FINAL Report

Remediation and Final Status Survey Bomb Throwing Device Site - Structures

Aberdeen Proving Ground, Aberdeen, Maryland

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EXECUTIVE SUMMARY

Cabrera Services, Inc. (CABRERA), under contract to the U.S. Army Field Support Command (FSC), performed remedial activities, remedial support surveys, and Final Status Surveys (FSS) for the Bomb Throwing Device (BTD) site at the Aberdeen Proving Ground (APG), Maryland. This document provides the results of post-remediation final status surveys for the structures associated with the BTD site. These surveys were designed so that the results of the individual integrated static measurements could be compared to the release criteria (DCGLw) by survey unit. If all of the survey units associated with a structure meet the criteria for unrestricted release, then the structure as a whole is considered a viable candidate for unrestricted release.

CABRERA conducted survey activities in accordance with the U.S. Nuclear Regulatory Commission (NRC) approved FSS work plan, prepared by CABRERA. This FSS Report addresses final status surveys performed on five BTD structures. The five structures are: the BTD Armor Reclamation Facility, Wash Rack #2, Wash Rack #3, Concrete Pad #2 located behind Building 701, and Concrete Pad #1 located behind the DU Test Enclosure Building.

FSS activities were designed in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (NRC, 2000).

The project had several major activities associated with the remediation and FSS including:

- Remediation of soils, debris, and structures within the confines of the BTD site,
- Deconstruction of structures on the BTD site,
- Removal of plate steel for on-site recycling,
- Removal and shipment of remediated soils and debris to Envirocare of Utah (the disposal site),
- Designation of the BTD land areas into 25 MARSSIM Class 1 Survey Units,
- FSS of the BTD site soils and structures, and
- Determination that the dose from residual contamination at the site is not greater than the release criterion for each Survey Unit.

The radiological contaminant of concern was depleted uranium (DU). The derived concentration guideline (DCGLw) for fixed (or total) DU activity was determined to be 100 disintegrations per minute alpha per 100 square centimeters (dpm/100cm^2). The maximum measurements from all of the survey units associated with the five structures were well below the DCGLw value.

Smear samples for gross transferable alpha contamination were collected and analyzed to determine if transferable activity is less than 10% of total activity, to confirm assumptions in the release criterion. The maximum smear measurements from all of the survey units associated with the five structures were below 10% (i.e., 10 dpm/100cm^2) of total activity.

The FSS data indicates that the five structures are suitable for release for unrestricted use, without regard for former operations with licensed radioactive material.

FSSs were also performed over a land area of approximately 46,000 square meters and on access roads and several support buildings situated on the BTD site. Discussions of the surveys over land areas are addressed in a separate FSS document.

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ACRONYMS AND ABBREVIATIONS

AFSC	U.S. Army Field Support Command
ALARA	As Low As Reasonably Achievable
APG	Aberdeen Proving Ground
ARL	Army Research Laboratory
ATC	Aberdeen Test Center
BARF	BTD Armor Reclamation Facility
BTD	Bomb Throwing Device
CABRERA	Cabrera Services, Inc.
CFR	Code of Federal Regulations
cm	Centimeters
DCGL or DCGLw	Derived Concentration Guideline Level
dpm alpha/100cm^2	Disintegrations per minute alpha per 100 square centimeters
DU	Depleted Uranium
FSC	U.S. Army Field Support Command
FSS	Final Status Survey
HEPA	High Efficiency Particulate Air filter
LAB	Liquid Abrasive Blaster
LBGR	Lower Bound of the Grey Region
m	Meters
m^2	Square Meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrem/yr	Millirem per year
NAD	Normalized Absolute Difference
NIST	National Institute of Standards and Technology
NRC	U. S. Nuclear Regulatory Commission
PSA	Plate Storage Area
QA	Quality Assurance
QC	Quality Control

ROPC	Radionuclides of Potential Concern
σ	Sigma
S/N	Serial Number
SU	Survey Unit
^{234}U	Uranium-234
^{235}U	Uranium-235
^{238}U	Uranium-238

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the United States Army Field Support Command (AFSC) to provide support to the Aberdeen Test Center (ATC) at the Aberdeen Proving Ground (APG) in Aberdeen, Maryland. CABRERA performed facility demolition, remediation, and site wide radiological surveys of the Bomb Throwing Device (BTD) site to support consideration for unrestricted release. The BTD site consists of approximately 46,000 square meters (m^2) of land on the APG used for the testing of Depleted Uranium (DU) munitions. The BTD site also contains a number of structures used to support operations.

For consistency with other decommissioning activities at APG, radiologically impacted soils and structures are addressed separately. This document presents the Final Status Survey (FSS) activities for five structures on site – the BTD Armor Reclamation Facility (BARF), Wash Rack #2, Wash Rack #3, Concrete Pad #2 located behind Building 701, and Concrete Pad #1 located behind the DU Test Enclosure Building. The Final Status Survey conducted on soils is addressed in a separate document titled, "*Remediation and Final Status Survey, Bomb Throwing Device Site – Soils*," (CABRERA, 2004). These final status surveys are designed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (U.S. Nuclear Regulatory Commission [NRC], 2000).

1.1 Site History

APG, located in Aberdeen, Maryland, is an active U.S. Army testing and research facility. The APG lies along the western shore of the Chesapeake Bay in Harford and Baltimore Counties, Maryland, approximately 15 miles northeast of Baltimore. The APG covers a total of 72,516 acres (land and water) and consists of two distinct areas: the northern portion of APG, referred to as the Aberdeen Area; and the southern portion of APG, referred to as the Edgewood Area. The Aberdeen Area became a formal military post, designated as the APG, in 1917.

The BTD site was used between 1982 and 1993 for the testing of DU munitions. In 1993, the site consisted of the BTD ARMOR RECLAMATION FACILITY, the DU Test Enclosure Building, the Enclosure Building High Efficiency Particulate Air (HEPA) system, the Plate Storage Area (PSA), Wash Racks #2 and #3, access roads, and several support buildings situated on approximately 46,000 square meters (m^2) (11.4 acres) of land. During operations, DU munitions were fired at steel plate and other targets placed inside the DU Test Enclosure Building. The High Efficiency Particulate Air (HEPA) ventilation system equipment was located outside the DU Test Enclosure Building on a concrete pad (Concrete Pad #1). Its function was to collect and filter potentially contaminated air exiting the DU Test Enclosure Building after the firing of DU munitions.

Prior to site remediation, approximately 40 tons of DU-contaminated armor plate was located within the DU Test Enclosure Building and surrounding grounds. Heavy equipment was used to transport the armor plates between the DU Test Enclosure Building and the PSA. As part of the remedial activities and subsequent to the removal of the armor plates, the DU Test Enclosure Building, the HEPA ventilation system, the footings for the DU Test Enclosure Building, the "White" Building, the "Rust" Building, and the Sabot Stripper were removed in their entirety from the site and processed separately from this report.

The BTD site decommissioning consisted of structure demolition, soil excavation, and removal of contaminated soil and demolition debris. As physical decommissioning actions were completed, FSSs were performed on both structures and land areas (this report addresses only five structures previously mentioned). Much of the plate steel that was generated during site cleanup and demolition (primarily the DU Test Enclosure Building) was transferred to the Army Research Laboratory (ARL) facility, at APG Spesutie Island, for decontamination and recycling. A cost analysis performed by the Army indicated that recycling was a less expensive option than offsite disposal of the material and that there was a beneficial reuse for the plate steel in support of APG's mission. Other demolition debris and excavated soil was considered unwanted radioactive material and was shipped via rail to Envirocare of Utah, an NRC licensed disposal facility, for shallow land burial.

During initial mobilization in February 2003, the CABRERA field crew entered the BARF and dismantled, surveyed, and removed the DU armor plate reclamation machine (the LAB) housed within the BTD Armor Reclamation Facility.

