0.5	0.8
3	13	0	0-4.8	1.4	1.5	125	0-4.9	1.3	1.1	5,288	0-6.9	1.1	1.1
4	12	0	0-2.5	0.9	1.1	98	0-4.5	1.3	1.1	5,946	0-6.0	0.8	1.1
5	8	0	0-0.6	0.2	0.3	55	0-2.3	0.7	0.7	2,608	0-7.6	0.8	0.9
6 & 7	8	0	0-2.8	0.7	0.9	73	0-3.4	0.5	0.8	1,569	0-5.4	0.6	0.9
8	2	0	0.2-0.3	0.3	0.1	9	0-1.7	0.4	0.6	363	0-1.7	0.3	0.7
9	2	0	0-0.2	0.1	0.1	12	0-2.3	0.6	0.7	946	0-3.6	0.3	0.6
10	4	0	0.1-2.6	1.4	1.0	105	0-5.1	1.1	1.3	2,570	0-6.3	0.7	1.1
11	4	0	0-3.5	0.9	1.7	15	0-3.8	0.8	1.3	888	0-3.6	0.3	0.6
12	5	0	0.6-4.7	2.3	2.0	79	0-4.9	1.2	1.2	NA	NA	NA	NA

(NA - Not Applicable)

2. Radiological data maps of the gamma-ray emission rate for areas between each static measurement location were generated using a scanning technique. In this technique, the technician carried a 2x2 NaI detector held approximately 18 inches above the soil surface, coupled to a ratemeter and GPS. The technician walked across the node at approximately 1.5 feet per second (fps), with transect spacing of about 3 ft. Gamma-ray count rates were data-logged at 2-second intervals, and tagged to a location identified by GPS.

An empirical method was used to estimate the residual concentration of Cs-137 from the static and scanning gamma-ray count rate measurements. A correlation study was performed on the data collected from each node, which compared the soil characterization sample results to the gamma-ray count rate measurements. The locations and estimated residual soil concentrations from the static and scanning surveys are depicted in Figures 2-4 through 2-14 in the final removal action report (WESTON, 2007), and are summarized in Table 4-2.

One-minute stationary in situ measurements were collected at 832 locations over the nodes. The estimated concentrations of Cs-137 as calculated from the 1-minute stationary measurements in 11 of the 12 nodes were all below the $DCGL_w$. Therefore, the Sign test would show that the nodes would meet the release criterion. In node 10, 105 1-minute stationary measurements were collected. The estimated Cs-137 concentration at one location was 5.1 pCi/g, which exceeds the release criterion. The median concentration over this node is 1.1 pCi/g, and the standard deviation of the 105 data points is 1.3 pCi/g. Therefore, MARSSIM recommends that the Sign test and an elevated measurement comparison (EMC) be performed.

Applying the Sign test to these 105 data points, the relative shift calculates as:

$$\begin{aligned} \text{Relative Shift} &= (\text{DCGLw-Lower Bound Gray Region [LBGR]})/\sigma \\ &= (5.0\text{-}1.1)/1.3 \\ &= 3 \end{aligned}$$

Using type I and type II decision errors of 0.05 each, the required minimum of measurement points, taken from MARSSIM Table 5.5, is 14, inclusive of the additional 20% in measurement numbers recommended by MARSSIM. Because 105 measurements were actually collected over this node, this number exceeds the minimum number required. Subtracting each measurement from the DCGL, and counting the positive differences generates the test statistic "S+." The value of "S+" is 104. For the case where N = 105, and $\alpha = 0.05$, the Sign test critical value is interpolated from MARSSIM (NRC, 2002), Table I.3, as 63. Because "S+" exceeds the critical value, the null hypothesis that the survey unit (node) exceeds the release criterion is rejected, and therefore, the node passes.

The EMC is not conclusive as to whether the survey unit (node) meets or exceeds the release criterion, but is a flag or trigger for further investigation. The EMC compares each measurement with the investigation level determined by scanning measurements. Any measurement that exceeds the investigation level indicates an area that should be investigated further, regardless of the outcome of the Sign test. The DCGL for the EMC is:

$$DCGL_{emc} = \text{Area factor x } DCGL_w$$

As stated previously, the transects applied during the scanning survey of the nodes during the removal action were spaced 3 ft (1 meter [m]) apart, the scanning speed was 1.5 fps, and data were logged every 2 seconds. This results in a scanning area of approximately 1 square meter (m^2). Table 5.6 of MARSSIM provides an Area Factor of 11.0 for Cs-137 assuming a scanning area of 1 m^2. Given the $DCGL_w$ is 5.0 pCi/g, the $DCGL_{emc}$ calculates to be 55 pCi/g. The minimum detectable concentration (MDC) for this technique as calculated in Subsection 5.5.1.2 of this report is 2 pCi/g. Because the actual scan MDC is less than $DCGL_{emc}$, no additional samples are necessary for assessment of small areas of elevated activity (MARSSIM, equation 5-3). The scanning technique exhibits adequate sensitivity to detect small areas of elevated activity.

During the scanning survey of the removal action nodes, small areas of elevated activity were identified and are depicted in Figures 2-4 through 2-14 of the removal action final report (WESTON, 2007). The range of residual soil concentrations as estimated from the scanning survey are presented in Table 4-2. The data in this table indicate that there may be small areas of residual elevated activity in nodes 1, 2, 3, 4, 5, 6, 7, and 10, with the highest concentration calculated to be 7.6 pCi/g. Reliable scanning data do not exist for node 12. Review of the figures, which depict the scanning results, indicates most nodes had elevated areas of 1 m^2. However, node 5 may have an area of elevated activity of 3 m^2. Applying an area factor of 5.0, taken from MARSSIM Table 5.6, the $DCGL_{emc}$ for this elevated area would be 25 pCi/g. Because the highest calculated concentration in this elevated area was 7.6 pCi/g, the node passes the release criterion. Node 10 may have an elevated area of 4 m^2. Interpolating the area factors in MARSSIM, Table 5.6, provides an area factor of 4.6, and results in a $DCGL_{emc}$ of 23 pCi/g. Because the highest calculated concentration in this elevated area was 6.3 pCi/g, the node passes the release criterion.

4.1.3 Scanning of Non-Excavated Areas and Nodes

Figure 4-1, APG Site Gamma Survey, depicts the results of a walk-over scan of available areas of the entire site conducted in May 2005, after the removal action of nodes 1 through 11 had been completed. Radioactive waste remained on node 12, therefore this area was not scanned, and shine from waste affected scanning measurements near the pile. Also, 10-ton lift liners filled with radioactive soil were still stored on the northwestern corner of the Rad Yard awaiting shipment to Envirocare (now Energy Solutions); therefore, scanning data were not available from this area as well. Since May 2005, the radioactive waste on node 12 and the 10-ton lift liners have been removed from the Rad Yard.

The scanning data were not interpreted in soil concentrations as was done for the above node data, but instead are shown here in counts per minute (cpm) units. Review of these scanning data shows that the gamma-ray activity emanating from theses areas of the Rad Yard is relatively uniform, and no significantly large elevated areas remain to be remediated. This conclusion supports the position that the Rad Yard is ready for an FSS to be conducted.

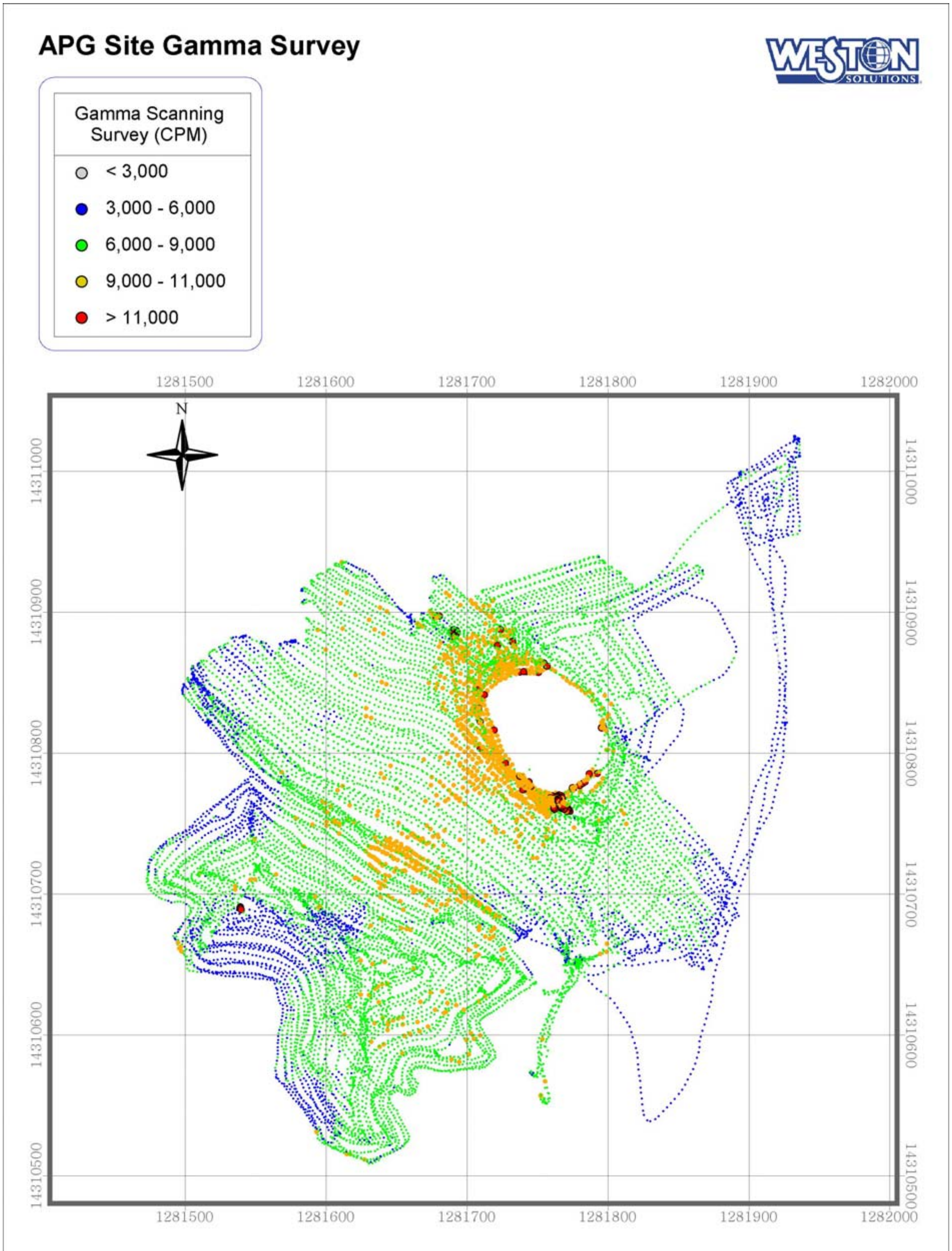


Figure 4-1 APG Site Gamma Survey

4.2 REMAINING CONCRETE STRUCTURES AND SLABS

Remaining structures at the Rad Yard are indicated in Figure 4-2, and include Building E2354 and Building E2371; concrete slabs from former Buildings E2356, E2366, and E2368; the abandoned 22^{nd} Street Landfill sump; an abandoned UST; and the basement to Building E2364. The abandoned 22^{nd} Street sump, the abandoned UST, the basement to Building E2364, and the concrete slab of former Building 2366 were comprehensively surveyed during the removal action according to the following protocol. Data demonstrating that these four structures that remain on-site meet the release criteria will be presented in the FSS Report.

Some characterization data, specifically five soil samples collected from beneath the concrete slabs for Buildings E2356 and E2368 during the removal action, are presented below. As discussed in Subsection 5.5.3, a surface contamination scanning survey will be performed over these concrete slabs during the FSS. No characterization currently exists for Buildings E2354 and E2371. The FSS of these buildings is also addressed in Subsection 5.5.3.

4.2.1 Survey Technique

To demonstrate compliance with this criterion, the surface area to be surveyed was divided into 1-m^2 areas. Each 1-m^2 area was scanned using a beta-sensitive probe, either a Ludlum 44-116 or a Ludlum 44-9 coupled with a portable scaler, with an audio output. The scanning rate was approximately one detector width per second, and the detector-to-surface distance was approximately 0.5 centimeters (cm). The technician performing the scan moved the probe over the surface covering the entire 1-m^2 area collecting an integrated count over 1 minute. If an increase in audible response was detected, the technician stopped and held the probe stationary over the spot. If no elevated spots were detected by the audio output, the technician recorded the integrated count for the entire 1-minute survey over the 1-m^2 area. If a hot spot was detected, the technician recorded the stationary 1-minute count over the hot spot. All areas selected for survey were monitored with a beta-sensitive instrument.

4.2.2 Static and Scanning Measurement Sensitivities

The measurement of contamination during clearance surveys often involves measuring contamination at near-background levels. Therefore, it is essential to determine the minimum amount of radioactivity that can be detected using a given survey instrument and measurement procedure. In general, the MDC is the minimum activity concentration on a surface that an instrument is expected to detect with 95% confidence.

Radiation detection instruments are selected based on the type and quantity of radiation anticipated. Prior surveys of the Rad Yard identified Cs-137 as the only contaminant found in significant quantities, as will be explained in Subsection 5.1. As a consequence, the primary survey instrument was selected specifically to monitor for this isotope on a routine basis. However, the presence on-site of other isotopes, such as Sr-90, Ra-226, uranium (U), and H-3, was thought to be possible but not probable. Therefore, specific samples and measurements were collected periodically for these other radionuclides.

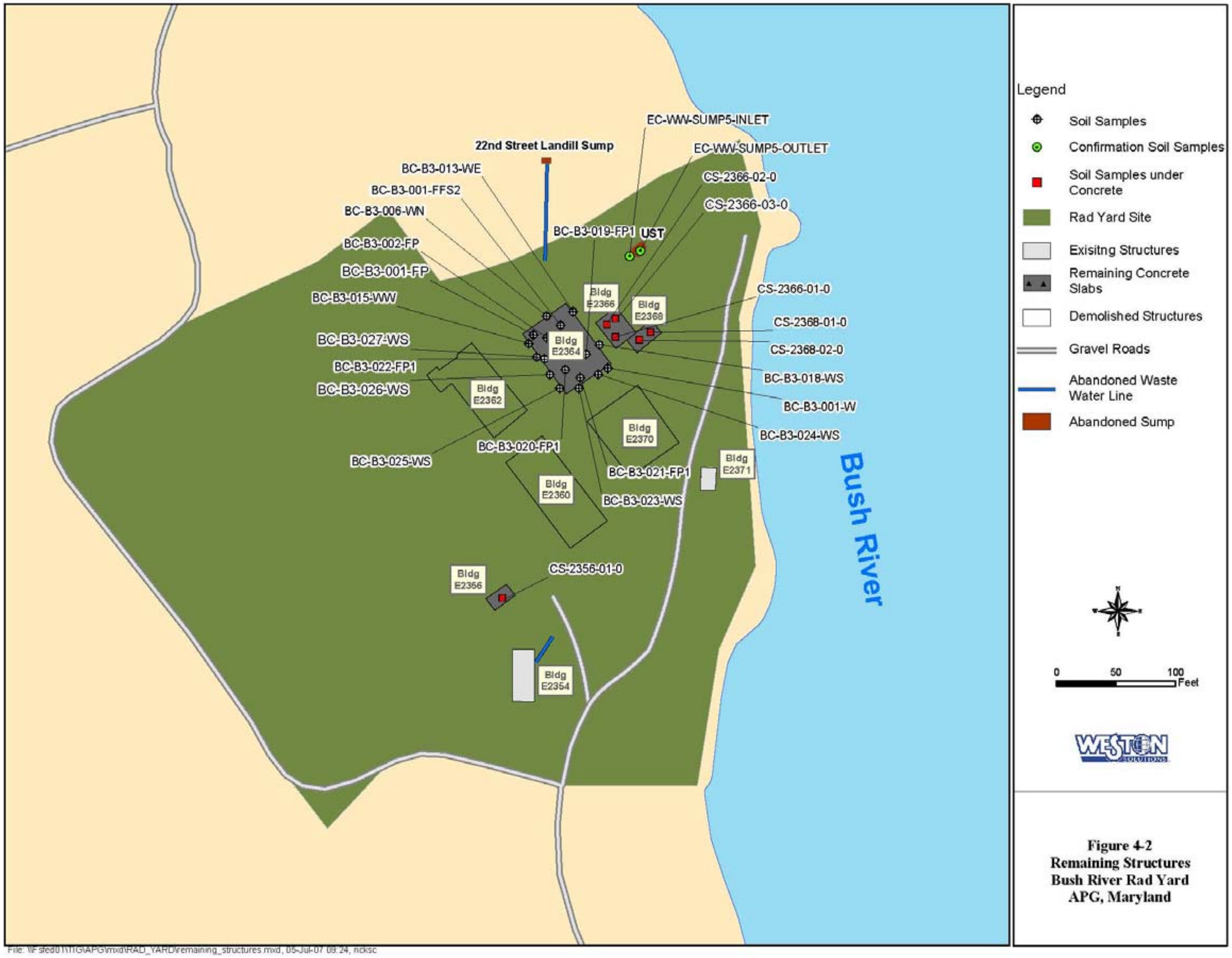


Figure 4-2 Remaining Structures

Cs-137 emits beta particles with a 514 keV maximum energy 94% of the transformations, and a 1.2 megaelectron-volt maximum energy for the remaining 6%. Tc99 was chosen as the calibration check source to determine instrument efficiency because it emits beta particles with a 292 keV maximum energy. By choosing a calibration source with a lower average energy, the instrument efficiency could be conservatively estimated. To detect any potential alpha contamination, thorium (Th)-230 was used as the instrument check source. All radiation detection instruments used on the Rad Yard project were on a 1-year calibration schedule. Annual calibration will be done by a licensed service traceable to National Institute of Standards and Technology (NIST), either Environmental Restoration Group in Albuquerque, NM (registration number 481-3), or Ludlum Measurements, Inc in Sweetwater, TX (Texas calibration license number LO-1963). Instruments used to make daily survey measurements were response-checked at the beginning and end of each work shift. If the instrument was not used that day, it was not response checked. An acceptable response for field instruments was a consistent instrument reading within ±10% of the established check source value. In like manner, the background of each instrument was recorded at the beginning and end of each work shift. This background check was collected in the office trailer.