In May 2003 CABRERA re-mobilized to perform a FSS on the inside of the BTD Armor Reclamation Facility, and demolish the DU Test Enclosure building. Most of the steel plate removed from the DU Test Enclosure Building was shipped across APG to the ARL Spesutie Island Facility for decontamination and beneficial reuse. Other steel/debris was containerized in intermodals for future rail shipment to Envirocare of Utah.

During June 2003, the CABRERA team performed remediation/FSS of Wash Racks 2 and 3, which included dismantling and ship out of the floor grids and left the scrap steel piled for transfer to ARL or other use, as instructed by ATC personnel. Concurrent to the dismantling operations and through the month of August 2003, the CABRERA team completed the majority of the gamma walkover survey, excavated contaminated soils, and stockpiled the remediated soil (approximately 1,200 cubic yards) into a lay down area within Survey Units 16 and 25. CABRERA demobilized at the end of August 2003.

In February and March 2004, the CABRERA team returned to the BTD site, performed data collection for survey gaps, and accomplished 95% of the remediated soil load out. The soil was packed into intermodal containers, and the intermodals were shipped via rail to Envirocare of Utah.

In June 2004, the remainder of the soil was loaded/shipped to Envirocare for disposal and both Concrete Pad #1 and Concrete Pad #2 surfaces were remediated with a steel ball blast/HEPA vacuum system. Following cleaning, the surfaces were surveyed and the FSSs were performed.

As of the time of this writing, all soil/debris shipped via rail to Envirocare of Utah has been transferred to Envirocare of Utah and final disposition documentation is forthcoming.

In the Figures section of this report, Figure 1 shows the location of the BTD Site relative to APG and surrounding towns. Figure 2 shows the relative locations of the five structures specifically addressed in this FSS Report. Appendix A contains site photos of the structures discussed below.

1.1.1 BTD Armor Reclamation Facility

The BARF is a steel beam and sheet metal constructed building with insulated walls and roof. The insulation is covered with a flexible protective plastic cover. The floor is a concrete pad. The interior of the BARF is approximately 12 meters (m) long by 14.8 m wide with a ceiling height of 6 m. The building is bisected by a sheetrock wall with doors leading from one side to the other. There are no drains, sumps, or ventilation system penetrations other than the liquid abrasive blaster (LAB) HEPA ventilation system. A small heating system with insulated ductwork, rollup doors for equipment entry, smaller doorways for personnel entry, and electrical circuit boxes are other general features found in the building.

The northern portion of the BARF contained the LAB decontamination equipment and a small capacity crane used to help lift and load steel plates into the LAB. The southern part of the building was used to store clean unused HEPA filters and small amounts of containerized contaminated trash. Routine radiation contamination surveys were executed on all floor areas within the BTD Armor Reclamation Facility, on stored boxes and containers, and occasionally on wall surfaces.

The ATC utilized the BARF to house the LAB. The LAB was an enclosed system used to decontaminate pieces of steel plate and other small objects with water jets and abrasive. A ventilation system with a pre-filter demister and a HEPA filter removed airborne particulates prior to ventilation release to the environment. A hopper attached to the LAB retained spent abrasive and removed contamination.

No contamination was found on either the LAB HEPA filter or areas downstream in the ventilation system ducts during removal of the LAB. Minor contamination was found within the LAB enclosure, the hopper which contained water and abrasive, the HEPA pre-filter, and small areas on the outside of the LAB enclosure near loading points. The lack of activity downstream of the HEPA filter indicates a well-designed system that did not release airborne radioactivity to the environs. Other general surveys do not show contamination on the walls of the BARF. Scan surveys showed only occasional activity on the floor areas surrounding the LAB. Surveys of selected areas overhead and on the crane are also negative with respect to contamination.

1.1.2 Wash Rack #2

Wash Rack #2 consists of a steel beam frame and sheet metal walls with no interior insulation or wallboard. The interior is approximately 17 m long by 8 m wide with a ceiling height of 6 m. The floor consists of steel plate with a recessed trough running the length of the facility. The trough area is approximately 6 m wide by 10 centimeters (cm) deep. The trough area contains multiple raised (approximately 3 inches) steel beams, which were used to support steel floor grating. The grating, which was removed prior to this FFS, was flush with the surrounding floor plate. There are no drains, sumps, heating, cooling, or ventilation systems present. Steel rollup doors for equipment entry are located at both ends of the structure. Previously documented routine surveys identified minor levels of DU contamination on the floor area of Wash Rack #2.

Since the construction of Wash Rack #2 in 1992, the ATC has utilized this facility as a warehouse. Wash Rack #2 has never been used as a wash rack. Instead, it was used to store items and equipment, some of which were contaminated with DU. Wash Rack #2 housed DU in

the form of penetrators, floor sweepings, liquid abrasive residue from previous decontamination activities, and range debris (e.g., paper, plastic, wood).

Since the wash rack was used as a storage facility for contaminated materials, the primary area of investigation is the floor, trough area, and lower wall surfaces (2 m and below).

1.1.3 Wash Rack #3

Wash Rack #3 is identical to Wash Rack #2, was also built in 1992, and was used for the storage of uncontaminated Navy accelerator parts and the temporary housing of a cutting table contaminated with DU. Contamination left by the cutting table was identified in the southwest corner of the facility. This contamination was removed though decontamination activities prior to the initiation of the FSS. Past routine surveys of this structure have identified minor levels of DU contamination on the floor.

Since the wash rack was used as a storage facility for contaminated materials, the primary area of investigation is the floor, trough area, and lower wall surfaces (2 m and below).

1.1.4 Concrete Pad #2 (Located Behind Building 701)

This concrete pad is located behind Building 701. Pad dimensions are approximately 22 m by 15 m. The pad was confirmed to have alpha contamination and therefore would not pass release criteria. Its purpose was to stage or store heavy armored vehicles.

1.1.5 Concrete Pad #1 (Located Behind the DU Test Enclosure Building)

Concrete Pad #1 is located adjacent to the DU Test Enclosure Building. It is somewhat smaller than Concrete Pad #2 and is approximately 10 m by 12 m. Its purpose was to provide a foundation for the HEPA system associated with the DU Test Enclosure Building.

1.2 Radionuclides of Potential Concern

The following three Final Status Survey Plans were utilized in producing this consolidated FSS report:

- *Final Status Survey Plan For BTD Armor Reclamation Facility, Aberdeen Proving Ground, Aberdeen, MD* (provided in Appendix B)
- *Final Status Survey Plan For Wash Rack Facilities #2 and #3, Aberdeen Proving Ground, Aberdeen, MD* (provided in Appendix C)
- *Final Status Survey Plan Bomb Throwing Device (BTD) Site, Aberdeen Proving Ground, Aberdeen, MD* (provided in Appendix D)

Section 2.2 of each FSS Plan identifies the site Radionuclides of Potential Concern (ROPC) as being limited to DU and its short-lived uranium progeny (decay products). The uranium ratios are based on isotopic uranium weight ratios used for shipments of routine DU waste from APG

(BARG, 1995). The activity fractions are calculated from the isotopic weight ratios and the specific activity of each uranium isotope. The result of the activity fraction calculation is a Uranium-234 (^{234}U):Uranium-235 (^{235}U):Uranium-238 (^{238}U) ratio of 0.084:0.012:0.904.