The MDC for a specific instrument and procedure depended on the counting time, geometry, sample size, detector efficiency, background count rate, surface roughness, and sometimes the skill of the surveyor. Two different MDCs were applicable to demonstrate compliance with the release criteria. MDC_{static} was used to quantify the average beta concentration over a 1-m^2 area, while MDC_{scan} was used to look for small elevated levels of beta activity. These MDCs are calculated differently.

The technician performing the survey moved the probe over the 1-m^2 area and listened to the audio output from the scaler. If no change in the count rate was discernible, the technician recorded the integrated 1-minute count, representing the average activity across the 1-m^2 area. This technique is analogous to taking a stationary 1-minute count, but with the improvement of collecting data over an area much larger than the probe face.

The equation (Abelquist, 2001) used to calculate the MDC_{static} for direct beta measurements was:

$$MDC_{static} = \frac{3 + 3.29\sqrt{R_b t_s (1 + t_s / t_b)}}{e_i e_s t_s A / 100}$$

where:

R_b =Background count rate (cpm).

t_b = Background count time (minutes).

t_s = Sample count time (minutes).

e_i = Instrument efficiency (cpm/disintegrations per minute [dpm]).

e_s = Surface efficiency (assumed 0.5).

A = Detector area (square centimeters [cm^2]).

Using this equation, a background and sample count time of 1 minute each, and specific background count rate, area, and efficiency values for each detector, the MDC_{static} for the Ludlum 44-116 large area beta scintillator was 430 dpm/100 cm^2, and for the Ludlum 44-9 pancake G-M detector was 2,400 dpm/100 cm^2. The release criterion for this measurement was 5,000 dpm/100 cm^2 (as described in Subsection 5.1.4.1), so both detector sets meet the desired MDC. However, because of the much lower MDC and the larger detector active area, the Ludlum 44-116 was routinely selected for clearance surveys.

Using the same equation, 1-minute count times, a surface efficiency of 0.5, and instrument specific background count rate and efficiency, the MDC_{static} for the Ludlum 43-5 alpha scintillation detector was calculated to be 150 dpm/100 cm^2.

While the MDC_{static} provides an estimate of the minimum contamination level that could be detected averaged over a 1-m^2 area, the minimum concentration that can be detected for an elevated area on a surface, or hot spot must be determined. This value is represented by the MDC_{scan} and is calculated by the equation (NRC, 2002):

$$MDC_{scan} = \frac{d''*(b_i)^{0.5} * 60/i}{e_i\ e_s\ (p)^{0.5}\ (A/100)}$$

where:

d' = Index of detectability (d').

i = Observation counting interval (seconds).

bi = Background count per observation interval.

p = Surveyor efficiency (assumed 0.5).

ei = Instrument efficiency (cpm/dpm).

es = Surface efficiency (assumed 0.5).

A = Detector area (cm^2).

The numerator of this equation is defined as the minimum detectable count rate (MDCR) and is the signal level that a surveyor is expected to recognize as having a signal-to-noise ratio that is distinctly above the ambient detector background noise. This MDCR is dependent on the observation interval, which is the time, usually 0.5 to 2 seconds, that the moving detector is physically above and able to detect the activity. Therefore, this observation interval is dependent on the dimensions of the hot spot and scan speed. The d' is another factor to be defined. Values of d' are taken from Table 6-5 of MARSSIM (NRC, 2002). These values are based on acceptable true positive and false positive decision errors. Accepting a "true positive" of 95% (activity above background is detected accurately 95% of the time), and a false positive of 60% (background activity is erroneously identified as contamination 60% of the time), the d' value from Table 6-5 is 1.38.

Accepting this value for d', and assuming the area of the hot spot is 100 cm^2, the observation interval is 1 second, the surveyor efficiency is 0.5, and specific background count rate, area, and efficiencies for each detector, the MDC_{scan} for the Ludlum 44-116 large area beta scintillator was

1,300 dpm/100 cm^2, and for the Ludlum 44-9 G-M pancake detector was 7,100 dpm/100 cm^2. Because the release criterion for hot spots is 15,000 dpm in any 100-cm^2 area (as described in Subsection 5.1.4.1), both detector sets meet the desired MDC.

The instrument-specific MDCs compared with building material release criteria are summarized in Table 4-3, Minimum Detectable Surface Contamination.

Table 4-3
Minimum Detectable Surface Contamination (dpm/100 cm^2)

	MDC_{static}	MDC_{scan}
Acceptable Surface Contamination Criteria (Subsection 5.1.4.1)	5,000 (average)	15,000 (maximum)
Measured using Ludlum Model 44-116	430 dpm/100 cm^2	1,300 dpm/100 cm^2
Measured using Ludlum Model 44-9	2,400 dpm/100 cm^2	7,100 dpm/100 cm^2

4.2.3 Building E2364 Basement

The sediment in the sumps of Building E2364 had elevated levels of radionuclides. This sediment was solidified using adsorbent material and was excavated and disposed of as radioactive-contaminated waste. Once the sumps had been removed as radioactive waste, the concrete floors to Building E2364 were removed. Based on contamination found on the underside of the concrete floors, most of the concrete floor was segregated for disposal as radioactive waste.

Under the concrete floor were two basements that were believed to have been used as white phosphorus storage pits prior to when the building was renovated for radioactive waste processing. A significant volume of contaminated debris was found in the west basement of Building E2364. All of this debris was segregated as radioactive waste. After removal of the contaminated debris, the floor and walls of the west basement were designated as Class 1. A 100-m^2 grid was applied, and a 100% survey of walls and floors was performed. Clean sand was found in the east basement of Building E2364. After removal of the sand, the east basement was designated as Class 2. A total of 18 1-m^2 grid blocks were systematically surveyed across the walls and floor of the east basement. A total of 145 1-minute integrated measurements were collected from the west basement floors and walls, and 18 grid measurements were collected from the walls and floors from the east basement. Of the total 159 1-minute integrated counts, 156 were below the MDC_{static} of 430 dpm/100 cm^2. The 3 measurements above the MDC_{static} were 448, 552, and 1,660 dpm/100 cm^2, which are all below the surface criterion of 5,000 dpm/100 cm^2. This data set will be depicted in a table and figure in the FSS Report. The east and west basements were left in place and backfilled with clean soil.

Three soil samples (BC-B3-020, 021, and 022) were collected from beneath the floor of the west basement, and one sample (BC-B3-019) was collected from beneath the floor of the east basement. Three soil samples (BC-B3-001-FFS2, BC-B3-001-FP, and BC-B3-002-FP) were collected from beneath the subfloor of sumps 2 and 3. Three samples (BC-B3-006-WN, BC-B3-013-WE, and BC-B3-015-WW) were collected from the north, east, and west walls, respectively, of the sumps. In addition, six trenches were dug to a depth of 1 m along the remaining outer walls of the east and west basements. The side of each basement outer wall was scanned with a 2x2 NaI detector, and soil samples (BC-B3-

018, -023, -024, -025, -026, and -027) were collected from the depth with the highest scan reading. The locations of these samples are depicted in Figure 4-2 and the analytical results are presented in Table 4-4. Analytical results for these 16 samples indicate typical concentrations for potassium (K)-40 and U and Th isotopes. All results for Co-60 were below the MDA. Concentrations of Cs-137 in 8 of the 16 samples were below the MDA. Those with positive results ranged from 0.1 to 1.7 pCi/g.

Table 4-4
Soil Sample Results from Beneath Concrete Slabs

Sample ID		Soil Sample Results - (pCi/g)							
		Co^{60}			MDA	Cs^{137}			MDA
Removal Action Report, January 2007									
EC-WW-SUMP5-INLET		0.0168	±	0.0354	0.0655	0.0339	±	0.0744	0.0589
EC-WW-SUMP5-OUTLET		0.0242	±	0.0268	0.0538	0.272	±	0.0710	0.0484
BC-B3-006-WN-1-0-0		-0.00353	±	0.0481	0.0869	0.0405	±	0.0497	0.0945
BC-B3-013-WE-1-0-0		0.00415	±	0.0262	0.0497	1.01	±	0.140	0.0563
BC-B3-015-WW-1-1-0		-0.00301	±	0.0297	0.0516	0.376	±	0.0803	0.0526
BC-B3-018-WS-1-1-1		0.0160	±	0.0508	0.0959	0.266	±	0.105	0.0842
BC-B3-019-FP-1-1-0		0.0279	±	0.0295	0.0599	0.000702	±	0.0314	0.0547
BC-B3-020-FP-1-1-0		0.0357	±	0.0484	0.0939	0.0577	±	0.0526	0.103
BC-B3-021-FP-1-1-0		0.00715	±	0.0268	0.0520	0.0902	±	0.0542	0.0523
BC-B3-022-FP-1-1-0		0.00559	±	0.0292	0.0580	0.779	±	0.128	0.0575
BC-B3-023-WS-1-1-0		-0.0249	±	0.0600	0.1050	0.0998	±	0.0739	0.104
BC-B3-024-W-1-1-0		0.00125	±	0.0322	0.0597	0.0777	±	0.0598	0.0574
BC-B3-025-W-1-1-0		0.0115	±	0.0355	0.0646	0.0129	±	0.0390	0.0693
BC-B3-026-W-1-1-0		-0.0228	±	0.0513	0.0878	0.0145	±	0.0667	0.0851
BC-B3-027-W-1-1-0		-0.0133	±	0.0335	0.0593	-0.0303	±	0.0341	0.0543
BC-B3-001-FFS2-1-0-0		-0.00946	±	0.029	0.0533	3.65	±	0.3	0.052
BC-B3-001-FP-2-1-0		0.015	±	0.0248	0.0482	0.395	±	0.0709	0.0390
BC-B3-002-FP-2-1-0		0.00789	±	0.0424	0.0741	1.66	±	0.228	0.0831
CS-2368-01-0		0.000	±	0.030 U	0.0690	0.750	±	0.1500	0.0900
CS-2368-02-0		-0.007	±	0.044 U	0.087	-0.037	±	0.044 U	0.070
CS-2366-03-0		-0.015	±	0.032 U	0.062	0.006	±	0.03 U	0.064
CS-2366-01-0		0.009	±	0.050 U	0.11	0.950	±	0.20	0.080
CS-2366-02-0		0.017	±	0.029 U	0.069	0.202	±	0.054	0.041
CS-2356-01-0		0.011	±	0.061 U	0.13	0.207	±	0.097	0.11

4.2.4 Concrete Slabs

Six soil samples of approximately 1 kilogram (kg) each were collected from beneath three concrete slabs left in-place at the Rad Yard, identified as E2356, E2366, and E2368. These six samples (CS-2356-01, CS-2366-02, -02, -03, and CS-2368-01 and -02) were forwarded under chain-of-custody (CoC) to a commercial laboratory for analysis by gamma spectrometry. Figure 4-2 shows these sample locations and Table 4-4 lists the results for all soil characterization samples from beneath these three concrete slabs.

None of the gamma spectrometry results for all six samples identified any unusual analytes. Gamma isotopic analysis identified the naturally occurring isotopes of U, Th, and K-40 at concentrations normally expected for this area, and as reported for the reference area in Subsection 2.1.9 of the Removal Action Report (WESTON, 2007). U and Th in these six samples ranged from about 0.2 pCi/g to 1.5 pCi/g, and K-40 ranged from about 2 to 10 pCi/g. Co-60 was not detected in any of the six samples above the minimum detection level (MDL) for the laboratory, which was about 0.1 pCi/g. Cs was not detected above the laboratory MDL in two of the six samples, and it was detected in two samples at a concentration of about 0.2 pCi/g, which is about equal to the 0.3 pCi/g detected in the reference area as described in Subsection 2.1.9. One sample each from beneath E2366 and E2368 indicated a low level of Cs-137 contamination. These results were 0.75 and 0.95 pCi/g, both with 2 sigma error terms of 0.2 pCi/g. While these samples are slightly above the concentration seen in the reference area, they are both below the DCGL of 5 pCi/g.

A 100% surface contamination survey was conducted of the Building 2366 slab. A total of 93 1-minute integrated measurements were collected and all were below the MDC_{static} for the instrument. These data will be depicted in the FSS Report.

4.2.5 Abandoned Underground Storage Tank

A 5,000-gallon UST that measured 8 ft x 12 ft x 8 ft was discovered during excavation of the wastewater line that ran from the valve pit to Bush River. The concrete manway on top of the UST was difficult to locate because it was covered with overburden material. After removing the water contained in the UST, the sediment in the bottom of the tank showed elevated radiation levels. This sediment was solidified, removed, and disposed of as radioactive waste. The floors and walls of the UST were designated as class 1, and a 100% surface contamination survey was performed. The floors and walls were gridded into 1-m^2 areas, and a 1-minute integrated count collected over each grid area. A total of 71 integrated measurements were collected from the UST. Of this total, 19 measurements were greater than the MDC_{static} of 430 dpm/100 cm^2 for this instrument. The maximum recorded was 1,228 dpm/100 cm^2, which is less than the release criterion of 5,000 dpm/100 cm^2. These data will be presented in the FSS Report.

Test trenches were excavated along the inlet and outlet sides of the UST, and two soil samples were collected near the bottom of the tank. These samples are EC-WW-SUMP5-INLET, and -OUTLET. Their locations are shown in Figure 4-2, and their analytical results are presented in Table 4-4. All sample results were below the release criteria. The UST was filled with 22 yd^3 of flowable concrete and abandoned in-place.

4.2.6 Abandoned 22nd Street Landfill Sump

The 22nd Street Landfill sump, located in a marshy area outside the current Rad Yard study area, is surrounded by grassy mounds. The mounds are believed to be part of the 22nd Street Landfill. It is believed that the sumps were used to receive drainage from the Building E2364 valve pit. During the removal action, WESTON cleaned loose sludge from the sump and surveyed the inside of the sump using a gamma scintillation detector, a beta scintillation detector, and swipes. For reference, the sump is approximately 3 ft square, and approximately 3 ft deep. Exposure rate readings were made within the sump using a Ludlum 44-2 1x1 inch NaI detector. Exposure rates ranges from 5 to 8 microRoentgen per hour (μR/h), which are similar to background levels. Gross beta measurements were collected from eight locations around the bottom perimeter of the sump using a Ludlum 44-116 beta scintillation detector. The highest reading observed was 41 dpm/100 cm^2, which is less than the MDC_{static} for the instrument of 430 dpm/100 cm^2. Swipe samples were collected from the same eight locations, and from the interiors and exteriors of three pipes found leading into the sump. These swipes were counted using a Ludlum 2929. Gross alpha readings for all 14 swipes were 0. The highest gross beta reading observed on a swipe collected from the sump perimeter was 41 dpm/100cm^2, and the highest from the interior or exterior of the pipes was 32 dpm/100 cm^2. Both of these results are less than the MDC of the instrument, which was 128 dpm/100 cm^2. The results of the survey determined that the sump was not contaminated with detectable radioactivity. As a result, the sump was abandoned in-place.

4.3 GROUNDWATER

Groundwater samples were collected and analyzed for radiological contamination as part of the 2002 FFS (GP, 2004). The following issues were considered for the purpose of this evaluation:

1. Are data available that reasonably represent the groundwater conditions at the site?
2. Is the quality of the data adequate for the purpose of this evaluation?
3. Do the data indicate that contamination levels are below a reasonable evaluation limit?

4.3.1 Available Data

As reported in the Southern Bush River FFS Data Report for Operable Unit 3 (GP, 2004), 53 groundwater samples and 4 duplicates were collected over two phases (October to November 1998 and January to March 2000) and analyzed for radiological parameters. Not all groundwater samples were analyzed for the same parameters, but most were analyzed for gross alpha, gross beta, and isotopic gamma. In addition to these parameters, 17 samples were also analyzed for H-3.

A total of 18 individual locations were sampled using direct push technology (Geoprobe®), of which 17 locations had samples collected from 2 depths, and 1 location was sampled from 3 depths, resulting in a total of 37 samples. A total of 10 samples were collected from 5 piezometer stations located in the Bush River offshore from the Rad Yard. All sampling locations were either on, or in close proximity to, the Rad Yard, as depicted in Figure 4-3, Groundwater Sample Locations. The Geoprobe sample locations covered the site from north to south and east to west, and several were east of the site boundary, in the Bush River. The piezometer stations were located in the Bush River along the northeastern site boundary, and the monitoring wells were located in the central and northeastern sections of the site.

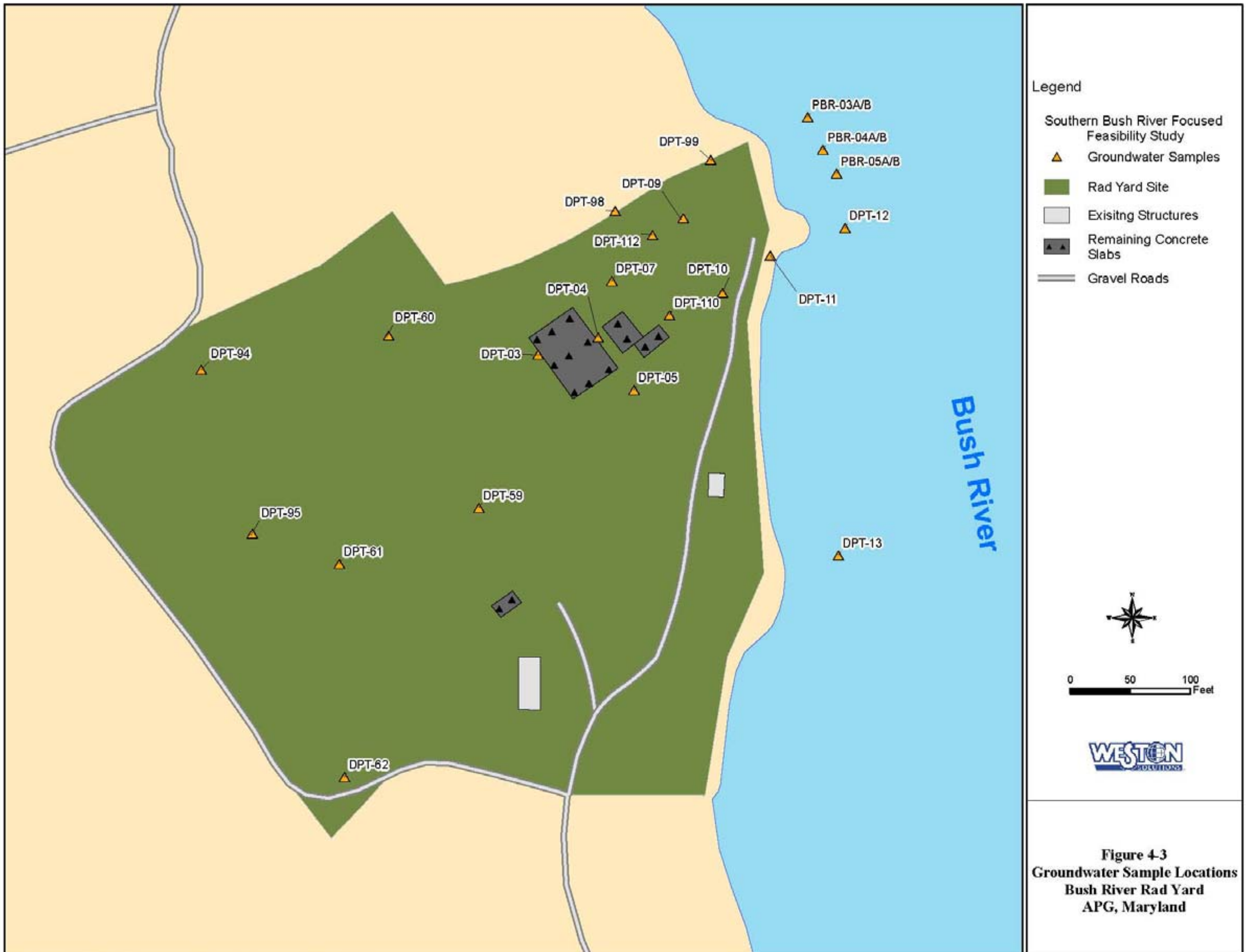


Figure 4-3 Groundwater Sample Locations

4.3.2 Evaluation of Cs-137 and Co-60 Concentrations

The radiochemistry analytical data presented in Appendix I to the FFS (GP, 2004) reveal that neither Cs-137 nor Co-60 was detected in any of the 47 (excluding duplicates) groundwater samples analyzed for these contaminants. The MDC for these analyses ranged from about 6 to 11 pCi/L, which is slightly above the MDC reported by EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, AL, which reports an MDC of 5 pCi/L for analysis of Cs-137 in their RadNet (previously ERAMS) nationwide environmental monitoring program. RadNet is a national network of monitoring stations that regularly collect air, precipitation, drinking water, and milk samples for analysis of radioactivity. As such, it appears that neither Cs-137 nor Co-60 is present in groundwater on or surrounding the Rad Yard site. Results from analyses of Cs-137 and Co-60 in groundwater samples are presented in Table 4-5.

4.3.3 Evaluation of Other Potential Contaminants

Several radiological parameters were measured in addition to Cs-137 and Co-60, including gross alpha and beta, H-3, and naturally-occurring radionuclides. The results are described herein, although those analytes were not CoCs at the Rad Yard. Gross alpha activity was measured in 49 samples (excluding duplicates) and the results ranged from non-detectable levels to a maximum of 48 pCi/L. Gross beta activity ranged from less than 1 pCi/L to a maximum of 65 pCi/L. The other analytical results identified many of the typical naturally occurring radionuclides, such as Ra-226, Pb-212, Pb-214, and K-40. While the FFS report does not specifically state if the groundwater samples were filtered prior to analysis, the data indicate that the samples probably were not filtered because much of the gross activity data did not concur with the activity levels associated with individual radionuclides in the same sample. As such, the levels of elevated gross alpha activity can be explained by assuming that the water samples contained unfiltered sediments, and therefore, drinking water standards do not strictly apply to these samples.

Concentrations of Pb-212 and Pb-214 were mostly at levels undetected by the laboratory analytical procedure, with all values for Pb-212 less than 30 pCi/L and Pb-214 less than 65 pCi/L. Concentrations of Ra-226 were measured above the detection limit in 15 samples, ranging from about 20 to 200 pCi/L. These analytical results are suspect for two reasons. While Ra-226 is an alpha-emitting radionuclide, the reported Ra-226 values were consistently and significantly greater than the gross alpha values reported in the same sample. Our review of the analytical data reports demonstrated that the Ra-226 analysis in the FFS was performed by gamma spectrometry, and not by one of the more sensitive methods. Therefore, the results are of limited use.

H-3 was one of the analytes reported as "estimated" in the FFS because all results were found at or below the analyte detection limit. These estimated results were all well below the error term of about 400 pCi/L, which is similar to the MDC reported by NAREL of 150 pCi/L. Therefore, this analyte was not reliably detected in groundwater from the Rad Yard.

Table 4-5
Concentrations of Co-60 and Cs-137 in Groundwater (pCi/L)

Phase I - October 1998 and Phase II - July 2000			
Sample ID	**Co-60**	**Cs-137**	
DPT - 03 (14'-18')	9.05 U	18.4 U	
DPT - 03 (39'-43')	9.40 U	7.81 U	
DPT - 04 (16'-20')	7.77 U	7.13 U	
DPT - 04 (35'-39')	10.7 U	8.34 U	
DPT - 05 (12'-15')	9.47 U	8.89 U	
DPT - 05 (35'-38')	11.5 U	9.466 U	
DPT - 07 (15'-18')	8.33 U	8.36 U	
DPT - 07 (35'-38')	12.6 U	8.03 U	
DPT - 09 (12'-15')	8.72 U	7.48 U	
DPT - 09 (29'-32')	9.49 U	7.64 U	
DPT - 10 (12'-15')	8.92 U	7.23 U	
DPT - 10 (28'-31')	10.3 U	8.27 U	
DPT - 11 (5'-8')	8.54 U	8.15 U	
DPT - 11 (23'-26')	12.0 U	8.33 U	
DPT - 12 (13'-17')	11.3 U	8.79 U	
DPT - 12 (17'-21')	8.54 U	8.05 U	
DPT - 13 (18'-22')	9.63 U	8.79 U	
DPT - 13 (24'-28')	9.96 U	8.78 U	
DPT - 13 (30'-34')	9.72 U	8.10 U	
DPT - 59 (12'-16')	9.72 U	8.10 U	
DPT - 59 (36'-40')	11.2 U	9.32 U	
DPT - 60 (14'-18')	11.8 U	8.30 U	
DPT - 60 (36'-40')	9.53 U	7.69 U	
DPT - 61 (14'-18')	12.2 U	8.89 U	
DPT - 61 (36'-40')	11.6 U	8.63 U	
DPT - 62 (32'-36')	8.54 U	8.98 U	
DPT - 62 (36'-40')	10.5 U	8.13 U	
DPT - 95 (9'-13')	8.9 U	9.7 U	
DPT - 95 (20'-24')	7.6 U	6.2 U	
DPT - 98 (7'-11')	8.8 U	8.0 U	
DPT - 98 (22'-26')	7.0 U	6.4 U	
DPT - 99 (6'-10')	7.9 U	7.7 U	
DPT - 99 (21'-25')	7.1 U	6.7 U	
DPT - 99 (21'-25') Dup	6.8 U	7.4 U	
DPT - 110 (4'-8')	7.0 U	6.0 U	
DPT - 110 (8'-12')	9.1 U	8.5 U	
DPT - 112 (4'-8')	5.1 U	6.2 U	
DPT - 112 (11'-15')	7.8 U	9.9 U	
PBR - 01A	8.0 U	11 U	
PBR - 01B	8.4 U	10 U	
PBR - 01B Dup	5.1 U	6.0 U	
PBR - 02A	6.7 U	5.8 U	
PBR - 02B	5.6 U	6.2 U	
PBR - 03A	6.4 U	5.9 U	
PBR - 03B	1.0 U	6.9 U	
PBR - 04A	7.3 U	9.9 U	
PBR - 04B	7.2 U	11 U	
PBR - 05A	6.0 U	6.4 U	
PBR - 05B	6.0 U	11 U	

Note:
U = Analyzed for, but not detected. The sample quantitation limit derived from the dilution factor and based on the estimated quantitation limit listed in the method is provided.

Source: Southern Bush River FFS Data Report for OU 3, dated February 2004

4.3.4 Comparison to Evaluation Limits

Several regulatory limits or guidance levels may be considered for comparing groundwater results, including EPA drinking water limits and NRC liquid effluent release limits. The drinking water limits do not apply to these data because the samples were not taken from a known drinking water source, the samples contained sediments, and the sample depths were shallower than would typically apply for a drinking water well. Effluent release limits provided in 10 CFR 20, Appendix B, Table 2, do not directly apply to groundwater samples, but may provide a reasonable basis for comparing the Rad Yard data because they are derived from dose-based calculations that assume continual ingestion of the material over a period of 1-year and result in a total effective dose equivalent of 50 millirem (mrem). The NRC License Termination Rule dose limit that applies for the release of a site is 25 mrem, and a linear relationship exists between intake and dose, thus, this evaluation utilizes one-half the value for each specific radionuclide taken from Table 2 for comparison with the groundwater data. The resulting limits are provided in Table 4-6, Groundwater Data Comparison Values.

Table 4-6
Groundwater Data Comparison Values

Radionuclide	10 CFR 20, Appendix B, Table 2 Limit (pCi/L)	25-mrem Limit (pCi/L)
Cs-137	1,000	500
Co-60	3,000	1,500
Ra-226	60	30
Pb-212	2,000	1,000
Pb-214	100,000	50,000
H-3	1,000,000	500,000

4.3.5 Groundwater Contamination Eliminated from Consideration

As shown in Subsection 4.3, groundwater samples were collected over two sampling periods in 1998 and 2000, from multiple locations and at multiple depths from on and around the Rad Yard, including the Bush River. None of these samples contained Cs-137 or Co-60 above the analytical detection limits, which were significantly less than the comparison values in Table 4-6. The only radioactivity reliably identified in the analyses appeared to be those radionuclides that would be naturally occurring in groundwater, and at concentrations similar to those reported by EPA's environmental monitoring program. Therefore, groundwater from the Rad Yard appears not to have been impacted with radionuclides from historical site activities.

5. FINAL STATUS SURVEY DESIGN

5.1 CONTAMINANTS OF CONCERN AND DCGL DETERMINATION PROCESS

COCs were identified and quantified, and initial contamination limits were calculated in several of the documents described previously, in preparation for the removal action. DCGLs inclusive of risk due to As contamination and in accordance with EPA protocols were established in the HHRRA (2004). Those DCGLs were used in planning the removal action, and are validated in this document by comparison with NRC screening limits. The following Subsections document the determination of the COCs using data from prior studies at the site.

5.1.1 Radionuclides Identified

Table 5-1, Soil Radionuclide Concentrations in Previous Investigations, lists the surface soil analytes, frequency of detection, and summary of radionuclide distributions observed in previous investigations, with the exception of the reference background sample results.

Table 5-2 lists summary statistics for radionuclides measured in an off-site reference area established for early investigations. The radioanalytical data can be summarized as follows:

- 26 radionuclides were on-site analytes, of which 24 were detected.
- 12 radionuclides were off-site reference analytes, of which 11 were detected.
- 10 of the radionuclides were analyzed both on-site and off-site.

5.1.2 Determination of COCs

The methodology of how Cs-137 and Co-60 were identified as the only COCs is presented in the HHRRA, Subsection 4.3. For the same radionuclides listed in Table 5-1 of the FSSP, the HHRRA presents a maximum concentration for each radionuclide detected in a sample collected from the Rad Yard, and the risk-based activity (RBA) for each radionuclide. The RBA is the concentration in soil that would result in a 10^{-6} risk to a residential receptor, as calculated using carcinogenic potency slope factors published by EPA in Federal Guidance Report No. 13, and are used in the RESRAD model. Referring only to Sr-90, technetium (Tc)-99 and carbon (C)-14, the maximum concentration detected in a surface soil sample collected from the Rad Yard for these three isotopes, the RBA, the NRC screening value for surface soil taken from NUREG-1757, Appendix B, and the NRC/EPA consultation triggers for residential soil contamination taken from the same NUREG document, Appendix H, are compared in the following table:

Isotope	Maximum Conc. Detected (pCi/g)	RBA (pCi/g)	NRC Screening Value (pCi/g)	NRC/EPA Trigger (pCi/g)
C-14	0.231	377	12	46
Sr-90	0.314	2.18	1.7	23
Tc-99	11.6	155	19	25

From this comparison, it is evident that the maximum concentration detected for each of these three isotopes was always less than their respective RBA. Therefore, C-14, Sr-90, and Tc-99 were dropped from further consideration as COCs by the HHRRA. It is also noted from this comparison that the maximum concentrations were always less than the NRC screening values and the NRC/EPA consultation triggers.

The list of isotopes identified for further consideration in the HHRRA as COCs included K-40, Co-60, Cs-137, Pb-210, Ra-226, Th-228, praseodymium (Pr)-231, and U-238. The maximum concentrations detected in Rad Yard soil for these isotopes were compared to background radiological data. A Mann-Whitney statistical test was used to assess whether Rad Yard data and reference background data sets were from identically distributed populations. Based on this statistical test, only Cs-137 and Co-60 were statistically different, and therefore, were identified as the only COCs.

As part of the verification process, the Removal Action Work Plan specified that all verification samples would be analyzed by isotopic gamma analysis, and gross alpha and beta analysis. The plan further required that if the gross beta analytical results exceeded background values by more than three standard deviations, the sample would be analyzed for Sr-90. Isotopic gamma data were presented and discussed in the removal action final report (WESTON, 2007) to demonstrate compliance with the primary criteria for Cs-137 and Co-60. However, all verification samples were also analyzed for gross alpha and beta activity, and these data were included in the laboratory analytical reports in the appendix of the removal action final report.

A total of 10 soil samples were collected from the reference area (see Subsection 5.1.3) and analyzed for isotopic gamma and gross alpha and beta activity. The average gross beta activity in these 10 samples was 30.3 pCi/g, and the standard deviation of this sample set was 5.0 pCi/g. Therefore, the gross beta trigger value to analyze any sample for Sr-90 content was 45.3 pCi/g. This gross beta trigger value was never exceeded in any of the verification samples. Therefore, it is concluded that no beta emitters such as Sr-90 or Tc-99 were present in detectable quantities in the verification samples.