1.3 Derived Concentration Guideline Levels

As described by MARSSIM, a Derived Concentration Guideline Level (DCGL) is a calculated radionuclide activity concentration within a designated survey unit that corresponds to a defined release criterion in radiation dose or risk units. Per the license requirement of 10 Code of Federal Regulations (CFR) 20 Subpart E, a release criterion of 25 millirem per year (mrem/yr) will be used for the buildings and structures included in this FSS Report. Doses from residual radioactivity will be kept as low as reasonably achievable (ALARA) whenever possible. Using MARSSIM Section 4.3.4 (equation below) and knowing that there is one alpha decay per decay of each uranium isotope, a single total uranium $DCGL_W$ of 100 disintegrations per minute alpha per 100 square centimeters (dpm alpha/100cm^2) was calculated for DU. This $DCGL_W$ was calculated using the values provided by the NRC screening guidelines of 90.6 dpm/100cm^2, 97.6 dpm/100cm^2, and 101 dpm/100cm^2 for U^{234}, U^{235}, and U^{238}, respectively, as presented in Table 5.19 of NUREG/CR-5512 (volume 3, October 1999), NUREG 1757, and the DU activity fractions discussed in Section 1.2. The $DCGL_W$ is calculated as follows:

$$DCGL_W = \frac{1}{\left(\frac{f_1}{DCGL_1}\right)+\left(\frac{f_2}{DCGL_2}\right)+\left(\frac{f_3}{DCGL_3}\right)} = \frac{1}{\left(\frac{0.084}{90.6}\right)+\left(\frac{0.012}{97.6}\right)+\left(\frac{0.904}{101}\right)} = 100 \text{ dpm alpha/100cm}^2$$

Where: $DCGL_w$ = Combined gross activity DCGL (i.e., release limit).

f_n = Activity fraction of radionuclide *n*

$DCGL_n$ = DCGL of radionuclide *n*

The total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 was used as the action level for both static and scanning measurements in the buildings and on the structures.

2.0 FINAL STATUS SURVEY DESIGN

The FSS performed at the BTD site was designed in accordance with Final Status Survey guidance from MARSSIM (NRC, 2000). FSS activities consisted of scanning surveys over 100% of the accessible structure surfaces. Integrated direct surface measurements were performed at frequencies based on MARSSIM guidance. Survey activities also included direct and biased smear sample collection. The FSSs were designed conservatively in that the radiological background present in the structure materials is neglected and the measured total activity is used for direct comparisons to the $DCGL_W$.

2.1 General Structure Classification Based on Contamination Potential and Survey Unit Identification

Using MARSSIM Section 5.3 as guidance, the five structures were subdivided into survey units and designated as Class 1, Class 2, or Class 3 survey units. The following subsections describe how each structure was subdivided and classified. Appendix E presents individual SU schematic diagrams along with direct (integrated) measurement/smear locations.

2.1.1 BTD Armor Reclamation Facility

The BARF was subdivided into four Class 1 SUs and one Class 3 SU as listed in Table 2-1. The floor and lower walls of the northern room of the BARF share similar contamination potential because this area housed the LAB decontamination equipment and was where the decontamination process was performed. Although the lab system was self-contained and surveys did not routinely identify transferable contamination on the floor or walls, contaminated materials were moved through this room via the south rollup door to be loaded in and out of the LAB system. In accordance with MARSSIM guidance, the south room floor and lower walls were considered Class 1 SUs as well because this area was once used to store containerized contaminated trash.

Since the upper wall and ceiling surfaces of the north and south rooms share similar potential for contamination, these areas were combined into one Class 3 SU. The potential for contamination on the upper walls and ceiling surface in the north room is small because no contamination was identified on the LAB HEPA filter or at downstream areas in the ventilation system. The lack of activity downstream of the HEPA filter indicates a well-designed system that did not release airborne radioactivity to the environs. In addition, transferable contamination was not identified during routine surveys in the BTD Armor Reclamation Facility, and the primary mechanism for transport (i.e., ventilation system) was not contaminated.

Maps presenting the BARF SU delineations and the reference coordinate system are presented in Appendix E.

Table 2-1: BTD Armor Reclamation Facility Survey Units

Description	Area (m^2)	Material	MARSSIM Survey Class
North Room Floor	88.8	Concrete	1
South Room Floor	88.8	Concrete	1
North Room Lower Walls	76.6	Foam / Sheet Metal	1
South Room Lower Walls	76.6	Foam / Sheet Metal	1
Ceilings and Upper Walls	488	Foam / Sheet Metal	3

2.1.2 Wash Rack #2

Wash Rack #2 was divided into three Class 1 SUs and one Class 2 SU as listed in Table 2-2. The floor and lower walls of Wash Rack #2 has a history of contamination and contamination potential because this structure was used to store DU waste. DU contamination has been identified previously on the floor of this facility during past routine surveys. The floor area in Wash Rack #2 was remediated for DU contamination prior to the initiation of the FFS.

The ceiling and upper walls of Wash Rack #2 are classified as Class 2 due to remediation activities being performed previously on the floor of this facility.

Maps presenting the Wash Rack #2 SU delineations and the reference coordinate system are presented in Appendix E.

Table 2-2: Wash Rack #2 Survey Units

Description	Area (m^2)	Material	MARSSIM Survey Class
Floor South Side	68	Metal	1
Floor North Side	68	Metal	1
Lower Walls	90	Metal	1
Ceiling and Upper Walls	346	Metal	2

2.1.3 Wash Rack #3

Wash Rack #3 was divided into three Class 1 SUs and one Class 2 SU as listed in Table 2-3. The floor and lower walls of Wash Rack #3 has a history of contamination and contamination potential because this structure was used to store DU waste. DU contamination has been identified previously on the floor of this facility during past routine surveys. The floor area in Wash Rack #3 was remediated for DU contamination prior to the initiation of the FFS.

The ceiling and upper walls of Wash Rack #3 are classified as Class 2 due to prior remediation activities performed on the floor of this facility.

Maps presenting the Wash Rack #3 SU delineations and the reference coordinate system are presented in Appendix E.

Table 2-3: Wash Rack #3 Survey Units

Description	Area (m^2)	Material	MARSSIM Survey Class
Floor South Side	68	Metal	1
Floor North Side	68	Metal	1
Lower Walls	90	Metal	1
Ceiling and Upper Walls	346	Metal	2

2.1.4 Concrete Pad #2

Concrete Pad #2 was designated a Class 1 survey unit. Due to its size, the pad was divided into two survey units – North and South. Each survey unit is approximately 107 m^2.

2.1.5 Concrete Pad #1

Concrete Pad #1 was designated a Class 1 survey unit. Due to its size, the pad was divided into two survey units – North and South. Each survey unit is approximately 60 m^2.

2.2 Survey Instrumentation and Survey Techniques

Instrumentation used in the survey consisted of direct alpha scan and integrated surface detectors, and alpha/beta smear counters. A number of both types of instruments were used due to the extended duration of the surveys. All instruments were properly calibrated (appendix I), QC checked (appendix F), and operated in accordance with standard operating procedures (section 4.0).

2.2.1 Direct Surface Alpha Radioactivity Scan Surveys and Integrated Direct Surface Alpha Radioactivity Measurements

Direct alpha scanning was performed to identify surface locations on structures where contaminant concentrations may exceed the criterion for unrestricted release. Integrated direct measurements (i.e., static measurements) of surface alpha radioactivity were performed during the FSS to compare contaminant levels at discrete sampling locations on building interior surfaces to the release criterion and to facilitate statistical testing, if necessary. Scanning and integrated direct surface measurements were performed using the instruments listed in Table 2-4.