Table 5-1
Soil Radionuclide Concentrations in Previous Investigations

Field Sample #	Depth (ft)	Date Collected	Cs-137	Co-60	Sr-90[a]	Tc-99[a]	C-14	Pu-238[b]	Pu-239/240[b]	U-238[b]	K-40	Pa-234	U-233/234[b]	Th-230[b]	Ra-226
SO110001A	0.5	9/1/94	0.9	<0.03	N/A	N/A	N/A	N/A	N/A	N/A	4.5	N/A	N/A	N/A	0.4
SO110002A	0.5	9/1/94	1.7	<0.04	N/A	N/A	N/A	N/A	N/A	N/A	2.1	N/A	N/A	N/A	0.3
SO110003A	0.5	9/1/94	1.6	<0.03	N/A	N/A	N/A	N/A	N/A	N/A	<3.5	N/A	N/A	N/A	0.5
SO110004A	0.5	9/1/94	0.7	<0.04	N/A	N/A	N/A	N/A	N/A	N/A	8.4	N/A	N/A	N/A	0.9
SBR-SS10-01-129	0.5	6/1/98	1.36	<0.174	N/A	N/A	N/A	N/A	N/A	N/A	12.1	<1.62	N/A	N/A	1.63
SBR-SS10-01-130	0.5	6/1/98	0.703	<0.17	N/A	N/A	N/A	N/A	N/A	N/A	8.07	<1.03	N/A	N/A	1.09
SBR-SS10-01-131	0.5	6/1/98	4.59	<0.116	N/A	N/A	N/A	N/A	N/A	N/A	8.61	<0.908	N/A	N/A	1.05
SBR-SS10-01-132	0.5	6/1/98	27.6	<0.183	N/A	N/A	N/A	N/A	N/A	N/A	6.1	<1.08	N/A	N/A	0.794
SBR-SS10-01-133	0.5	6/1/98	398	3.6	N/A	N/A	N/A	N/A	N/A	N/A	4.43	<1.7	N/A	N/A	<0.799
SBR-SS10-01-134	0.5	6/1/98	2420	1.13	N/A	N/A	N/A	N/A	N/A	N/A	3.47	<1.65	N/A	N/A	<1.7
SBR-SS10-01-135	0.5	6/1/98	225	0.687	N/A	N/A	N/A	N/A	N/A	N/A	3.21	<1.25	N/A	N/A	0.65
SBR-SS10-01-136	0.5	6/1/98	238	<0.22	N/A	N/A	N/A	N/A	N/A	N/A	10.5	<1.43	N/A	N/A	<1.01
SBR-SS10-01-137	0.5	6/1/98	81.3	<0.135	N/A	N/A	N/A	N/A	N/A	N/A	7.89	<0.816	N/A	N/A	0.819
SBR-SS10-01-138	0.5	6/1/98	316	<0.281	N/A	N/A	N/A	N/A	N/A	N/A	8.75	<1.65	N/A	N/A	<1.02
SBR-SS10-01-139	0.5	6/1/98	436	<0.252	N/A	N/A	N/A	N/A	N/A	N/A	9.62	<1.53	N/A	N/A	<1.19
SBR-SS10-01-140	0.5	6/1/98	54.5	<0.131	N/A	N/A	N/A	N/A	N/A	N/A	3.86	<0.951	N/A	N/A	<0.455
SBR-SS04-01-281	0.5	9/1/98	100	4.44	N/A	N/A	N/A	N/A	N/A	N/A	6.81	<0.296	N/A	N/A	1.4
SBR-SS04-01-282	0.5	9/1/98	1.93	<0.081	N/A	N/A	N/A	N/A	N/A	N/A	10	<0.139	N/A	N/A	1.36
SBR-SS04-01-283	0.5	9/1/98	1.46	<0.087	N/A	N/A	N/A	N/A	N/A	N/A	6.24	<0.135	N/A	N/A	0.778
SBR-SS04-01-284	0.5	9/1/98	164	<0.09	N/A	N/A	N/A	N/A	N/A	N/A	8.38	<0.361	N/A	N/A	0.993
SBR-SS04-01-285	0.5	9/1/98	0.952	<0.08	N/A	N/A	N/A	N/A	N/A	N/A	7.8	<0.132	N/A	N/A	0.668
SBR-SS04-01-289	0.5	9/1/98	0.793	<0.1	N/A	N/A	N/A	N/A	N/A	N/A	9.53	<0.137	N/A	N/A	0.995
SBR-SS04-01-290	0.5	9/1/98	0.195	<0.079	N/A	N/A	N/A	N/A	N/A	N/A	5.72	<0.128	N/A	N/A	0.593
SBR-SS10-01-1053	0.5	9/14/99	17.53	0.149	0.311	N/A	<0.0735	<0.102	<0.082	N/A	6.544	<0.124	N/A	0.175	0.333
SBR-SS10-01-1054	0.5	9/14/99	3466	3.465	<0.246	11.6	<0.0733	N/A	0.065	N/A	2.722	<1.11	N/A	N/A	<0.709
SBR-SS10-01-1055	0.5	9/14/99	2034	1.855	<0.376	N/A	<0.0719	N/A	0.036	0.708	14.29	<0.918	N/A	N/A	<0.781
SBR-SS10-01-1056	0.5	9/14/99	137	0.662	0.314	0.63	0.231	N/A	0.033	N/A	3.51	<0.226	N/A	0.274	<0.157
SBR-SS10-01-1057	0.5	9/14/99	223.7	0.19	<0.3	N/A	0.155	<0.203	<0.125	0.723	5.886	<0.328	0.661	N/A	<0.176
SBR-SS10-01-1058	0.5	9/14/99	1.579	<0.023	0.215	N/A	<0.0728	N/A	0.018	0.841	12.29	<0.078	N/A	0.203	0.511
SBR-SS10-01-1059	0.5	9/14/99	227.8	0.077	N/A	11.3	<0.0734	N/A	0.047	0.614	9.742	<0.322	N/A	N/A	<0.203
SBR-SS10-01-1060	0.5	9/14/99	971.3	0.742	N/A	4.53	<0.0729	N/A	<0.114	N/A	5.795	<0.58	N/A	N/A	<0.476
SBR-SS10-01-1061	0.5	9/14/99	126.1	0.098	<0.41	N/A	<0.0705	<0.127	0.049	<0.577	8.391	<0.217	N/A	N/A	0.191
SBR-SS10-01-1062	0.5	9/14/99	9.557	0.043	<0.224	N/A	<0.0711	<0.133	<0.113	N/A	11.56	<0.11	N/A	0.344	<0.053
SBR-SS10-01-1063	0.5	9/14/99	10.21	0.064	<0.327	N/A	<0.0759	<0.11	-0.042	N/A	15.48	<0.1	N/A	0.21	0.835
SBR-SS10-01-1065	0.5	9/14/99	4620	4.466	N/A	N/A	N/A	N/A	N/A	N/A	2.04	<1.72	N/A	N/A	<0.982
SBR-SS10-01-1066	0.5	9/14/99	19.26	<0.032	N/A	N/A	N/A	N/A	N/A	N/A	8.074	<0.116	N/A	N/A	<0.145
SBR-SS10-01-1071	0.5	9/14/99	0.949	<0.029	N/A	N/A	N/A	N/A	N/A	N/A	8.506	<0.079	N/A	N/A	0.59
SBR-SS10-01-1072	0.5	9/14/99	4.694	<0.022	N/A	N/A	N/A	N/A	N/A	N/A	6.024	<0.071	N/A	N/A	0.375
SBR-SS10-01-1073	0.5	9/14/99	0.843	<0.02	N/A	N/A	N/A	N/A	N/A	N/A	9.252	<0.091	N/A	N/A	0.41
SBR-SS10-01-1074	0.5	9/14/99	0.651	<0.025	N/A	N/A	N/A	N/A	N/A	N/A	7.041	<0.072	N/A	N/A	0.917
SBR-SS10-01-1075	0.5	9/14/99	1.874	<0.026	N/A	N/A	N/A	N/A	N/A	N/A	12.44	<0.082	N/A	N/A	0.458
SBR-SS10-01-1076	0.5	9/14/99	0.949	<0.017	N/A	N/A	N/A	N/A	N/A	N/A	3.933	<0.057	N/A	N/A	<0.028
SBR-SS10-01-1077	0.5	9/14/99	2.244	<0.025	N/A	N/A	N/A	N/A	N/A	N/A	8.025	<0.079	N/A	N/A	0.488
SBR-SS10-01-1078	0.5	9/14/99	0.27	<0.02	N/A	N/A	N/A	N/A	N/A	N/A	7.505	<0.059	N/A	N/A	0.331
SBR-SS10-01-1079	0.5	9/14/99	10.9	<0.02	N/A	N/A	N/A	N/A	N/A	N/A	7.954	<0.097	N/A	N/A	<0.047
SBR-SS10-01-1080	0.5	9/14/99	1.309	0.018	N/A	N/A	N/A	N/A	N/A	N/A	5.237	<0.057	N/A	N/A	0.446
SBR-SS10-01-1081	0.5	9/14/99	1.459	<0.018	N/A	N/A	N/A	N/A	N/A	N/A	5.558	<0.057	N/A	N/A	0.331
SBR-SO04-01-286	6-8	9/1/98	0.078	<0.078	N/A	N/A	N/A	N/A	N/A	N/A	6.39	<0.135	N/A	N/A	0.611
SBR-SO04-01-287	4-6	9/1/98	0.109	<0.075	N/A	N/A	N/A	N/A	N/A	N/A	8.04	<0.132	N/A	N/A	0.812

Table 5-1
Soil Radionuclide Concentrations in Previous Investigations
(Continued)

Field Sample #	Depth (ft)	Date Collected	Cs-137	Co-60	Sr-90[a]	Tc-99[a]	C-14	Pu-238[b]	Pu-239/240[b]	U-238[b]	K-40	Pa-234	U-233/234[b]	Th-230[b]	Ra-226
SBR-SO04-01-288	6-8	9/1/98	0.101	<0.075	N/A	N/A	N/A	N/A	N/A	N/A	6.76	<0.14	N/A	N/A	0.957
SBR-SS10-02-1065A	0.5-2	9/14/99	16.56	<0.037	N/A	N/A	N/A	N/A	N/A	N/A	17.33	<0.12	N/A	N/A	<0.154
SBR-SS10-02-1067	0.5-2	9/14/99	1.798	<0.022	N/A	N/A	N/A	N/A	N/A	N/A	8.894	<0.072	N/A	N/A	0.398
SBR-SS10-02-1065B	2-4	9/14/99	4.86	<0.027	N/A	N/A	N/A	N/A	N/A	N/A	14.48	<0.094	N/A	N/A	0.453
SBR-SS10-02-1067B	2-4	9/14/99	0.686	<0.022	N/A	N/A	N/A	N/A	N/A	N/A	12.18	<0.094	N/A	N/A	<0.046
SBR-SS10-02-1068	2-4	9/14/99	0.498	<0.027	N/A	N/A	N/A	N/A	N/A	N/A	11.14	<0.076	N/A	N/A	<0.115
SBR-SS10-02-1065C	4-6	9/14/99	8.622	<0.026	N/A	N/A	N/A	N/A	N/A	N/A	14.37	<0.109	N/A	N/A	<0.055
SBR-SS10-02-1069	4-6	9/14/99	0.683	<0.025	N/A	N/A	N/A	N/A	N/A	N/A	11.94	<0.074	N/A	N/A	<0.041
SBR-SO04-01-291	2-4	9/1/98	0.222	<0.078	N/A	N/A	N/A	N/A	N/A	N/A	4.28	<0.142	N/A	N/A	0.621
Maximum Detected Concentration			4620	4.466	0.314	11.6	0.231	0	0.065	0.841	17.33	0	0.661	0.344	1.63
Minimum Detected Concentration			0.078	0.018	0.215	0.63	0.155	0	-0.042	0.614	2.04	0	0.661	0.175	0.191
Arithmetic mean			282.8	1.4	0.3	7.0	0.2	0	0.0	0.7	8.1	0	0.7	0.2	0.7
Standard deviation			841.9	1.7	0.1	5.4	0.1	NA	0.0	0.1	3.5	NA	NA	0.1	0.3
Number of detections			58	16	3	4	2	0	7	4	57	0	1	5	36
Number of measurements			58	58	9	4	11	5	11	5	58	54	1	5	58

Field Sample #	Depth (ft)	Date Collected	Pb-214	Bi-214	Pb-210	Th-232[b]	Ac-228	Th-228[b]	Th-228	Ra-224	Pb-212	Bi-212	U-235/6[b]	Pa-231	Ra-223
SO110001A	0.5	9/1/94	N/A	N/A	N/A	N/A	N/A	N/A	0.6	N/A	N/A	N/A	N/A	N/A	N/A
SO110002A	0.5	9/1/94	N/A	N/A	N/A	N/A	N/A	N/A	0.3	N/A	N/A	N/A	N/A	N/A	N/A
SO110003A	0.5	9/1/94	N/A	N/A	N/A	N/A	N/A	N/A	0.5	N/A	N/A	N/A	N/A	N/A	N/A
SO110004A	0.5	9/1/94	N/A	N/A	N/A	N/A	N/A	N/A	1.3	N/A	N/A	N/A	N/A	N/A	N/A
SBR-SS10-01-129	0.5	6/1/98	1.01	<0.81	<1.83	N/A	<1.26	N/A	N/A	<12.2	1.08	<2.74	N/A	<4.64	<0.649
SBR-SS10-01-130	0.5	6/1/98	0.969	<0.575	<1.53	N/A	<0.945	N/A	N/A	<3.02	1.02	<2.3	N/A	<2.66	<0.503
SBR-SS10-01-131	0.5	6/1/98	1.06	<0.495	<1.15	N/A	<0.84	N/A	N/A	11.1	0.98	<2.19	N/A	<3.45	<0.552
SBR-SS10-01-132	0.5	6/1/98	0.935	<0.47	<1.17	N/A	<0.804	N/A	N/A	<3.15	0.633	<1.98	N/A	<4.53	<0.73
SBR-SS10-01-133	0.5	6/1/98	<1.09	<0.804	<1.67	N/A	<1.04	N/A	N/A	<6.56	0.795	<2.6	N/A	<13.5	<2.02
SBR-SS10-01-134	0.5	6/1/98	<2.51	<1.69	<1.4	N/A	<0.762	N/A	N/A	<15.2	<1.35	<2.98	N/A	<32.2	<4.8
SBR-SS10-01-135	0.5	6/1/98	0.815	<0.682	<1.16	N/A	<0.749	N/A	N/A	<5.04	<0.441	<1.83	N/A	<10.2	<1.51
SBR-SS10-01-136	0.5	6/1/98	<1.2	<1	<2.11	N/A	<1.25	N/A	N/A	<7	1.07	<2.86	N/A	<13.9	<1.97
SBR-SS10-01-137	0.5	6/1/98	1.12	<0.555	<1.11	N/A	<0.824	N/A	N/A	<3.99	0.706	<1.87	N/A	<6.53	<1.02
SBR-SS10-01-138	0.5	6/1/98	<1.26	<1.02	<1.4	N/A	<0.988	N/A	N/A	<7.68	0.979	<3.21	N/A	<15.1	<2.27
SBR-SS10-01-139	0.5	6/1/98	<1.46	<1.19	<1.8	N/A	<1.29	N/A	N/A	<8.83	1.38	<3.54	N/A	<17.9	<2.61
SBR-SS10-01-140	0.5	6/1/98	<0.482	<0.444	<1.1	N/A	<0.587	N/A	N/A	<3.39	0.402	<1.97	N/A	<5.62	<0.867
SBR-SS04-01-281	0.5	9/1/98	0.946	<0.482	<1.16	N/A	<0.779	N/A	N/A	<2.89	0.793	<1.8	N/A	<5.13	<0.767
SBR-SS04-01-282	0.5	9/1/98	1.12	1.36	1.22	N/A	1.58	N/A	N/A	<1.15	1.18	<1.64	N/A	<2.29	<0.37
SBR-SS04-01-283	0.5	9/1/98	0.616	<0.292	<0.736	N/A	<0.467	N/A	N/A	<1.75	0.618	<1.35	N/A	<1.93	<0.316
SBR-SS04-01-284	0.5	9/1/98	0.949	<0.444	<0.841	N/A	<0.526	N/A	N/A	<3.42	0.765	<1.33	N/A	<6.13	<0.943
SBR-SS04-01-285	0.5	9/1/98	0.719	<0.321	<0.891	N/A	1.24	N/A	N/A	<1.09	0.865	<1.34	N/A	<2.03	<0.322
SBR-SS04-01-289	0.5	9/1/98	0.928	<0.38	<1	N/A	<0.636	N/A	N/A	<1.97	0.828	<1.6	N/A	<2.36	<0.331
SBR-SS04-01-290	0.5	9/1/98	0.712	<0.348	<0.895	N/A	0.994	N/A	N/A	<0.984	0.675	<1.41	N/A	<2.07	<0.302
SBR-SS10-01-1053	0.5	9/14/99	0.643	0.628	<6.17	0.43	1.012	0.236	N/A	0.532	0.837	0.996	<0.103	0.892	<0.149
SBR-SS10-01-1054	0.5	9/14/99	<1.13	<0.732	<43.6	0.39	<0.614	0.061	N/A	<8.71	<0.794	<3.05	<0.134	<15.2	<1.19
SBR-SS10-01-1055	0.5	9/14/99	<1.22	1.165	<8.01	0.59	<0.693	0.139	N/A	8.14	0.714	<3.37	<0.135	<16	<0.85
SBR-SS10-01-1056	0.5	9/14/99	0.833	0.69	<9.05	0.42	0.373	0.104	N/A	<1.79	0.403	0.526	<0.11	<3.02	<0.244
SBR-SS10-01-1057	0.5	9/14/99	<0.28	<0.182	<16.8	0.45	0.956	0.117	N/A	<2.11	0.717	1.342	<0.121	<3.71	<0.384
SBR-SS10-01-1058	0.5	9/14/99	0.786	0.708	<3.2	0.59	1.458	0.249	N/A	2.154	1.385	1.737	<0.127	<0.881	0.095
SBR-SS10-01-1059	0.5	9/14/99	1.096	1.099	<16.6	N/A	1.246	0.136	N/A	2.1	1.125	1.544	0.058	<3.63	<0.377

Table 5-1
Soil Radionuclide Concentrations in Previous Investigations
(Continued)

SBR-SS10-01-1060	0.5	9/14/99	<0.75	<0.492	<5.01	0.48	<0.303	0.073	N/A	5.66	0.445	<1.39	<0.261	<9.94	<0.537
SBR-SS10-01-1061	0.5	9/14/99	0.729	0.719	<8.48	0.39	1.106	0.122	N/A	1.081	0.915	1.051	<0.535	<2.84	<0.233
SBR-SS10-01-1062	0.5	9/14/99	1.177	1.202	<5.36	0.8	1.434	0.278	N/A	1.386	1.389	1.348	<0.139	<0.972	<0.138
SBR-SS10-01-1063	0.5	9/14/99	0.605	0.486	<0.917	0.59	1.579	0.278	N/A	4.774	1.232	1.711	<0.249	1.877	<0.111
Field Sample #	**Depth (ft)**	**Date Collected**	**Pb-214**	**Bi-214**	**Pb-210**	**Th-232[b]**	**Ac-228**	**Th-228[b]**	**Th-228**	**Ra-224**	**Pb-212**	**Bi-212**	**U-235/6[b]**	**Pa-231**	**Ra-223**
SBR-SS10-01-1065	0.5	9/14/99	<1.52	<1.02	<87.9	N/A	<0.763	N/A	N/A	<11	<1	<3.86	N/A	<19.9	<1.99
SBR-SS10-01-1066	0.5	9/14/99	1.089	1.246	<1.03	N/A	1.383	N/A	N/A	6.924	0.956	1.196	N/A	<1.8	<0.122
SBR-SS10-01-1071	0.5	9/14/99	0.433	0.361	<0.65	N/A	1.115	N/A	N/A	1.876	1.055	1.118	N/A	<0.847	<0.089
SBR-SS10-01-1072	0.5	9/14/99	0.246	0.257	<2.66	N/A	0.827	N/A	N/A	1.059	0.85	0.847	N/A	<0.692	0.063
SBR-SS10-01-1073	0.5	9/14/99	0.627	0.615	<4.3	N/A	1.215	N/A	N/A	1.162	1.131	1.285	N/A	<0.701	0.155
SBR-SS10-01-1074	0.5	9/14/99	0.144	<0.108	<0.633	N/A	0.997	N/A	N/A	<1.05	1.24	1.095	N/A	0.841	<0.084
SBR-SS10-01-1075	0.5	9/14/99	0.744	0.658	<3.24	N/A	1.376	N/A	N/A	1.282	1.416	1.33	N/A	0.552	0.213
SBR-SS10-01-1076	0.5	9/14/99	0.221	0.22	<2.77	N/A	0.48	N/A	N/A	0.475	0.424	0.568	N/A	<0.512	0.07
SBR-SS10-01-1077	0.5	9/14/99	<0.06	<0.049	<0.606	N/A	0.968	N/A	N/A	<0.977	1.045	1.108	N/A	<0.993	<0.085
SBR-SS10-01-1078	0.5	9/14/99	0.482	0.505	<2.31	N/A	0.956	N/A	N/A	1.042	0.923	1.132	N/A	<0.666	<0.073
SBR-SS10-01-1079	0.5	9/14/99	0.693	0.704	<4.87	N/A	1.055	N/A	N/A	0.6	1.011	1.557	N/A	<0.94	<0.124
SBR-SS10-01-1080	0.5	9/14/99	<0.046	<0.077	<0.517	N/A	0.613	N/A	N/A	3.066	0.498	0.648	N/A	<0.655	<0.064
SBR-SS10-01-1081	0.5	9/14/99	0.226	0.188	<2.18	N/A	0.721	N/A	N/A	0.438	0.653	0.653	N/A	<0.604	0.042
SBR-SO04-01-286	6-8	9/1/98	0.579	<0.296	<0.71	N/A	<0.527	N/A	N/A	<1.78	0.668	<1.26	N/A	<1.99	<0.295
SBR-SO04-01-287	4-6	9/1/98	0.785	<0.332	<0.875	N/A	1.18	N/A	N/A	<1.96	0.825	<1.46	N/A	<2.1	<0.324
SBR-SO04-01-288	6-8	9/1/98	0.625	<0.32	<0.784	N/A	<0.571	N/A	N/A	<1.92	0.771	<1.28	N/A	<2.05	<0.325
SBR-SS10-02-1065A	0.5-2	9/14/99	1.581	1.59	<1.06	N/A	1.877	N/A	N/A	14.57	1.163	1.951	N/A	3.273	<0.129
SBR-SS10-02-1067	0.5-2	9/14/99	0.622	0.535	<2.93	N/A	1.152	N/A	N/A	1.457	1.146	1.139	N/A	<0.674	0.192
SBR-SS10-02-1065B	2-4	9/14/99	0.881	0.918	<3.69	N/A	1.742	N/A	N/A	2.486	1.702	2.082	N/A	<1.09	0.214
SBR-SS10-02-1067B	2-4	9/14/99	0.913	0.916	<4.66	N/A	1.423	N/A	N/A	1.725	1.367	1.555	N/A	<0.868	0.116
SBR-SS10-02-1068	2-4	9/14/99	1.318	1.118	<0.684	N/A	1.243	N/A	N/A	7.385	0.529	1.484	N/A	2.275	<0.089
SBR-SS10-02-1065C	4-6	9/14/99	0.946	1.046	<5.33	N/A	1.399	N/A	N/A	1.455	1.42	1.511	N/A	<0.93	0.129
SBR-SS10-02-1069	4-6	9/14/99	0.943	0.889	<2.97	N/A	1.287	N/A	N/A	1.353	1.278	1.683	N/A	<0.653	0.151
SBR-SO04-01-291	2-4	9/1/98	0.169	<0.286	<0.714	N/A	<0.481	N/A	N/A	<1.69	0.497	<1.23	N/A	<2.01	<0.299
Maximum Detected Concentration			1.581	1.59	1.22	0.8	1.877	0.278	1.3	14.57	1.702	2.082	0.058	3.273	0.214
Minimum Detected Concentration			0.144	0.188	1.22	0.39	0.373	0.061	0.3	0.438	0.402	0.526	0.058	0.552	0.042
Arithmetic mean			0.8	0.8	1.2	0.5	1.2	0.2	0.7	3.3	0.9	1.3	0.1	1.6	0.1
Standard deviation			0.3	0.4	NA	0.1	0.3	0.1	0.4	3.6	0.3	0.4	NA	1.0	0.1
Number of detections			41	25	1	10	31	11	4	26	50	27	1	6	11
Number of measurements			54	54	54	10	54	11	4	54	54	54	11	54	54

Table notes:All results reported in picocuries per gram.
[a]Concentration determined using proportional beta counter.
[b]Concentration determined using alpha spectroscopy.

Table 5-2
Summary Statistics for Offsite Background Reference Area in Early Studies

Radionuclide	Range	Mean	Standard Deviation	Frequency of Detection
K-40	6.60 – 9.40	7.87	1.42	3/3
Cs-137	0.0420 – 0.730	0.301	0.199	16/18
Bi-214	1.50	0.198	0.326	1/18
Pb-214	0.2300 – 1.50	0.794	0.342	17/18
Ra-226	1.50	0.198	0.326	1/18
Actinium-228	0.830 – 1.40	0.424	0.390	4/18
Thorium-234	-	0.884	0.306	0/13
U-233/234	1.00 – 2.30	1.36	0.380	11/11
U-235/236	0.290 – 0.460	0.433	0.117	9/9
U-235	0.00460 – 0.100	0.193	0.0678	5/18
U-238	0.610 – 7.000	1.34	1.43	18/18

Notes: Table adapted from GP, 2002b. Raw data not available.

5.1.3 Removal Action Reference Area Survey

Prior to the removal action, another reference area survey was performed, and the results from that survey are proposed for the FSSP. For this recent reference area survey, an area outside the APG boundary was chosen that closely mimics the geomorphological and topographical features of the Rad Yard. Permission was obtained through the Harford County Parks and Recreation Department to perform this survey at Flying Point Park on Willoughby Beach Road in Edgewood, MD. Flying Point Park is located approximately 4 miles northwest of the Rad Yard. Like the Rad Yard, Flying Point Park is located along the western bank of the Bush River. Flying Point Park is upstream of APG.

A series of 10 soil samples was collected in a grid pattern over an area of approximately 1 acre. Each location was a composite of five samples with approximately 2 ft x 2 ft dimensions in an “X” pattern. Samples were collected from the surface to a depth of 15 cm. Composite samples were identified as RS-31-N through RS-40-N and submitted to the analytical laboratory for gross alpha, gross beta, gamma isotopic, and total Sr analyses. The laboratory was instructed to identify all gamma-emitting isotopes in the samples.

Gamma isotopic analyses identified the naturally occurring isotopes of the U and Th series and K-40 at concentrations normally expected for this area. The U series isotopes averaged 0.7 ±0.1 pCi/g, and the thorium series isotopes averaged 0.8 ± 0.1pCi/g. The concentration of K-40 was 7.6 ±1.7 pCi/g. The concentration of Cs-137 ranged from 0.2 to 0.4pCi/g, and averaged 0.3 ±0.1 pCi/g. Neither Co-60 nor total Sr was detected above the MDC for the analyses. No anomalous gross alpha or beta activity was detected in any of the samples.

In situ measurements of gamma-ray activity emanating from the surface of the reference area at each sample location were also collected using a Ludlum 44-10 2x2 NaI detector coupled to a scaler and a Ludlum 44-2 microR meter. Measurements were collected at ground surface and at 45 cm above the surface for both sets of in situ measurements. Data collected with the NaI detector ranged from 6,606 to 8,596 cpm on contact and 6,409 to 8,466 cpm at a 45-cm height. The average count rates were approximately 7,800 ±700 cpm for both the contact and 45-cm height measurements. This agreement in contact and elevated measurements indicates that the ambient gamma activity is relatively uniform. Data collected with the microR meter ranged from 9 to 12 microRoentgen per hour (μR/h), and averaged 10 μR/h on both contact and at a 45-cm height.

5.1.4 Cleanup Criteria

NRC staff developed surface soil volumetric concentration values and building surface area contamination values to support implementation of the license termination rule (10 CFR 20, Subpart E) and to simplify decommissioning in cases where low levels of contamination exist. The use of these screening values provides reasonable assurance that the dose criteria will be met for sites that fit the NRC conditions. The cleanup criteria for soil and building surfaces selected for the FSS are lower than the screening values listed in Appendix B to NUREG-1757 (NRC, 2006) to comply with the unrestricted release dose criteria in the license termination rule, and to demonstrate that the site was cleaned to levels that were ALARA.

When using the screening values, licensees are required to demonstrate that the particular site conditions are compatible and consistent with the model assumptions used to calculate the screening values. The following Subsections describe the particular site conditions at the Rad Yard and compare these conditions to the NRC model assumptions.

5.1.4.1 Building Surface Cleanup Criteria

The site conditions included in the NRC screening model assumed:

1. Contamination on building walls, floors, and ceilings should be surficial and non-volumetric.

   During the removal action of the Rad Yard, very little surface contamination was found, and that which was detected was always surficial, and not embedded into the structure itself.

2. Contamination on surfaces is mostly fixed (not loose), with the fraction of loose contamination not to exceed 10% of total surface activity.

   During the removal action of the Rad Yard, no loose contamination was identified on any of the swipes taken.

3. The surface screening criteria may not be applied to surfaces such as buried structures (e.g., drainage or sewer pipes).

No drainage or sewer pipes were left within the Rad Yard after the removal action. A building basement and a UST were left in-place after the removal action. However, after they were surveyed for radioactive contamination and found to meet release criteria, the basement and UST were filled with flowable concrete or clean soil. These structures are now buried.

Table 5-3, Applicable Surface Contamination Limits, presents the surface screening values for Cs-137 and Co-60 taken from Table B.1 of Appendix B in NUREG-1757, Volume 1 and the surface contamination criteria from Regulatory Guide 1.86 (NRC, 1974) that were applied to concrete floors, walls, and building slabs left on-site following the removal action. The activity-based criteria used during the removal action for beta-gamma emitters (Cs-137 and Co-60) are significantly more restrictive than the dose-based screening values from NUREG 1757 (NRC, 2006).

Table 5-3
Applicable Surface Contamination Limits

NUREG-1757, Table B.1 Screening Values (dpm/100 cm^2)		Removal Action Surface Contamination Criteria from Reg. Guide 1.86 (dpm/100cm^2)
Cs-137	Co-60	Beta-gamma emitters
28,000	7100	5,000 avg., 15,000 max

As shown by the comparison of the cleanup criteria, the criteria actually used during the removal action and now proposed for the FSS were lower than the NRC allowable screening values. These lower values were selected for two reasons: (1) they were considered to be ALARA, and (2) they were considered to be technically feasible from the standpoint that the lower concentrations were reliably detectable. The actual survey technique employed during the removal action is described in Subsection 4.2.1, the static and scanning measurement sensitivities are described in Subsection 4.2.2, and the survey results of the various structures are discussed in Subsections 4.2.3 through 4.2.6.

5.1.4.2 Surficial Soil Cleanup Criteria

The site conditions NRC assumed in the screening model are:

1. The initial residual radioactivity (after decommissioning) is contained in the top 15 cm layer of surface soil.

   During the FSS of the Rad Yard, depth profile samples will be collected to demonstrate that the low level of residual contamination, while all below the release criteria, is contained within the top 15 cm of the soil surface. If any contamination above background is identified in samples below 15 cm, the area will be evaluated further.

2. The unsaturated zone and the groundwater are initially free of contamination.

   Subsection 4.3 of this FSSP demonstrates that groundwater is not contaminated.

3. The vertical saturated hydraulic conductivity is greater than the infiltration rate.

   Groundwater at the Rad Yard was found at a depth of 12 ft below grade, which is near the elevation of the Bush River. Therefore, vertical hydraulic conductivity is greater than the rate of water infiltration.

4. The residual radioactive contamination is relatively homogeneous across the surface of the site.

   Subsection 4.1 of the FSSP demonstrates that the residual concentration is relatively uniform across the site, with an average residual Cs-137 concentration of 0.9 pCi/g and a standard deviation of the sample set of 1.2 pCi/g. Co-60 was never detected above the MDC of the measurement.

5. The site does not contain wastes other than soils, have multiple source areas, or have radionuclides that may generate gases such as C-14 or H-3.

   Conditions at the Rad Yard do not have any of these features.

6. The site does not contain chemicals or a chemical environment that could facilitate radionuclide releases.

   Conditions at the Rad Yard do not have any of these features.

7. The site cannot contain soils that have preferential flow conditions, a perched water table, surface ponding, transient flow, or groundwater discharges to springs or seeps.

   Conditions at the Rad Yard do not have any of these features.

8. The site cannot have significant heterogeneity in subsurface properties.

   The subsurface properties of the Rad Yard are essentially homogeneous.

9. The site cannot have stacks or other features that could transport radionuclides off the site at a higher concentration than on-site.

   Conditions at the Rad Yard do not have these features.

Therefore, actual site conditions at the Rad Yard do not preclude the use of NRC-acceptable screening values as cleanup criteria for this site. Additionally, the NRC has entered into an MOU with EPA entitled *Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites* (NUREG-1757, Volume 1, Appendix H.) This MOU is intended to address issues related to involvement under CERCLA in the cleanup of radiologically contaminated sites under the jurisdiction of NRC. In this document, NRC has agreed to consult with EPA on the appropriate approach at particular sites where radioactive contamination in soils at the time of license termination exceeds the values, identified as consultation triggers, in Table H.1 of NUREG-1757 (NRC, 2006).

In the case of the Rad Yard removal action, the actual cleanup criteria or DCGLs applied were 5 pCi/g of Cs-137 and 0.5 pCi/g of Co-60. These criteria are also proposed for the FSS. The NRC screening values, the MOU consultation triggers, and the DCGLs for the removal action and the FSS are compared in Table 5-4, Comparison of Surface Soil Cleanup Criteria.

Table 5-4
Comparison of Surface Soil Cleanup Criteria (pCi/g)

Radionuclide	NRC Screening Values Table B.2	MOU Triggers Table H.1		Removal Action/FSS DCGL
		Residential	Industrial	
Cs-137	11	6	11	5
Co-60	3.8	4	6	0.5

The actual cleanup criteria values to be employed during the FSS of the Rad Yard are lower than the NRC acceptable screening values and the MOU triggers. These lower cleanup values were selected because they are ALARA, and because they are technically feasible from the standpoint that the lower concentrations were reliably detectable. As will be demonstrated in this FSSP, field detection levels less than the proposed DCGLs may not be reliable and are financially unreasonable for the miniscule reduction in dose that could be accomplished, and therefore, would not be ALARA.

5.1.4.3 ALARA Analysis

Appendix N of NUREG 1757, Vol. 2 states the following on page N-1:

> "In light of the conservativism in the building surface and surface soil generic screening levels developed by NRC, NRC staff presumes, absent information to the contrary, that licensees who remediate building surfaces or soil to the generic screening levels do not need to provide analyses to demonstrate that these screening levels are ALARA. In addition, if residual radioactivity cannot be detected it may be assumed that it has been reduced to levels that are ALARA. Therefore, the licensee may not need to conduct an explicit analysis to meet the ALARA requirement."

This plan uses the conservative generic NRC screening levels as the basis for its DCGLs, which meets the first condition in the exemption stated above. The preceding sections confirm that the conditions for using the generic screening levels are met for this site. In addition, the DCGLs were reduced below the generic levels by approximately a factor of 2 for Cs and greater than 2 for Co, which further meets the ALARA analysis criteria. Finally, the residual levels documented at the site demonstrate that near background conditions have been attained, further supporting this justification that the DCGLs meet the ALARA requirement.