Table 2-4: Instruments Used for Scanning and Integrated Direct Surface Measurements

Instrument Used (Meter and Probe)	Dates Used	Building or Structure Where Used
Ludlum Model 2224-1 portable alpha/beta scaler/ratemeter (serial number [S/N] 162425) with the Ludlum model 43-93 100 cm^2 alpha/beta detector (S/N 182403)	5/28/03, 5/29/03, 6/4/03 6/11/03, 6/12/03, 6/13/03, 6/19/03, 6/20/03 6/27/03 7/9/03, 7/10/03 8/12/03	Wash Rack #2 Wash Rack #3 Wash Racks #2 and #3 Wash Rack #3 DU Test Enclosure Building
Ludlum Model 2224-1 portable alpha/beta scaler/ratemeter (S/N 162426) with the Ludlum model 43-89 126 cm^2 alpha/beta detector (S/N 193921)	5/5/03, 5/14/03, 5/15/03 5/19/03, 5/20/03, 5/22/03, 5/28/03, 5/29/03. 6/6/03 6/9/03 6/10/03 6/11/03, 6/12/03, 6/13/03 6/19/03 6/20/03 6/26/03, 6/27/03, 7/9/03, 7/10/03 3/30/04 3/31/04	BTD Armor Reclamation Facility Wash Rack #2 Wash Racks #2 and #3 DU Test Enclosure Building DU Test Enclosure Building and Wash Rack #3 Wash Rack #3 DU Test Enclosure Building and Wash Rack #3 Wash Racks #2 and #3 Wash Rack #3 Wash Rack #2
Ludlum Model 2224 portable alpha/beta scaler/ratemeter (S/N 183048) with the Ludlum Model 43-68 large area (126 cm^2) gas proportional detector (S/N 161781)	5/8/03	BTD Armor Reclamation Facility
Ludlum Model 2360 alpha/beta data logger (S/N 193675) with the Ludlum Model 43-37 area floor monitor (S/N 161687)	5/7/03, 5/8/03, 5/9/03, 5/12/03, 5/13/03, 5/14/03, 5/15/03, 6/2/03 6/4/03, 6/5/03, 6/6/03 6/9/03 6/11/03, 6/12/03, 6/16/03, 6/19/03 6/20/03, 6/23/03, 6/24/03 6/25/03	BTD Armor Reclamation Facility Wash Rack #2 Wash Racks #2 and #3 Wash Rack #3 Wash Racks #2 and #3
Ludlum Model 2360 alpha/beta data logger (S/N 184938) with the Ludlum Model 43-37 area floor monitor (S/N 178371)	6/8/04, 6/9/04, 6/10/04	Concrete Pads #1 and #2
Ludlum Model 2360 alpha/beta data logger (S/N 202398) with the Ludlum model 43-93 100 cm^2 alpha/beta detector (S/N 211706)	6/8/04, 6/9/04, 6/10/04	Concrete Pads #1 and #2

2.2.2 Smear Sample Collection and Analysis

Gross transferable alpha contamination was collected and analyzed to determine if transferable activity is less than or equal to 10% of total activity as assumed in the NUREG/CR-5512 and NUREG 1757 documents for screening level guidelines.

Smear samples were collected over approximately 100 cm^2 areas at systematic and biased locations identified during scanning activities. Smear samples were analyzed for alpha and beta radioactivity using a Ludlum Model 2929 alpha/beta scintillation counter. Three different units were used during the field activities, as summarized in Table 2-5.

Table 2-5: Alpha/Beta Scintillation Counter Used for Transferable Activity Measurements

Instrument Used (Meter and Probe)	Dates Used	Building or Structure Where Used
Ludlum Model 2929 alpha/beta scintillation counter (S/N 163827) with attached 43-10-1 probe (S/N 171322)	5/5/03, 5/8/03, 5/9/03, 5/12/03, 5/13/03, 5/14/03	BTD Armor Reclamation Facility
	5/15/03	BTD Armor Reclamation Facility, Wash Rack #2
	5/19/03, 5/20/03, 5/21/03, 5/22/03, 5/28/03, 5/29/03, 5/30/03	Wash Rack #2
	6/2/03, 6/3/03, 6/4/03, 6/6/03, 6/9/03	DU Test Enclosure Building and Wash Rack #2
	6/10/03	DU Test Enclosure Building
	6/11/03, 6/12/03, 6/16/03	Wash Rack #3
	6/26/03, 6/27/03	Wash Racks #2 and #3
	7/8/03	Wash Rack #2
	7/9/03, 7/10/03	Wash Rack #3
Ludlum Model 2929 alpha/beta scintillation counter (S/N 180830) with attached 43-10-1 probe (S/N 207849)	3/30/04	Wash Rack #3
	3/31/04	Wash Rack #2
Ludlum Model 2929 alpha/beta scintillation counter (S/N 171590) with attached 43-10-1 probe (S/N 174813)	6/8/04, 6/9/04, 6/10/04	Concrete Pads #1 and #2

2.3 Number of Static Measurements

MARSSIM provides a method to determine the number of measurement locations required in a given survey unit. A minimum number of measurement locations are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The following subsections describe the bases for and derivation of the minimum required measurement locations per survey unit.

2.3.1 Estimation of Relative Shift

The minimum number of measurement locations required is dependent on the distribution of site residual radionuclide concentrations relative to the $DCGL_w$ and acceptable decision error limits (α and β).

The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated using the guidance found in Section 5.5.2.3 of MARSSIM. The relative shift is calculated as follows:

$$\Delta/\sigma = \frac{DCGL_w - LBGR}{\sigma}$$

Where: $DCGL_w$ = Derived Concentration Guideline Level

LBGR = concentration at the lower bound of the gray region. The Lower Bound of the Grey Region (LBGR) is the concentration at which the survey unit has an acceptable probability of passing the statistical tests.

σ = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system).

As previously stated, the $DCGL_w$ for surface alpha radioactivity is 100 dpm/100cm^2. The LBGR was conservatively estimated at 70 dpm alpha/100 cm^2 based on previous studies with similar instruments on concrete. Without prior survey, it is reasonable to assume a coefficient of variation on the order of 30 percent (MARSSIM Section 5.5.2.2). Using a coefficient of variation of 30 percent and the LBGR as an estimate of the sample mean, a sigma value of 21 dpm/100cm^2 is estimated. Using the parameters discussed above, the relative shift is calculated as 1.4.

2.3.2 Determination of N (Number of Required Measurement Locations)

The final number of required measurement locations per survey unit is 20 as per MARSSIM (Table 5.5) given a relative shift of 1.4 and an error rate for both Type I and Type II errors of five percent (i.e., $\alpha = \beta = 0.05$). The actual number of measurements taken in each survey unit ranges from 20 to 24 samples based on the size of the survey area.

2.4 Elevated Measurement Criterion ($DCGL_{EMC}$)

MARSSIM states that, for Class 1 survey units, a dose area factor should be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion. For the purpose of ALARA, the $DCGL_W$ will be used as the $DCGL_{EMC}$, which corresponds to an area factor of one. Since the

scan minimum detectable concentration of the instrumentation is sensitive enough to identify the $DCGL_W$ with a 90% confidence limit (refer to Appendices B, C, and D), it is unlikely that small areas of elevated activity exceeding the $DCGL_W$ would be missed during surface scans.

2.5 Static Measurement Locations

Measurement locations in Class 1 and Class 2 survey units were established using a random start point in a systematic rectangular grid. The Class 3 survey unit measurement locations were randomly selected. The grid spacing for Class 1 and Class 2 survey units was determined, based on the measured area of the survey unit, using the following equation (Equation 5-7 from MARSSIM).

$$L = \sqrt{\frac{A}{0.866N}}$$

Where: L = rectangular grid spacing for survey unit

A = area of survey unit

N = number measurement locations

Measurement spacing results (L) using the equation above are presented in Table 2-6. Maps presenting the SU delineations are presented in Appendix E.