5.2 DATA QUALITY OBJECTIVES FOR RADIOLOGICAL DATA

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the field and laboratory data quality needed to support specific decisions or regulatory actions. DQOs describe what data are needed, why the data are needed, and how they will be used to meet the needs of the project. DQOs also establish numeric limits to allow the data user (or reviewers) to determine whether the data collected are of sufficient quality for their intended use.

The MARSSIM DQO process uses statistical hypothesis testing rather than the construction of confidence intervals to evaluate residual radiation. This allows a balance to be reached between the risk of possibly releasing an incompletely remediated site and the risk of possibly requiring further remediation at an already adequately remediated site. One of the primary goals of the DQO process is to determine acceptable decision error rates for the hypothesis test, i.e., those that will reflect the relative importance of these risks at a specific site. The DQO process is used to incorporate site-specific information and sound scientific judgment into the survey design and data analysis so that the objective of safely releasing a site can be met while reducing the number of unnecessarily arbitrary and conservative assumptions that are sometimes invoked in the face of uncertainty.

DQOs for this plan were developed in accordance with the *Guidance for Data Quality Objectives Process* EPA QA/G-4 (EPA, 1994) and *Guidance for Data Quality Assessment*, *Practical Methods for Data Analysis,* EPA QA/G-9 (EPA, 1998). DQOs were developed in steps collectively referred to as the DQO process. The steps and a summary of the results for each step are provided in Tables 5-5 and 5-6. The following subsections define how existing data were evaluated and how FSS data will be assessed to meet the DQOs. The criteria that will be used to define acceptable limits of uncertainty are also described.

5.2.1 Problem identification

As demonstrated in Section 4:

1. There is no evidence of radiological contamination of groundwater associated with the Rad Yard.
2. The areas or nodes that were remediated during the removal action would be in compliance with the release criterion if the characterization data were evaluated using a MARSSIM-like investigation.
3. All remaining structures and concrete slabs, except Buildings E2354 and E2371, which were not surveyed during the removal action, would be in compliance with the release criterion if the characterization data were evaluated using a MARSSIM-like investigation.

Table 5-5
Data Quality Objectives for Surface Soil

DQO Step	Surface Soil
State the Problem	
Problem statement	Survey each of the MARSSIM Class 1 (scan and sample) survey units at the Rad Yard. Compare radioactivity in these areas to site-specific DCGL determined previously in this FSSP. Perform Sign test on concentrations in soil samples and compare to their respective DCGLs.
Relevant deadlines	Results of final survey to be reported within 12 months after completion of the FSS.
Identify the Decision	
Principal study question(s)	Do the concentrations of residual Cs-137 and Co-60 exceed their respective DCGLs?
Alternative actions	Average residual radioactivity in soil exceeds the DCGL for Cs-137, or the sum of contaminant fractions exceeds unity, or radioactivity in elevated areas exceeds the $DCGL_{EMCs}$. Continue excavating until residual radioactivity is below the DCGL, the sum of hot spot fractions is less than unity, or radioactivity in elevated areas is below area-specific $DCGL_{EMCs}$.
Identify Inputs to the Decision	
Physical inputs	Radiological scans of land surface using a 2x2 NaI or alternate detector. Off-site gamma spectroscopy analytical results for soil samples. Cs-137 and Co-60 are the primary radionuclides to consider.
Radiochemical inputs	Soil analytical results from the following method: Gamma spectroscopy (EPA 901.1 modified).
Action levels (DCGLs)	5.0 pCi/g Cs-137 and 0.5 pCi/g Co-60 taken as a fraction of NRC screening values.
Define Study Boundaries	
Horizontal boundary	See Figure 2-2 showing site boundaries at beginning of FSSP.
Vertical boundary	Assumed less than 0.5 ft bgs to be verified with depth study in FSSP.
Develop Decision Rule	
Parameter of interest	Scanning gamma-ray counts; and Cs-137 and Co-60 concentrations in individual samples.
Scale of decision making	Class 1 Land Areas: Survey unit areas up to 2,000 m^2.
Action level	DCGLs as listed above.
Alternative action	None.
Specify Tolerance Limits on Decision Errors	
Maximum/average value for parameter of interest (data following removal action.)	Concentrations of Cs-137 in soil (pCi/g): 4.7 maximum/0.9 median Concentrations of Co-60 in soil (pCi/g) = 0
False positive – Type I	5 %
False negative – Type II	Provisionally 5 %
Null hypothesis	The mean concentration of residual activity in a survey unit exceeds the DCGL.
Governing error	Type I (incorrectly releasing a survey unit) because it is more protective of long-term human health and the environment than Type II (incorrectly failing to release survey unit).
Lower boundary of gray region	As established in Subsection 5.4.1.

Notes:

pCi/g = Picocuries per gram
DCGL = Derived concentration guideline level
EMC = Elevated measurement comparison
EPA = U.S. Environmental Protection Agency
m^2 = Square meter
MARSSIM = Multi-Agency Radiation Site and Survey Investigation Manual (NRC, 2002)
bgs = Below ground surface

Table 5-6
Data Quality Objectives for Building Surfaces

DQO Step	Building Surfaces
State the Problem	
Problem statement	Survey each of the Class 1 and 2 survey units, and compare results to site-specific DCGLs.
Relevant deadlines	Results of FSS to be reported within 12 months after completion of field work.
Identify the Decision	
Principal study question(s)	Do the concentrations of residual beta activity exceed the surface contamination criteria?
Alternative actions	Residual beta contamination on building surfaces exceeds criteria. Decontaminate surface, or remove and package surface as radioactive waste.
Identify Inputs to the Decision	
Physical inputs	Building surface scans using beta scintillation or G-M pancake detector.
Radiochemical inputs	None
Action levels (DCGLs)	5,000 dpm beta/100 cm^2, avg. 15,000 dpm/100 cm^2 max.
Define Study Boundaries	
Horizontal boundary	See Figure 2-2 for location of Buildings E2354 and E2371, and concrete slabs E2366 and G2368.
Vertical boundary	None; surface contamination only.
Develop Decision Rule	
Parameter of interest	Scanning beta counts.
Scale of decision making	Individual measurement locations of 1 m^2.
Action level	Surface contamination limits listed above.
Alternative action	None.
Specify Tolerance Limits on Decision Errors	
Maximum/average value for parameter of interest (data following removal action.)	Beta Surface contamination 1,600 dpm/100 cm^2 maximum, < MDC median
False positive – Type I	5 %
False negative – Type II	5 %
Null hypothesis	The mean beta surface contamination in a 1 m^3 measurement location exceeds the release criteria.
Governing error	Same
Lower boundary of gray region	As established in Subsection 5.4.2

Notes:

pCi/g = Picocuries per gram
DCGL = Derived concentration guideline level
EMC = Elevated measurement comparison
EPA = U.S. Environmental Protection Agency
m^2 = Square meter
MARSSIM = Multi-Agency Radiation Site and Survey Investigation Manual (NRC, 2002)

Therefore, the tasks to be conducted during the FSS will be:

1. Perform a survey for surface contamination on walls and floors of Buildings E2354 and E2371, and the concrete pads of E2356 and E2368.
2. Perform a surface soil survey over the entire Rad Yard site.
3. Perform a MARSSIM evaluation of the surface contamination data from the structures, and a MARSSIM evaluation of the soils data collected during the FSS and the surface soil characterization data from prior site activities.

5.2.2 Data Types

The data types required for this site are based on the type of investigation, the project-specific DQOs, the end use of the analytical data, and the level of documentation. Both screening and definitive data will be collected during the FSS. Methods of sample collection, preparation, and analysis determine whether data are considered screening or definitive.

Screening data are those collected using non-standard sampling methodology or collected using methods of analysis with limited means to assess their accuracy and precision. Screening data provide analyte identification and quantitation; however, analyte identity and/or quantity confirmation may not be possible.

Definitive data are those collected using standard sampling and analytical methodology of known precision and accuracy. The data are analyte-specific, with confirmation of both the analyte identity and concentration. The analytical methodologies provide tangible raw data or electronic files that can be stored or recovered. Table 5-7 lists the DQOs, the types of data that will be collected to support the Rad Yard DQOs, and their end uses.

5.2.3 Practical Quantitation Limits

The practical quantitation limit (PQL) is the lowest concentration that can be achieved reliably within limits of precision and accuracy during routine operating conditions and is based on the MDL for each analyte. Subsection 5.5.2.6 will present the MDC for laboratory analysis of FSS samples, and Subsection 5.5.1.2 will present the MDC for surface soil scanning.

Table 5-7
Data Quality Objectives, Types, and Uses

Remedial Action	Data Quality Objectives	Data	Method	Data Type	Data Uses
FSS	Delineate the extent of radiological contamination and establish MARSSIM survey units. Determine a relationship between field gamma-ray counts and actual concentrations, and characterize the distribution of Cs-137 and Co-60.	Gamma-ray scanning	SOP	Screening	License termination and unrestricted use.
		Off-site gamma spectroscopy	EPA 901.1 modified	Definitive	

5.3 STATISTICAL TEST SELECTION

As described in Subsection 5.1, results of the reference area survey conducted prior to the removal action in October 2005 revealed that Co-60 was not detected above the MDC of the analysis (0.05 to 0.14 pCi/g). However, Cs-137 concentrations ranged from 0.2 to 0.4 pCi/g, and averaged 0.3 ± 0.1 pCi/g. MARSSIM guidance states that if the radionuclide contaminants do not occur in the reference material, or if the background levels are shown to be a small fraction of the $DCGL_w$ (e.g., less than 10%), the survey unit radiological conditions may be compared directly to the specified DCGL value and a reference area background survey is not necessary. Because Co-60 was not detected in the reference area, and the detected Cs-137 concentration was less than 10% of the 5 pCi/g DCGL applied during the removal action, then the correct statistical test to be applied at the Rad Yard is the one-sample Sign test.

5.4 SUMMARY OF THE DATA SET USED TO DESIGN THE FINAL STATUS SURVEY PLAN

5.4.1 Surface Soil

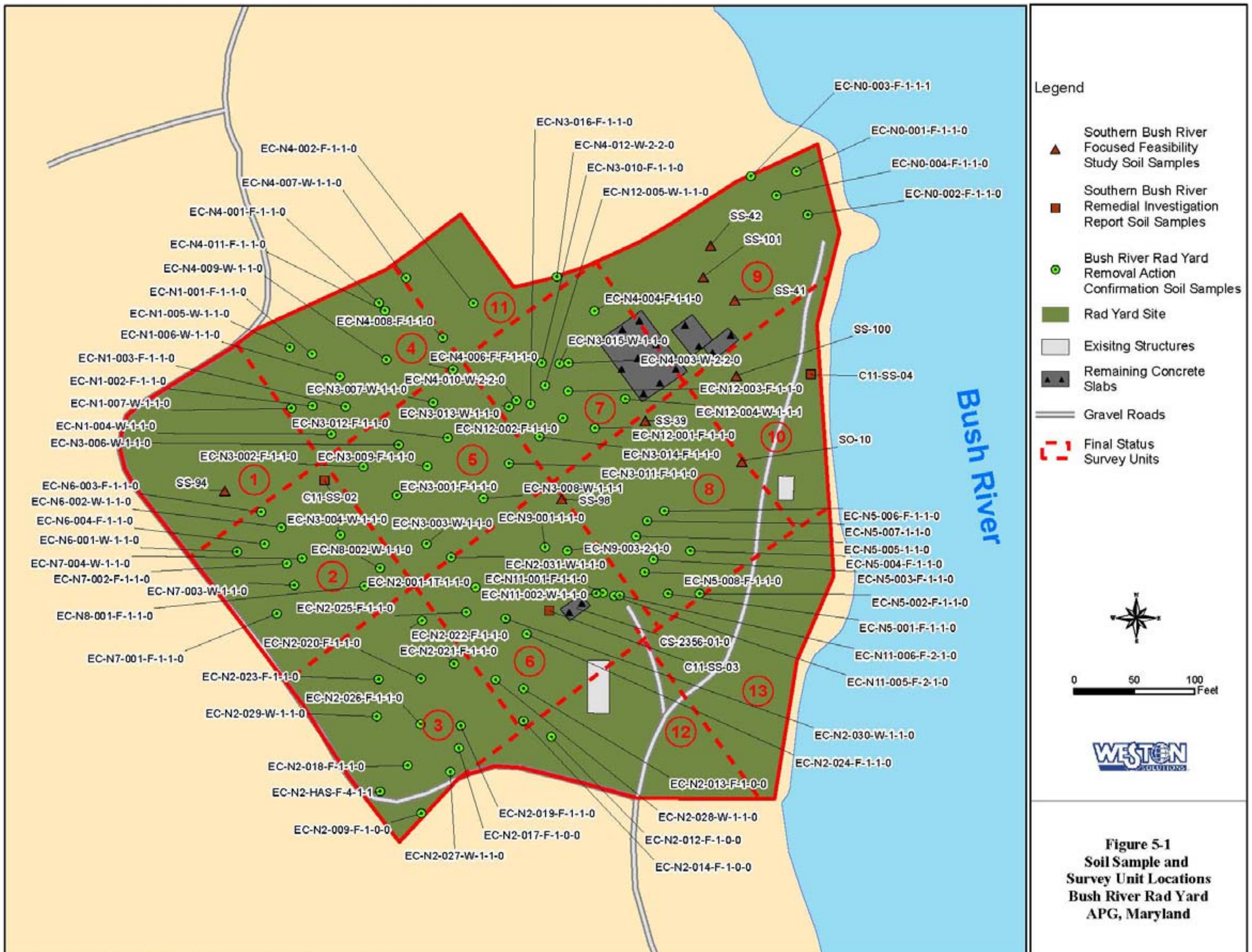
A total of 84 characterization soil samples were collected during the 2004-2006 removal action at the Rad Yard after contaminated soils were removed from 12 separate excavation areas or nodes shown in Figure 2-2. Sample locations are indicated in Figure 5-1 for those characterization samples and 11 additional characterization samples collected during prior site investigations. Table 4-1 provides analytical results for the characterization samples from the removal action, which show that concentrations of Co-60 were below the MDC and analytical results for Cs-137 ranged from -0.280 to 4.71 pCi/g. The median Cs-137 concentration in the 84 samples was 0.9 pCi/g, and the standard deviation of the sample set was 1.19 pCi/g.

5.4.1.1 Calculate the Relative Shift

Using the actual median concentration of Cs-137 in the 84 characterization samples (0.9 pCi/g) as representative of the LBGR, as recommended by Abelquist (p. 272), the standard deviation of the sample set (1.19 pCi/g), and a DCGL of 5.0 pCi/g, the relative shift calculates to 3.45. MARSSIM recommends using a relative shift of between 1 and 3, therefore, a value of 3.0 was used in subsequent calculations.

5.4.1.2 Determine Number of Data Points

NUREG-1757 (NRC, 2006) guidance recommends a Type I decision error (α) of 0.05, but allows the licensee to select the Type II decision error (β), with possible values ranging from 0.01 to 0.25. A mid-range value for (β) of 0.05 was selected for this analysis. Applying a relative shift of 3.0, and decision errors (α) and (β) of 0.05 each, the value of N, or the number of samples per survey unit, can be taken from Table 5.5 of MARSSIM. This value is 14, which includes the recommended 20% increase in sample set size recommended by MARSSIM.



ile: \\Fsfed01\TIG\APG\mxd\RAD_YARD\RADYard_Fig5_1survey_units.mxd, 05-Jul-07 13:29, ricksc

Figure 5-1 Soil Sample and Survey Unit Locations

Instead of using the average Cs-137 concentration of 0.9 pCi/g as measured in the characterization samples, if the LBGR value selected were 50% of the DCGL as recommended by MARSSIM for a first case approximation, the relative shift calculates to 2.1. Applying the same decision errors, the number of samples required per survey unit taken from MARSSIM Table 5.5 recalculates to 15.

Because the two values for the number of samples required are so similar, 14 samples using the characterization sample average concentration and 15 samples using the more conservative MARSSIM first approximation, it is proposed that 15 data points (samples) will be required in each of 13 Class 1 survey units that will be established across the Rad Yard to demonstrate compliance with the release criteria. The survey units are designed to be less than 2,000 m^2 in area, and are located as shown in Figure 5-1.

The analytical data for the 84 characterization samples collected during the removal action (Table 4-1) and from the 11 characterization samples collected during other prior investigations will be considered for use as one of the 15 data points required in each survey unit. For example, survey unit 1 contains 1 soil sample (SS-94) collected during a prior investigation. Therefore, 14 additional soil samples will be collected during the FSS. In survey unit 2, 11 characterization samples were collected during the removal action and 1 sample was collected during a prior investigation. Therefore, during the FSS, 3 additional samples will be collected. Table 5-8 depicts the number of existing characterization samples, and the minimum number of samples to be collected during the FSS such that the total number of samples used in the Sign test for each survey unit is 15.

The protocol for selecting soil sample locations during the FSS is discussed in Subsection 5.5.2.4. The sample locations will be laid out according to MARSSIM protocols using a triangular pattern. The existing characterization sample data points are not uniformly spread across each survey unit and may or may not be close to a designated grid point on the survey grid, once the grid is established. Data from existing sample locations that are close to a grid point will be used to represent the soil concentration at that grid point, and no additional sampling will be required for that grid point. When an existing sample location is not near enough to a grid location (as described further in Subsection 5.5.2.4), the data for the existing sample will not represent any of the grid points, and another sample will be collected during the FSS. For this reason, the estimated numbers of samples per survey unit to be collected during the FSS in Table 5-8 is the minimum number of samples to be collected.

5.4.1.3 Classification of Rad Yard Survey Units

The Rad Yard has been divided into 13 survey units, ranging in area from approximately 700 to 1,900 m^2. All survey units are within the area defined by the security fence separating the 22nd Street Landfill on the north, the Bush River security fence on the east, and the dirt/gravel road along the western and southern boundaries. However, as stated in Subsection 2.3, if a contaminated area starts on-site and extends beyond these boundaries, the impacted area will be included in the survey unit.

Table 5-8
Estimated Numbers of Additional Samples to be Collected from Survey Units

Survey Unit	No. of Existing Characterization Samples	Minimum No. of Samples to be Collected during FSS	Total
1	1	14	15
2	12	3	15
3	12	3	15
4	11	4	15
5	11	4	15
6	14	1	15
7	13	2	15
8	10	5	15
9	7	8	15
10	2	13	15
11	2	13	15
12	1	14	15
13	0	15	15

Figure 5-1 depicts the survey units, the locations of the characterization samples collected during the removal action, and the locations of the buildings remediated during the removal action. Because all of the survey units except 10, 12, and 13 encompass areas that were subject to previous remedial actions during the removal action, all 13 survey units are designated as Class 1. No Class 2 or Class 3 survey units are proposed for the FSS because the area under consideration is tightly bound by the above description.

5.4.2 Building Surface

The remaining building surfaces to be surveyed during the FSS are Buildings E2354 and E2371, and the concrete pads of E2356 and E2368. In order to estimate the number of measurement points required by MARSSIM to accurately characterize these pads and structures, surface survey data that were collected from the concrete pad for Building E2366 during the removal action would be most representative of the conditions anticipated for the buildings and concrete pads listed above. The concrete pad for E2366 was not decontaminated during the removal action and therefore, the level of activity measured should be similar to the remaining pads and buildings. Surface survey data for pad E2366 are presented in Appendix A to the removal action report, and were collected on May 26, 2005.

5.4.2.1 Calculate the Relative Shift

A total of 93 1-minute gross beta measurements integrated over 1 m^2 each were collected over the surface of pad E2366, with results ranging from 64 cpm to 201 cpm. The average count rate was 113 cpm, and the standard deviation of the data set was 23 cpm. The survey instrument used was a Ludlum 44-116 beta scintillation detector with an active probe face of 126 cm^2, an efficiency of 0.22 cpm/dpm, and a background count rate of 150 cpm. Assuming a surveyor efficiency of 0.5, the 5,000 dpm/100 cm^2 release criteria equates to 717 gross cpm, which includes background. Comparing the release action level of 717 cpm to the average count rate observed of 113 cpm and a sigma of 23 cpm indicates that the data set is uniform, and well below the release criteria. Using these data would result in a very large relative shift. Therefore, assuming an LBGR of 50% of the release criteria, as recommended as a first approximation by MARSSIM, and using the actual sigma of 23 cpm, the relative shift calculates to 15.6. This value is still well above the range of 1 to 3 recommended by NRC. Therefore, a value of 3.0 was used in subsequent calculations.

5.4.2.2 Determine the Number of Data Points

Using the same Type I and Type II decision errors as assumed for surface soil, and applying a relative shift of 3.0, the number of measurement points per survey unit is 14, taken from Table 5-5 of MARSSIM. This includes the recommended 20% increase in sample set size recommended by MARSSIM.

5.5 PROCEDURES FOR SURVEYS AND SAMPLING

WESTON maintains a Corporate Quality Assurance (QA) Program which is an umbrella document that provides overall requirements for its project activities. For the BRSA FSS, WESTON's QA Program for U.S. Department of Energy Projects (DOE QAP) provides the QA required for this project. The DOE QAP is based on current DOE Order 414.1C. The WESTON DOE QAP and related work instructions are primarily implemented for DOE clients, but were developed for use by other Nuclear Programs Operations staff as well. The WESTON Project Manager (PM) and Site Manager are directly responsible for ensuring compliance with applicable QA controls. In the FSSR, the following documents affecting quality will be included; radiation safety training records, radiation survey instrument calibration certificates, daily source check logs, radiation source check calibration certificates, field survey data collection sheets, and Level 3 data packages from the commercial radiochemistry laboratory. In addition, written procedures for WSTON's radiological programs are incorporated under its radiological services license granted by NMED. Those procedures specify maintenance and calibration programs for radiation detection instruments, documentation procedures and forms for data collection, instrument use procedures, QA program requirements that cover audits, reviews, and training programs, and radioactive materials handling requirements. On-site activities are performed in compliance with these procedures and requirements. Copies of WESTON's Corporate QA Program, license, and written procedures are available for review upon request.

5.5.1 Soil Scanning Protocols

Near-surface scans will be performed over 100% of the site, using an estimated 3-ft transect spacing. Data will be collected using 2x2 NaI detectors coupled to a ratemeter/scaler set in scaler (count rate) mode. Detector windows will be opened completely and the scaler/ratemeter threshold will be set at 40 keV. Radiological data will be automatically tagged with location coordinates when count rates are recorded, using a differential correction GPS system with submeter accuracy. GPS coordinates will be referenced to a state plane coordinate system, or on-site reference system.

ArcView GIS® software will be used to present the spatial distribution of gamma-ray counts at each training site, superimposed on each Class 1 survey unit.

To confirm constancy in instrument response, the response of survey instruments will be compared twice daily—prior to use and at the end of the day—to a Cs-137 check source. This check source will mimic the activity of site soils, in which Cs-137 is the predominant radionuclide in terms of activity. The site-specific scan MDCs for radiological survey instruments used in the FSS are presented in the following subsection.

5.5.1.1 Radiological Correlation Studies

A preliminary correlation study was performed during the removal action to estimate the response of portable field gamma ray detecting instruments to known soil concentrations of Cs-137 within the Rad Yard. A total of 10 locations were selected based on a range of in situ measurements using a Ludlum 44-10 2x2 NaI detector coupled to a scaler. In situ measurements were collected both on contact with the soil and at a height of 45 cm. Measurements collected on contact with the soil at these locations ranged from approximately 7,000 cpm to 670,000 cpm. At some of the correlation locations, the in situ measurements were significantly different at 45 cm above the soil versus on contact. This information led to the conclusion that the soil concentration at these locations was not homogeneous, and therefore, soil sample results may not have been indicative of the average concentration within the in situ instrument's field of view. Soil samples were collected at the 10 locations from depths of 0 to 15 cm and forwarded to the analytical laboratory for gross alpha, gross beta, gamma isotopic, and total Sr analyses.

Concentrations of Cs-137 in these 10 samples ranged from 0.7 to 344 pCi/g. Co-60 was detected in 2 of the 10 samples, with the highest concentration observed at 1.1 pCi/g. The naturally occurring U and Th series isotopes, and K-40 were detected at concentrations normally expected for this area. Gross beta activity generally trended with Cs-137 concentrations. No anomalous gross alpha activity was detected in any of the samples.

When in situ gamma-ray data were compared with Cs-137 concentrations, a linear correlation was observed. However, the correlation coefficient was poor, probably due to the non-homogeneity of the soil described previously. From these data, it was concluded that an approximate response of 700 cpm per pCi/g of Cs-137 would be a conservative correlation factor for the 2x2 NaI detector to guide the daily soil excavation effort. However, as the Cs-137 residual concentration approached homogeneous background levels, and the gamma-ray contribution from the naturally occurring U and Th isotopes became more significant to the overall gross count rate, node-specific correlation equations were developed that resulted in a reasonably accurate estimate of the soil concentration from in situ measurements.

The scanning portion of the FSS is used primarily to identify areas of elevated activity and to perform an elevated measurement comparison as described in Subsection 4.1.2. The scanning data can also be used to estimate the variability of contamination in residual soils.

5.5.1.2 Determining the MDC_{scan}

The MDC_{scan} is the ability to detect a radionuclide soil concentration that is distinguishable from background with 95% confidence while scanning.

MARSSIM recommends that the scan MDC_{scan} be determined empirically on the contaminated site but recommends methods to calculate it when site data are not available. Normally, a best estimate is developed from calculations and confirmed during the site remediation. The remainder of this subsection presents the calculation approach.

The detection efficiency for the 1173 and 1332 keV gamma rays from the decay of Co-60 will be lower than that for gamma rays from Cs-137 (662 keV). This arises primarily from the higher detection efficiencies of the detector for the lower-energy gamma rays, as indicated by empirical data provided by the manufacturer. The gamma-ray emission probabilities per decay for Cs-137 and Co-60 are 0.90 (Cs-137) and 2.0 (Co-60). Ignoring the detector efficiency differences and assuming equal concentrations of Cs-137 and Co-60, for every Cs-137 gamma ray detected, there will be 2.22 Co-60 gamma rays detected (2/0.9 = 2.22). Therefore, for soils with Cs-137 and Co-60 concentrations of 5 pCi/g and 0.25 pCi/g, respectively, for each 662 keV gamma ray detected from Cs-137, approximately 0.11 high energy gamma rays will be detected from the Co-60 (2.2 x 0.05 = 0.11). In terms of the MDC_{scan}, the presence of Co-60 can be ignored because the effect is probably within the accuracy of the method.

Site characterization data collected during the removal action indicate that the background gamma count rate of a 2-inch by 2-inch Ludlum Model 44-10 NaI detector is approximately 4,000 cpm. The method for calculating the MDC is given in NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC, 1997). This method is incorporated into MARSSIM.

The calculations that follow consider a Ludlum 44-10 detector with its lower threshold discriminator set about 40 to 60 keV, the base of the detector held at 10 cm above the ground surface, a scanning speed of 0.5 meters per second (m/s), and a background count rate of 4,000 cpm. Cs-137 detection properties were modeled for this detector in NUREG-1507, assuming a contaminated circular area with a diameter of 56 cm. Using the method presented in Section 6.8.2 of NUREG-1507 and the assumptions that the desired level of performance is 95% correct detections and at most, 60% false positives (d' = 1.38), the $MDCR_{scan}$ was calculated to be 680 cpm. If one assumes that the technician has a surveyor efficiency of 50%, then the MDCR is divided by the square root of 0.5, resulting in an $MDCR_{surveyor}$ = 960 cpm. Dividing the MDCR by the response factor of 700 cpm per pCi/g, which was determined empirically during the removal action, results in values for the MDC_{scan} and $MDCR_{surveyor}$ of 1 pCi/g and 1.4 pCi/g, respectively. Because the FSS will be done using a GPS-based gamma system coupled to an automatic data logger, human error is eliminated and the MDC_{scan} should approach 1 pCi/g.

While the MDC_{scan} calculated in the previous paragraph uses site-specific parameters and MARSSIM mathematical protocols, the calculated value appears a little low when compared with field experience. Another source of information on this subject is MARSSIM, Table 6.7. This table indicates an MDC_{scan} of 6.4 pCi/g for Cs-137. However, this value is based on an ambient gamma-ray background of 10,000 cpm, which is significantly higher than the 4,000 cpm background count rate in the aforementioned calculation. The likely MDC_{scan} for this site is between these two values, and for the purposes of the FSS, an MDC_{scan} value of 2 pCi/g is reasonable.

5.5.2 Soil Sampling Protocols

5.5.2.1 Unity Rule for Multiple DCGLs

MARSSIM advises that at sites affected by multiple radionuclides, the DCGL for each radionuclide be weighted together using a unity rule. However, the ALARA DCGLs for Cs-137 and Co-60 were selected arbitrarily below the NRC release criterion and the sum of their predicted doses is less than unity.

The land area DCGLs for the Rad Yard are 5.0 pCi/g Cs-137 and 0.5 pCi/g Co-60 for a release to a residential land-use scenario. These DCGLs are lower than modeled DCGLs and represent ALARA levels. These ALARA levels represent residual levels of surface contamination expected to result in total effective does equivalents of 2.6 (Cs-137) and 0.8 millirem per year (mrem/yr) (Co-60). The combined dose is 2.6+0.8 = 3.4 mrem/yr, which is a factor of more than seven lower than the NRC decommissioning release criterion of 25 mrem/yr above background.

5.5.2.2 Sign Test for Co-60 and Cs-137

The Sign test is a one-sample test that compares the distribution of residual Co-60 and Cs-137 concentrations in a survey unit to, in the case of the Rad Yard, the DCGL for Co-60 and Cs-137. To use the one-sample Sign test, background concentrations of Co-60 and Cs-137 are considered to be either zero or insignificant in comparison to the DCGL . Thus, there is no reference to background in statement of the null and alternative hypothesis. The null hypothesis is assumed to be true unless the statistical test indicates that it should be rejected in favor of the alternative. The parameter of interest is the mean concentration. The median is equal to the mean when the measurement distribution is symmetric, and is an approximation otherwise.

The null hypothesis restated is that the probability of a measurement less than the DCGL is less than one-half, i.e., the 50^{th} percentile (or median) is greater than the DCGL. The median is the concentration that would be exceeded by 50% of the measurements. Note that some individual survey unit measurements may exceed the DCGL even when the survey unit as a whole meets the release criterion. In fact, a survey unit that averages close to the DCGL might have almost half of its individual measurements greater than the DCGL . Such a survey unit may still meet the release criterion.

The chronological steps of the Sign test are:

- List the survey unit measurements. If a measurement is listed as "less than" a given value, insert that value for the measurement.
- Subtract each measurement from the DCGL. If any difference is exactly zero, discard it from the analysis, and reduce the sample size by the number of such zero measurements.
- Count the number of positive differences. The result is the test statistic S+. Note that a positive difference corresponds to a measurement below the DCGL and contributes evidence that the survey unit meets the release criterion.
- Large values of S+ indicate that the null hypothesis is false. If S+ is greater than the critical value, k, in that table, the null hypothesis is rejected.

5.5.2.3 Sample Identification and Handling

WESTON will use their corporate sampling program known as FieldFast for sampling activities conducted at the Rad Yard. FieldFast is a database that helps organize large quantities of sampling data and generates computerized forms and labels. For the Rad Yard removal action project, the FieldFast database was populated with project-specific values to help generate sample identifications (IDs), CoC forms, and sample labels.

5.5.2.4 Sampling Grid

As described in Subsection 5.4.2, a minimum of 15 soil samples are required for each survey unit to perform a Sign test. The sampling locations will be collected systematically, starting at a random point, from each of the triangular grid sections, which will be established from the following MARSSIM equation:

$$L = \sqrt{A / 0.866n}$$

where:

L = Length of grid section.
A = Area of survey unit.
n = Number of samples from COMPASS.

The procedure used for a laying out the triangular sampling grid for the soil area survey unit is as follows:

- Locate a random starting point by drawing two random numbers from a uniform distribution on the interval [0,1]. Scale the first number by the length of the east-west coordinate axis. Round the coordinates to the nearest values that can be easily measured in the field (e.g., nearest meter). Similarly, scale a second random number by the length of the north-south coordinate axis to the nearest meter. This gives the starting coordinate for the sampling grid. If this point falls outside the area to be sampled, the next two random numbers are taken and continue to be taken until a point that falls within the sampling area is obtained.

- Compute the spacing, L, of the sampling locations on the triangular grid using the number of sampling locations required, n, rounded down to the nearest meter. Rounding down helps to place the requisite number of sampling points on the sampling grid.
- From the starting location, lay out a row of sampling points parallel to the X-axis and distance L apart.
- To start additional rows, locate the midpoint between two adjacent sampling locations on the sample row and mark a spot at a distance perpendicular to the row. Again, this number should be rounded down if necessary. This is the starting location for the new row.
- Continue until all grid points within the sampling area have been located. Ignore any sampling locations that fall outside the area to be sampled.

The locations of characterization samples collected during the removal action and previous characterization surveys will be compared to the grid sampling locations that have been identified by the above method. These existing sample locations are depicted in Figure 5-1. If the sample location from previous surveys is within 5 ft of the MARSSIM-survey-required location, a new sample will not be collected and the prior survey sample result will be used in the Sign test. In addition to the sample locations depicted in Figure 5-1, supplemental soil samples were collected during the removal action and placed into secured storage in Building E2371. These samples were not analyzed as part of the removal action but were collected for future analysis, if needed. The locations of these supplemental samples, designated ss, are depicted in Figures 2-4 through 2-14 in the removal action report. If any of the "ss" samples are located within 5 ft of MARSSIM-survey required location, the sample will be pulled from storage and analyzed. If neither the removal action verification sample nor the supplemental sample is within 5 feet of the MARSSIM-specified location, another sample will be collected. If clean fill has been placed over the soil at this location, it will be carefully removed until the original post-removal action grade is visually observed, at which depth the new sample will be collected. The corners of survey units and grid sections need not be marked because all sample points will be located using GPS.

5.5.2.5 Soil Depth Profile Samples

Soil samples will be collected from the soil surface at the locations across the Rad Yard, as described in the preceding subsections. Samples will be collected from the surface to a depth of 6 inches.

In order to verify that soil contamination is contained within the top 6 inches of the soil surface, depth profile samples will be collected at select locations. At sampling locations that appear to have residual contamination above background (but still less than the DCGL) as determined by scanning, two additional soil samples will be collected from depths of 6 to 12 inches and 12 to

18 inches. One sampling location will be selected for this depth profile sampling protocol from each of the 13 survey units.