Table 2-6: Summary of Area, Number of Data Points, and Grid Spacing by SU

Survey Unit Description	Survey Unit Class	Area, A (m^2)	Number of Data Points, N	Grid Spacing, L (m)
BARF – North Room Floor	1	88.8	24	2.058
BARF – South Room Floor	1	88.8	24	2.058
BARF – North Room Lower Walls	1	76.6	24	1.920
BARF – South Room Lower Walls	1	76.6	24	1.920
BARF – Ceilings and Upper Walls	3	488	21	5.180
Wash Rack #2 – Floor South Side	1	68	20	1.859
Wash Rack #2 – Floor North Side	1	68	20	1.859
Wash Rack #2 – Lower Walls	1	90	24	2.134
Wash Rack #2 – Ceiling and	2	346	20	4.176

Survey Unit Description	Survey Unit Class	Area, A (m^2)	Number of Data Points, N	Grid Spacing, L (m)
Upper Walls				
Wash Rack #3 – Floor South Side	1	68	20	1.859
Wash Rack #3 – Floor North Side	1	68	20	1.859
Wash Rack #3 – Lower Walls	1	90	24	2.134
Wash Rack #3 – Ceiling and Upper Walls	2	346	20	4.176
Concrete Pad #2 – North	1	107	20	2.486
Concrete Pad #2 -- South	1	107	20	2.486
Concrete Pad #1 -- North	1	60	20	1.861
Concrete Pad #1 -- South	1	60	20	1.861

3.0 RESULTS

Field activities took place during three separate mobilizations. The first mobilization began May 3, 2003 and ended August 27, 2003. The second mobilization began February 10, 2004 and ended March 31, 2004. The third mobilization began June 8, 2004 and ended June 15, 2004. Appendix F contains a table that documents every day that CABRERA personnel were on-site, the instruments used, and the activities performed.

All raw data collected on Radiological Survey Maps for each SU (survey unit) are provided in Appendix G. Scan survey results are provided graphically in the Figures section of this FSS Report and are referenced in the following sub-sections. Additional data for each SU include worksheets that convert the raw data (recorded in counts per minute) to dpm/100cm^2 for integrated direct measurements (integrated one minute counts) from each one meter square grid with cross-reference to grid numbers) and 100 cm^2 smear results from each one meter square grid with cross-reference to grid numbers. These worksheets are provided in Appendix H.

3.1 BTD Armor Reclamation Facility

3.1.1 Surface Alpha Radioactivity Scan Surveys

The floors and the lower walls were surveyed for surface alpha radioactivity in the BTD Armor Reclamation Facility. All of these areas are designated MARSSIM Class 1. The ceiling and upper walls are designated MARSSIM Class 3. In the Figures section, Figures 3 through 11 graphically depict the results of the scan surveys. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.1.2 Integrated Direct Surface Alpha Radioactivity Measurements

The BARF was divided into five SUs – the North Floor Room, the South Floor Room, the North Room Lower Walls, and the South Room Lower Walls were Classified MARSSIM Class 1 SUs. The Ceiling and Upper Walls were classified MARSSIM Class 3 SUs. Twenty-four integrated direct surface alpha measurements were taken on the North Floor Room and the maximum reading was 30.1 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the South Floor Room, and the maximum reading was 20.0 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the North Room Lower Walls and the maximum reading was 12.0 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the South Room Lower Walls and the maximum reading was 10.0 dpm/100cm^2. Twenty-one integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 14.3 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.1.3 Smear Sample Collection and Analysis

All smear samples taken from the BARF resulted in alpha measurements of less than 10 dpm/100cm^2. Twenty-four smear samples were taken on the North Floor Room and the maximum alpha reading was 6.5 dpm/100cm^2. Twenty-four smear samples were taken on the

South Floor Room and the maximum alpha reading was 6.5 dpm/100cm^2. Twenty-two smear samples were taken on the North Room Lower Walls and the maximum alpha reading was 5.8 dpm/100cm^2. Twenty-five smear samples were taken on the South Room Lower Walls and the maximum reading was 4.1 dpm/100cm^2. Twenty-three smear samples were taken on the Ceiling and Upper Walls and the maximum reading was 4.2 dpm/100cm^2.

3.1.4 Recommendation

In accordance with the BARF FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, the North Room Floor, the South Room Floor, the North Room Lower Wall, the South Room Lower Wall, and the Ceiling and Upper Walls SUs are recommended for unrestricted release.

3.2 Wash Rack #2

3.2.1 Surface Alpha Radioactivity Scan Surveys

The floor and the lower walls were surveyed for surface alpha radioactivity in Wash Rack #2. All of these areas are designated MARSSIM Class 1. The ceiling and upper walls are designated MARSSIM Class 2 and approximately 10% of the total area was scanned for alpha activity. All scans of ceiling and upper walls resulted in alpha counts that were equal to or below background, so results of these scans were not recorded on official CABRERA forms. In the Figures section of this FSS, Figures 12 through 16 graphically depict the results of the scan surveys on the floor and lower walls. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.2.2 Integrated Direct Surface Alpha Radioactivity Measurements

Wash Rack #2 was divided into four SUs – the North Floor, the South Floor, and the Lower Walls were classified Class 1 and the Ceiling and Upper Walls were classified Class 2. Twenty integrated direct surface alpha measurements were taken on the North Floor and the maximum reading was 15.0 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the South Floor and the maximum reading was 11.9 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the Lower Walls and the maximum reading was 13.9 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 10.0 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.2.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on the North Floor and the maximum reading was 2.7 dpm/100cm^2. Twenty smear samples were taken on the South Floor and the maximum reading was 2.7 dpm/100cm^2. Twenty-four smear samples were taken on the Lower Walls and the

maximum reading was 2.7 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 2.7 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.2.4 Recommendation

In accordance with the Wash Rack FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, the North Floor SU, the South Floor SU, the Lower Walls SU, and the Ceiling and Upper Walls SU of Wash Rack #2 are recommended for unrestricted release.

3.3 Wash Rack #3

3.3.1 Surface Alpha Radioactivity Scan Surveys

The floor and the lower walls were surveyed for surface alpha radioactivity in Wash Rack #3. All of these areas are designated MARSSIM Class 1. The ceiling and upper walls are designated MARSSIM Class 2 approximately 10% of the total area was scanned for alpha activity. All scans of ceiling and upper walls resulted in alpha counts that were equal to or below background, so results of these scans were not recorded on official CABRERA forms. In the Figures section of this FSS, Figures 17 through 21 graphically depict the results of the scan surveys on the floor and lower walls. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.3.2 Integrated Direct Surface Alpha Radioactivity Measurements

Wash Rack #3 was divided into four SUs – the North Floor, the South Floor, and the Lower Walls were classified Class 1 and the Ceiling and Upper Walls were classified Class 2. Twenty integrated direct surface alpha measurements were taken on the North Floor and the maximum reading was 14.9 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the South Floor and the maximum reading was 6.8 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the Lower Walls and the maximum reading was 8.8 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 10.0 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.3.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on the North Floor and the maximum reading was 0.9 dpm/100cm^2. Twenty smear samples were taken on the South Floor and the maximum reading was -0.6 dpm/100cm^2. Twenty-four smear samples were taken on the Lower Walls and the maximum reading was 2.4 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 0.9 dpm/100cm^2.

Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.3.4 Recommendation

In accordance with the Wash Rack FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, the North Floor SU, the South Floor SU, the Lower Walls SU, and the Ceiling and Upper Walls SU of Wash Rack #3 are recommended for unrestricted release.

3.4 Concrete Pad #2

This 22- by 15-m pad was cleaned by shot blasting it with a Blastrac™. Then the pad was surveyed with a floor monitor and Total Station. The pad was divided into two survey units (under MARSSIM requirements, this Class 1 structure was treated similar to a building interior). Systematic fixed count surveys with alpha/beta meter were completed along with smears at those locations.

3.4.1 Surface Alpha Radioactivity Scan Surveys

One hundred percent of the surface of Concrete Pad #2 was surveyed for surface alpha radioactivity. Concrete Pad #2 is designated MARSSIM Class 1. In the Figures section of this FSS, Figures 22 and 23 graphically depict the results of the scan survey. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.4.2 Integrated Direct Surface Alpha Radioactivity Measurements

Concrete Pad #2 was divided into two Class 1 SUs and they were designated North and South. Twenty integrated direct surface alpha measurements were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 27.1 dpm/100cm^2 and the maximum measurement taken on the South SU was 18.0 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.4.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 2.9 dpm/100cm^2 and the maximum measurement taken on the South SU was 1.6 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.4.4 Recommendation

In accordance with the BTD FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2.

Therefore, both the North SU and the South SU of Concrete Pad #2 are recommended for unrestricted release.

3.5 Concrete Pad #1

This pad is somewhat smaller than the pad behind Building 701. As with Concrete Pad #2, the pad was divided into two survey units. Systematic fixed count surveys with alpha/beta meter were completed along with smears at those locations.

3.5.1 Surface Alpha Radioactivity Scan Surveys

Concrete Pad #1 is designated MARSSIM Class 1. In the Figures section of this FSS, Figures 24 and 25 graphically depict the results of the scan survey. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.5.2 Integrated Direct Surface Alpha Radioactivity Measurements

Concrete Pad #1 was divided into two Class 1 SUs and they were designated North and South. Twenty integrated direct surface alpha measurements were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 33.2 dpm/100cm^2 and the maximum measurement taken on the South SU was 16.3 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.5.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 4.2 dpm/100cm^2 and the maximum measurement taken on the South SU was 1.6 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.5.4 Recommendation

In accordance with the BTD FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, both the North SU and the South SU of Concrete Pad #1 are recommended for unrestricted release.

4.0 FINAL STATUS SURVEY INSTRUMENT QUALITY ASSURANCE AND QUALITY CONTROL

The purpose of this section is to document the calibration of the radiological survey instruments used during the FSS, and the quality control tracking of each instrument as specified in the Work Plans (as documented in Appendices B, C, and D). Data collection activities were performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. The Project Engineer ensured that individuals were appropriately trained to use project instrumentation and other equipment, and that instrumentation met the required detection sensitivities.

Scanning and integrated direct measurements were performed to measure surface radioactivity levels for total uranium. These measurements were based solely on alpha emissions due to high specificity and sensitivity, and low background interference. For smear measurements, beta measurements were collected in tandem with alpha measurements as a qualitative assessment to confirm survey assumptions. Prior to the initiation of alpha survey activities, surfaces of interest were cleaned to remove dirt and grime that could shield alpha emissions from detection.

Current calibration/maintenance records were kept on site for review and inspection (included in Appendix I). The records include, at a minimum, the following:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

Instrumentation was maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments were maintained. Instruments were calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using National Institute of Standards and Technology (NIST) traceable sources. Copies of the calibration certificates for the sources are also provided in Appendix I. A chronological summary of field activities at each structure/SU and instrumentation is presented in Appendix F.

QC measurements were performed on all deployed field instruments each day, before and after each use at a minimum. A controlled area was used to perform these checks. The QC investigation levels for count rate instruments used during the FSS were ±2-sigma (2σ) (warning) and ±3σ (fail). Exposure rate and other radiation detection instruments were evaluated using a qualitative ±20% against the indicated check source response on the meter. If any single measurement was found to be outside of its investigation level, the measurement was repeated. If the second count was also found to be outside of this criterion, the instrument was investigated to assess whether any external biases or instrument physical damage was present. If response checks were found to be outside of ±3σ, the instrument was taken out of service unless evaluated and approved by the Field Radiological Engineer or the Project Manager. Control charts for check source response, background count rates (where applicable), and copies of the daily check source logs for all instruments are provided in Appendix I.

Gross transferable alpha contamination was collected and analyzed to determine if transferable activity is less than or equal to 10% of total activity as assumed in the NUREG/CR-5512 and NUREG 1757 documents for screening level guidelines.

Smear samples were collected over approximately 100 cm^2 areas at systematic and biased locations identified during scanning activities. Smear samples were analyzed for alpha and beta radioactivity using a Ludlum Model 2929 alpha/beta scintillation counter.

Control charts for check source response, background count rates (where applicable), and copies of the daily check source logs for all instruments are provided in Appendix I.

5.0 REFERENCES

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(CABRERA, 2003) CABRERA Work Plan, "Final Status Survey Plan for the Bomb Throwing Device (BTD) Site, Aberdeen Proving Ground, Aberdeen, MD", Contract DAAA09-00-G-0002/0039.

(CABRERA, 2004) CABRERA Report, "Remediation and Final Status Survey, Bomb Throwing Device Site – Soils," Contract DAAA09-00-G-0002/0039.

(NRC, 2000) NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), U.S. Nuclear Regulatory Commission, dated August, 2000.