5.5.2.6 Analytical Methods

Soil samples collected during the FSS will be of approximately 1-kilograms (kg) mass, and will be collected from the top 6 inches of soil surface. All sample locations will be documented by GPS. Large stones or gravel and vegetation will be removed from the sample. Sample containers will be wide-mouth polypropylene jars, or other suitable container. Soil samples will be in visual contact by the sampling crew at all times. Samples will be identified by a discrete sample number, date, and initials of sampling personnel. At the end of each sampling period, samples will be collected and brought to a secured area where they will be logged into WESTON's FieldFast corporate sampling program to generate sample identification and CoC documentation. At the end of each work day, samples will be placed into locked secure storage, or will be forwarded under CoC to a laboratory qualified to perform the requested analyses and to generate a Level 3 radiochemistry data package.

Upon arrival at the laboratory, samples will be logged into their sample management system, which will track and document the sample's progress through the laboratory.

Stones larger than 0.5 inch will be removed from the sample and set aside for weighing. The entire remaining soil sample will be dried, homogenized, and weighed. A minimum 500 grams aliquot of the soil will be packed into a suitable counting geometry and analyzed by gamma spectrometry with a count time and background suitable to attain an MDC of 0.2 pCi/g for Cs-137 and Co-60. The laboratory will also be instructed to report all other identifiable and quantifiable radioisotopes. However, the sample will not be set aside for 15 to 30 days to allow for in-growth of Ra-226 progeny because Ra-226 is not considered a COC at the Rad Yard.

A Level 3 data package will be generated and returned to WESTON within 45 days of receipt of the samples at the laboratory.

5.5.2.7 Releasing Survey Units and Evaluating Hot Spots

Survey units are individually released when the following conditions occur in each survey unit:

- All Cs-137 and Co-60 concentrations in final status soil samples are below their respective DGCLs.
- Non-parametric tests for Cs-137 and Co-60 show that the null hypotheses representing false (not the true condition) distributions for each contaminant are rejected.
- Elevated areas of residual radioactivity pass the elevated measurement comparison.
- Elevated areas of residual activity, when weighted in conjunction with the average activity in the survey unit, pass a Unity Rule.

The Sign test applies only to uniform distributions of residual activity in a survey unit. Radioactive hot spots within in situ soils will be addressed using the MARSSIM Elevated Measurement Comparison method (NRC, 2002).

5.5.3 Release Survey for Buildings E2354 and E2371, and Concrete Slabs E2356 and E2368

As discussed in Subsection 4.2, Buildings E2356 and E2368 were demolished during the removal action, and five soil samples were collected from beneath the remaining slabs and analyzed for radionuclides. While these slabs are not anticipated to have residual surface contamination because they were located within the inner controlled access fence of the Rad Yard, they will be classified as Class 1 survey units. During the FSS, a 100% surface contamination survey of these two slabs will be conducted. The slabs will be gridded into 1-m^2 areas, and a beta surface contamination survey performed in compliance with the procedure described in Subsection 4.2.1.

During the removal action, Buildings E2354 and E2371 were designated as support areas. These two buildings were located outside the controlled access fence of the Rad Yard. Building E2354 was originally used by National Guard troops providing surveillance of the Bush River. After departure of the National Guardsmen in January 2005, the washrooms in Building E2354 were used by WESTON personnel assigned to the removal action. Building E2371 was used to store verification samples collected during the removal action. Both of these buildings received a cursory radiological survey prior to their use by WESTON during the removal action, and no contamination was identified.

As a result, Buildings E2354 and E2371 are classified as Class 2 structures for the purposes of the FSS. Building E2354 is a 1-story structure with a footprint of approximately 330 ft^2 (31 m^2). Building E2371 is a 1-story structure with a footprint of approximately 177 ft^2 (16 m^2). Each building will be evaluated as one survey unit, which is consistent with MARSSIM guidance that Class 2 structure survey units have a recommended area of between 100 and 1,000 m^2. A total of 1-m^2 survey points will be located on the floors and lower walls of each building. The same methods as described in Subsection 5.5.2.4 for land areas will be used to locate these survey points. Measurement locations will be systematically identified, starting at a random point and using triangular grid sections.

Examples of possible measurement locations are depicted in Figures 5-2 and 5-3, Building Survey Unit Locations. Interior walls in these buildings are not depicted on this figure because the walls were not accurately known at the time of FSSP preparation. The location of interior walls will be depicted in the FSSR. Also, additional suspect areas such as sink and shower drains will be biased surveyed, and the results provided in the FSSR. Each measurement point will be surveyed for surface contamination in accordance with the procedure described in Subsection 4.2.1. As a result, 14 m^2 of floor or wall area within each building survey unit will be scanned during the FSS. The total floor and interior wall areas within Buildings E2354 and E2371 are approximately 88 m^2 and 57 m^2, respectively. Therefore, approximately 16% of the interior surface of Building E2354 and 25% of the interior surface of Building E2371 will have been surveyed during the FSS. This level of coverage is in compliance with guidance presented in

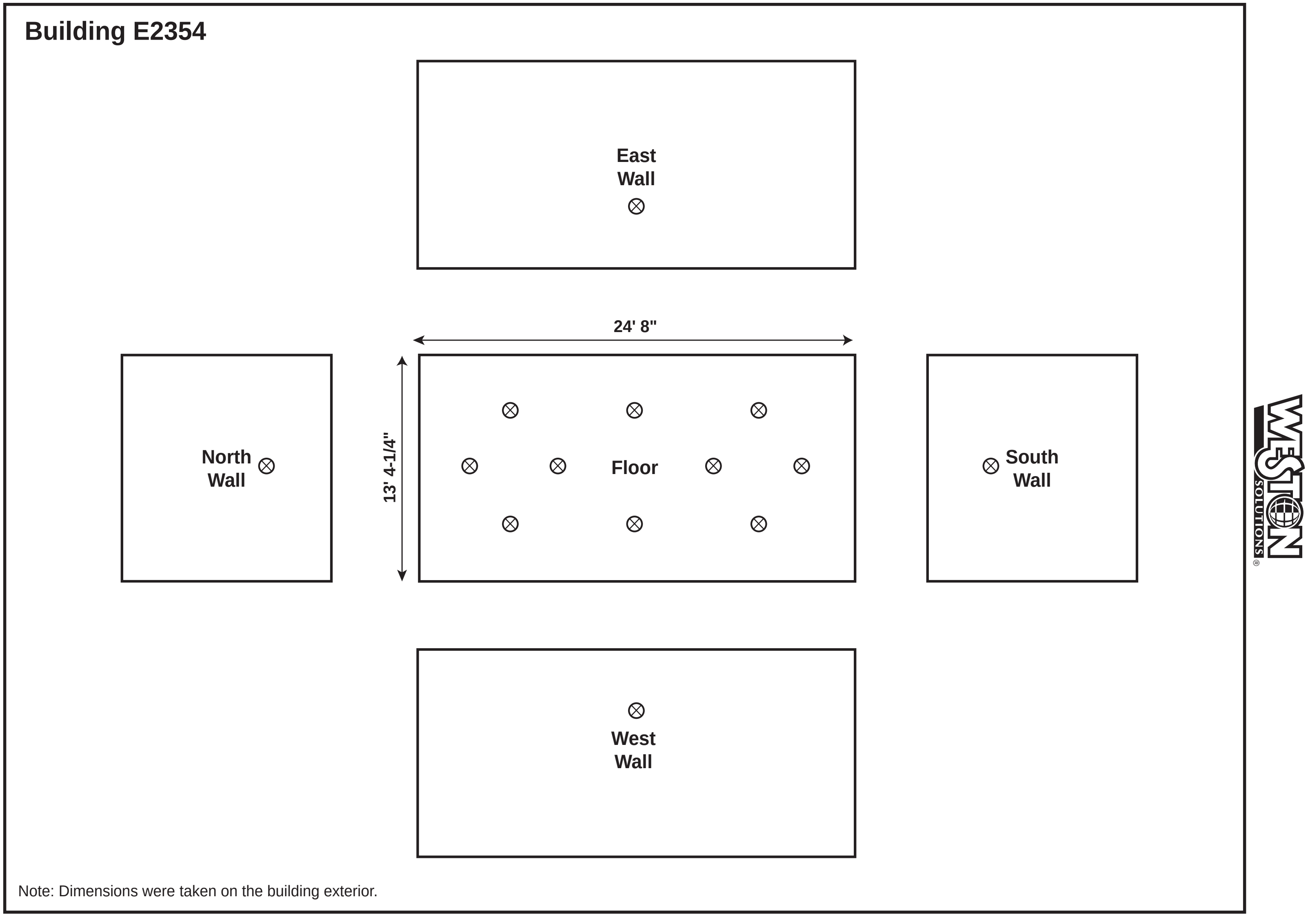


Figure 5-2 Building E2354 Survey Unit Locations
Bush River RAD Yard, APG, MD

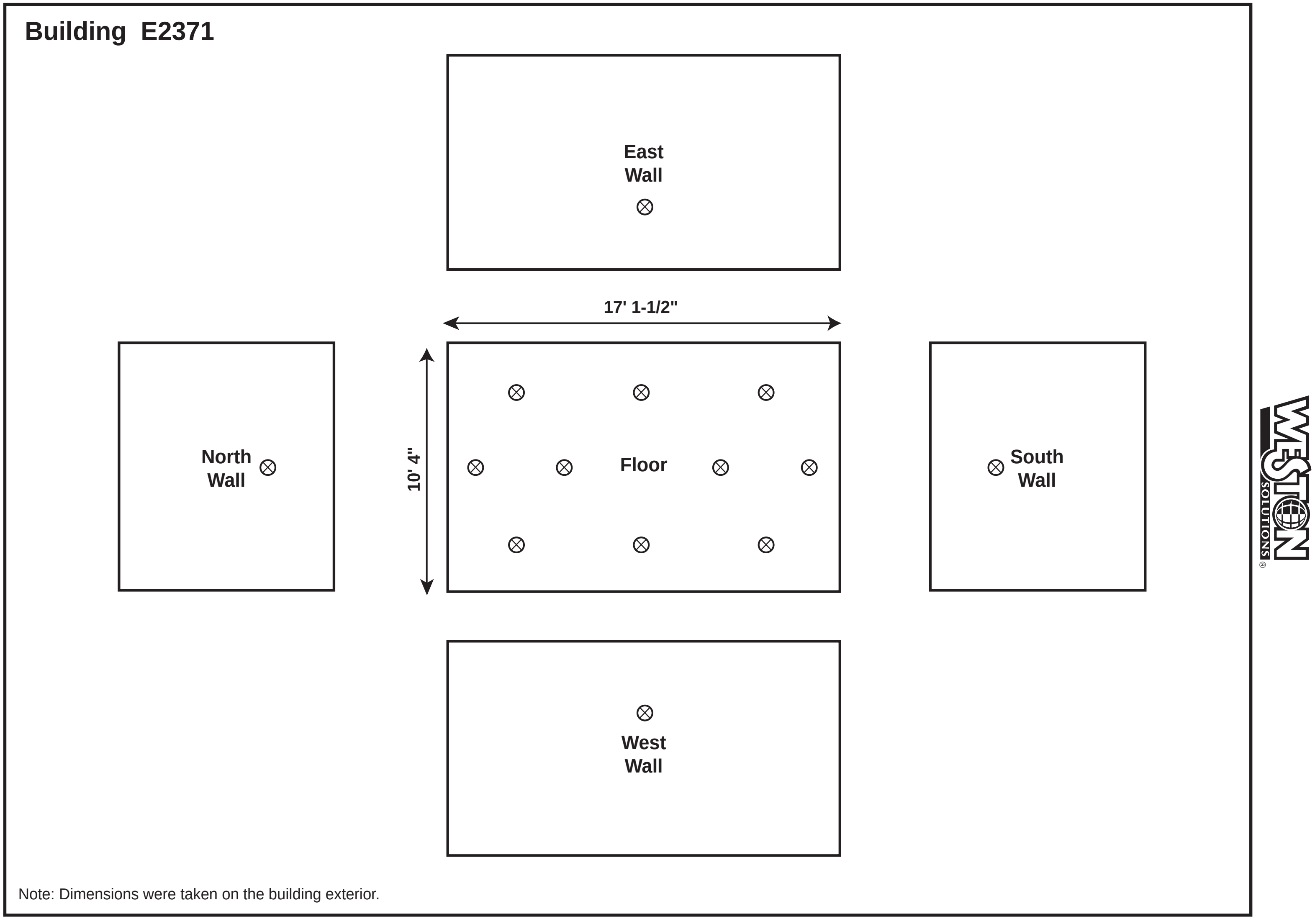


Figure 5-3 Building E2371 Survey Unit Locations
Bush River RAD Yard, APG, MD

Table 5.9 of MARSSIM, which recommends survey coverage of between 10 and 100% for Class 2 structures. In the event any measurement location is found to have residual contamination above the release criterion, the entire building will be reclassified as Class 1, and a 100% surface contamination survey will be performed of the entire survey unit.

5.5.4 Radiation Safety Protocol During FSS

It is anticipated that no radioactivity above the release criteria will be encountered during the FSS. Therefore, the FSS will be performed in Level D personal protective equipment (PPE), and no personnel or environmental monitoring for radioactivity or radiation will be conducted. In the event radioactive contamination is encountered during the FSS, frisking at access control points and appropriate PPE will be added to the work plan. The FSS will be performed by a Certified Health Professional (CHP) and Radiological Control Technician (RCT), and at least one will have prior experience with the removal action at the Rad Yard. Prior to commencing field work, a hazard analysis will be performed to familiarize the field team with the potential and anticipated hazards at the site. Both team members will have current Hazardous Watse Operations and Emergency Response (HAZWOPER) certification. Before commencing work each morning, the CHP and RCT will discuss the planned activities for the day and associated radiological and industrial safety concerns. The hazard analysis and a log of the daily "tailgate" discussions will be retained in project files.

6. REFERENCES

Abelquist, E.W. 2001. *Decommissioning Health Physics, A Handbook for MARSSIM Users*, Institute of Physics Publishing, Philadelphia, PA.

Earth Tech, Inc. 1998. *Focused Feasibility Study Work Plan, Southern Bush River, Bush River Study Area, Edgewood Area.* Aberdeen Proving Ground, MD.

EPA (U.S. Environmental Protection Agency), 1994. *Guidance for Data Quality Objectives Process* EPA QA/G-4. U.S. Environmental Protection Agency, Washington, DC. September 1994.

EPA. 1998. *Guidance for Data Quality Assessment*, *Practical Methods for Data Analysis* EPA QA/G-9. U.S. Environmental Protection Agency, Washington, DC. January 1998.

EPA. 2000a. *Soil Screening Guidance for Radionuclides: User's Guide*. EPA 540-R-00-007, 9355.4-16A Office of Radiation and Indoor Air and Office Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. October 2000.

EPA. 2000b. *Soil Screening Guidance for Radionuclides:Technical Background Document*. EPA 540-R-00-006, 9355.4-16. Office of Radiation and Indoor Air and Office Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. October 2000.

Foster Wheeler Environmental Corporation (FW). 1997. *Final Technical Report for the Adamsite Storage Vaults Removal Action*, Aberdeen Proving Ground, MD Edgewood Office. January 1997.

General Physics Corporation (GP), 1999. *Phase II Addendum to the Focused Feasibility Study Work Plan, Southern Bush River, Bush River Study Area, Edgewood Area.* Aberdeen Proving Ground, MD.

GP. 2002a. *Remedial Investigation Report, Bush River Study Area, Edgewood Area.* Prepared for the Directorate of Safety, Health and Environment, Aberdeen Proving Ground, MD. 2002.

GP. 2003. *Engineering Evaluation/Cost Analysis, Radioactive Waste Management Facility Removal Action*. U.S. Army Garrison, Aberdeen Proving Ground, MD.

GP. 2004a. *Bush River Study Area: Southern Bush River Focused Feasibility Study Data Report for Operable Unit 3 – Ton-Container Steamout Site, Bush River Radioactive Material Disposal Facility, 22nd Street Landfill, and Northern Groundwater Plume*. Edgewood, MD. February 2004 .

GP. 2004b. *Bush River Study Area: Human Health and Radiological Risk Assessment, Radioactive Waste Management Facility*. Edgewood, MD. September 2004.

NRC (U.S. Nuclear Regulatory Commission). 1974. Regulatory Guide 1.86 *Termination of Operating Licenses for Nuclear Reactors*. U.S. Nuclear Regulatory Commission, Washington, DC. June 1974.

NRC. 1997 NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. U.S. Nuclear Regulatory Commission, Washington, D.C. September 1997.

NRC. 2002 NUREG-1575, with 2002 updates. *Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. U.S. Nuclear Regulatory Commission, Washington, DC. August 2000.

NRC. 2006 NUREG-1757, *Consolidated Decommissioning Guidance: Decommissioning Process for Materials Licensees*. U.S. Nuclear Regulatory Commission, Washington, DC. September 2006.

WESTON (Weston Solutions, Inc.). 2004. *Site-Specific Work Plan (SSWP) for the Bush River Study Area Radioactive Waste Management Facility Non-Time Critical Removal Action,* Edgewood Area, Aberdeen Proving Ground, MD. May 2004.

WESTON. 2007. *Bush River Study Area Removal Action Report for Non-Time Critical Removal Action, Radioactive Waste Management Facility, Final.* U.S. Army Garrison, Aberdeen Proving Ground, MD. January 2007.