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FIGURES

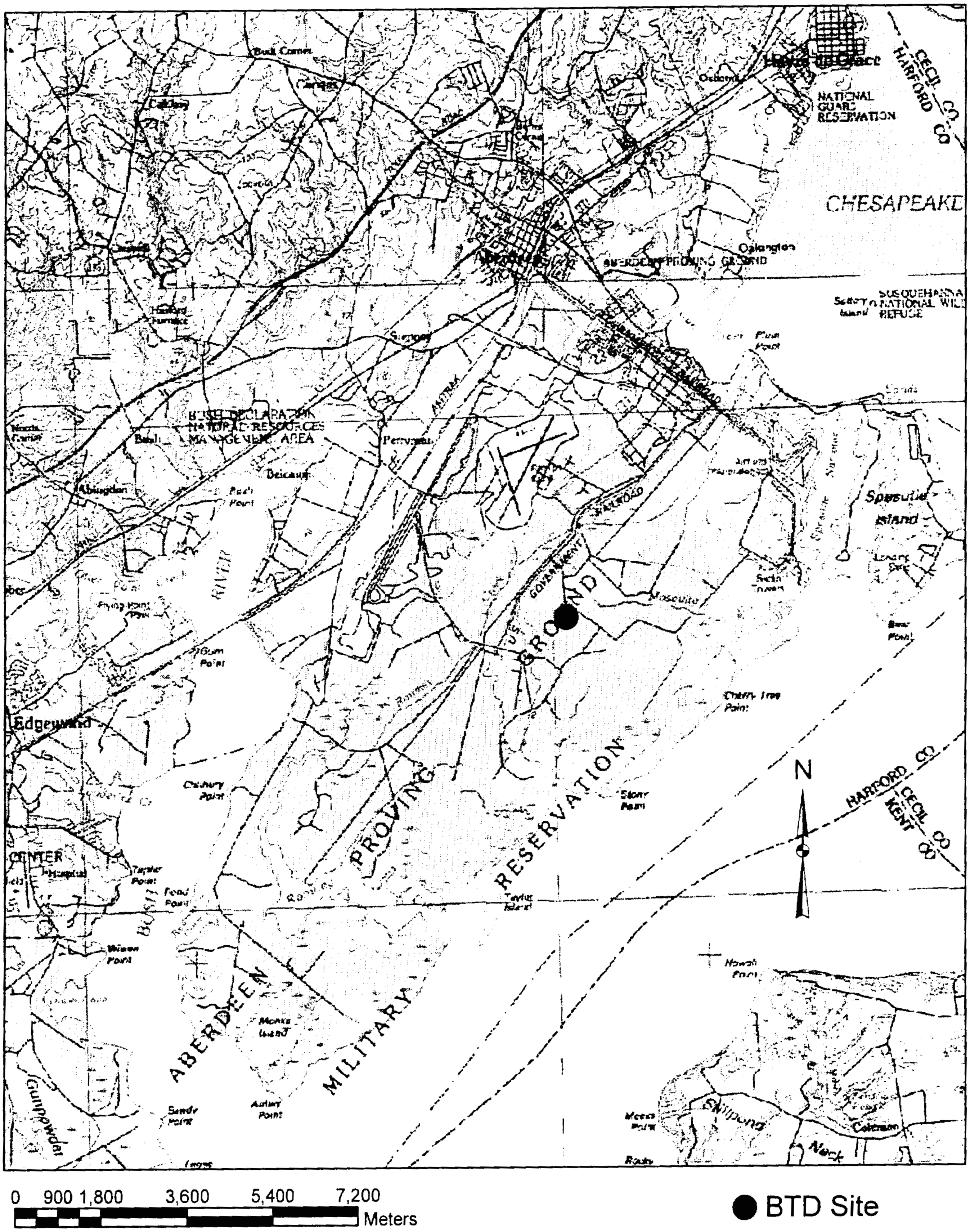

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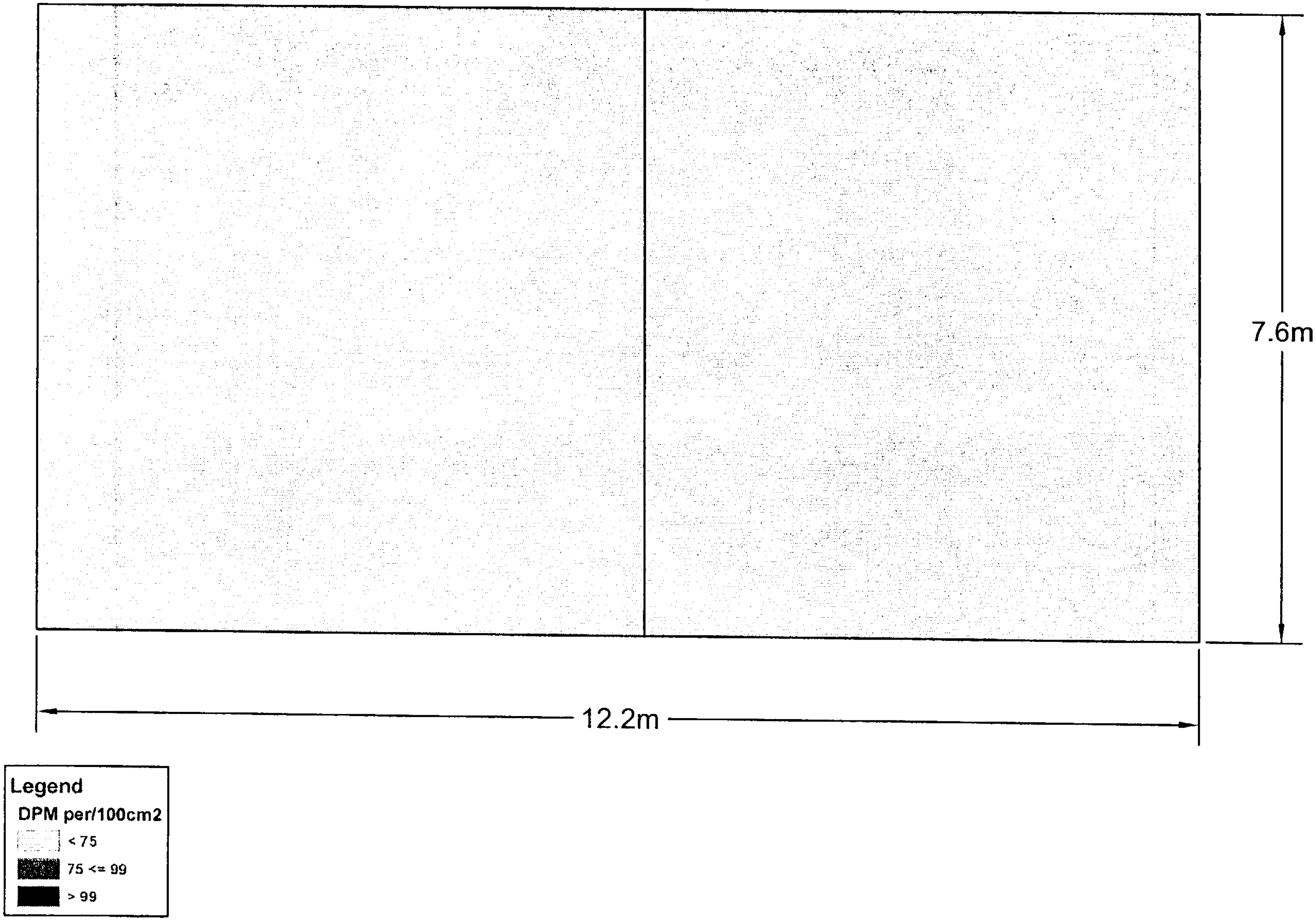
Figure 2, Restricted Data Removed

BARF Building - Alpha Scan
North Room - Floor Survey Units A & B



10/29/2004
Scale: N.T.S.

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Figure: 3

BARF Building - Alpha Scan
South Room - Floor Survey Units A & B

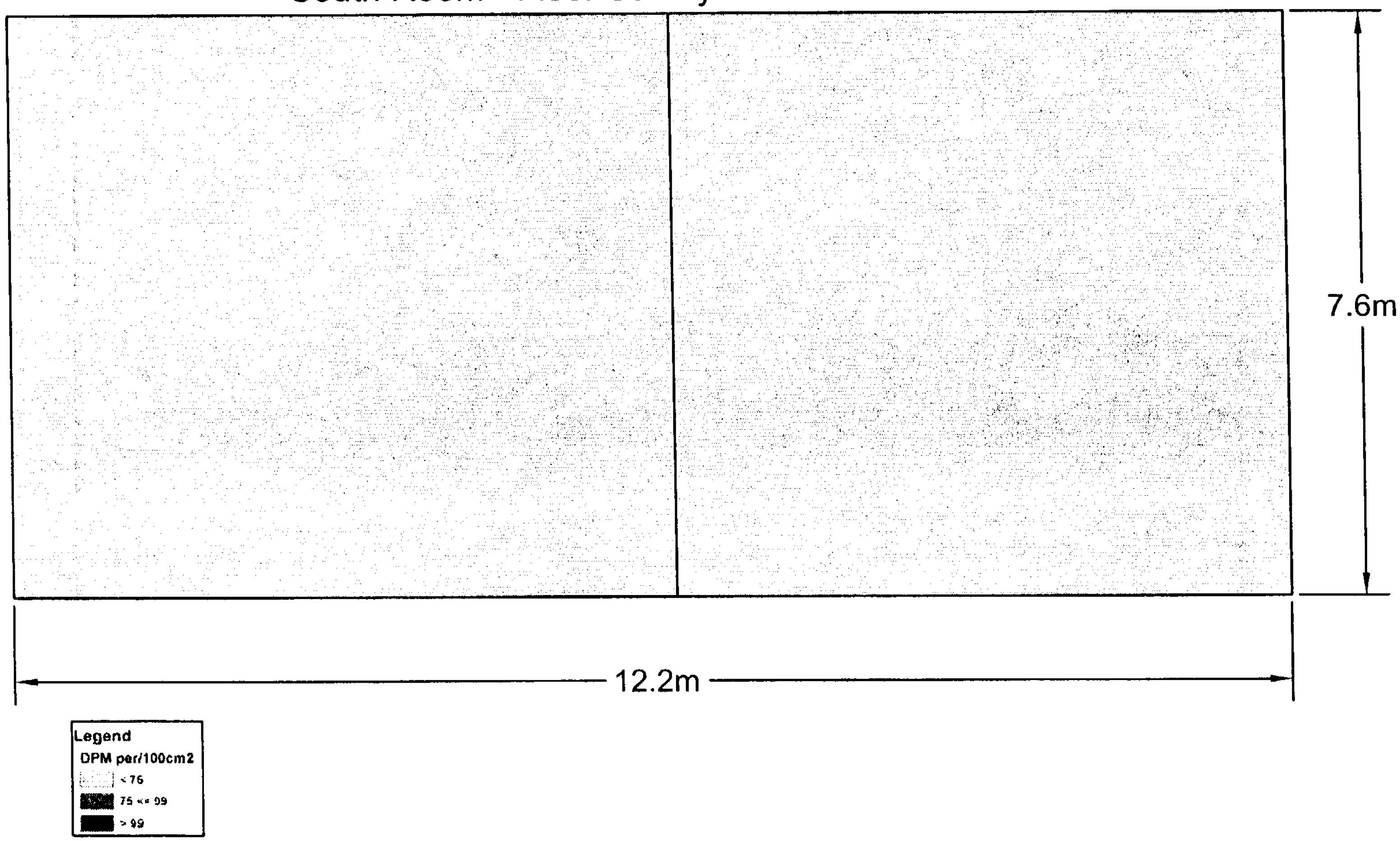

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Figure: 4

BARF Building - Alpha Scan
North Room - South Wall

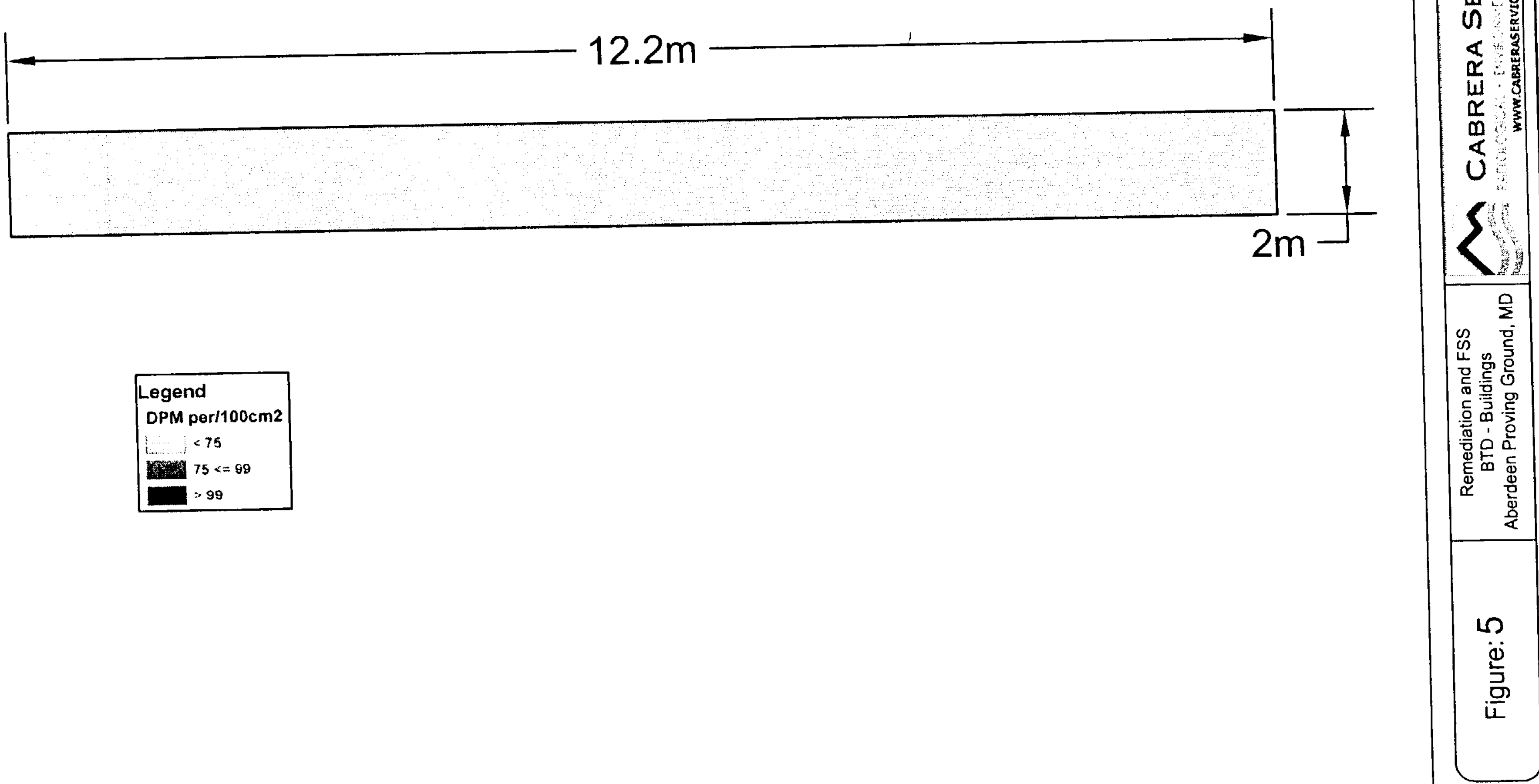
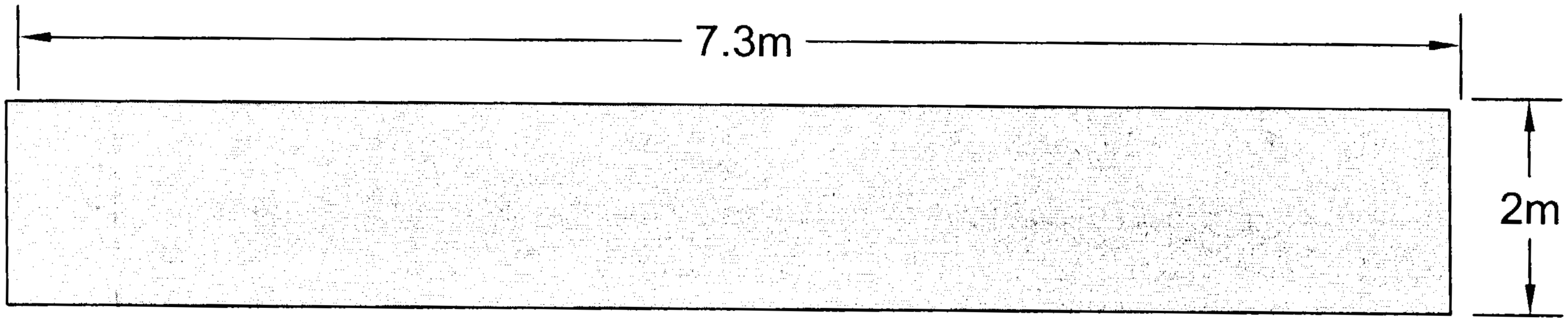


Figure: 5

BARF Building - Alpha Scan
North Room -East Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004
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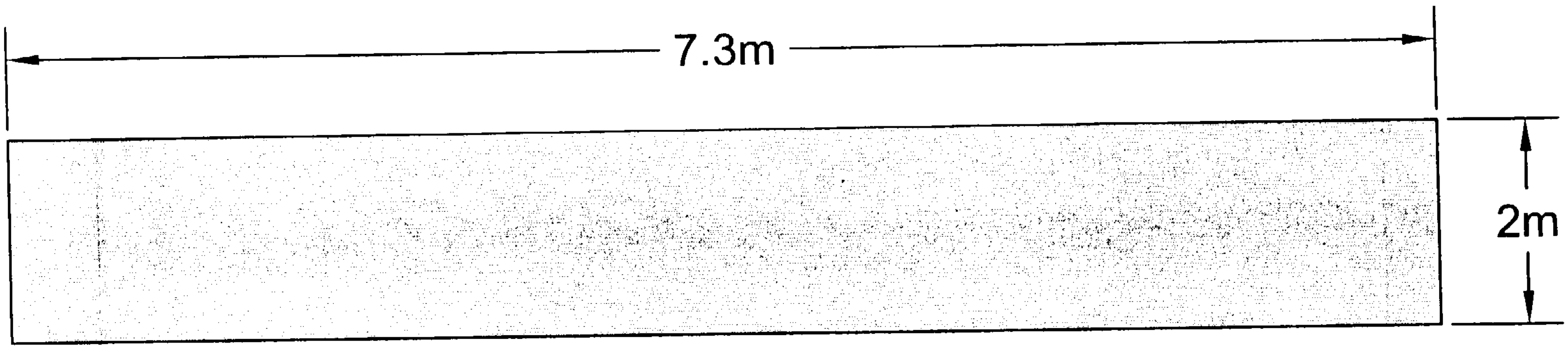
Figure: 6

BARF Building - Alpha Scan
North Room - West Wall



Legend
DPM per/100cm2
< 75
75 <= 99
> 99

Date: 11/2/2004
Created by: JTM

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Figure: 7

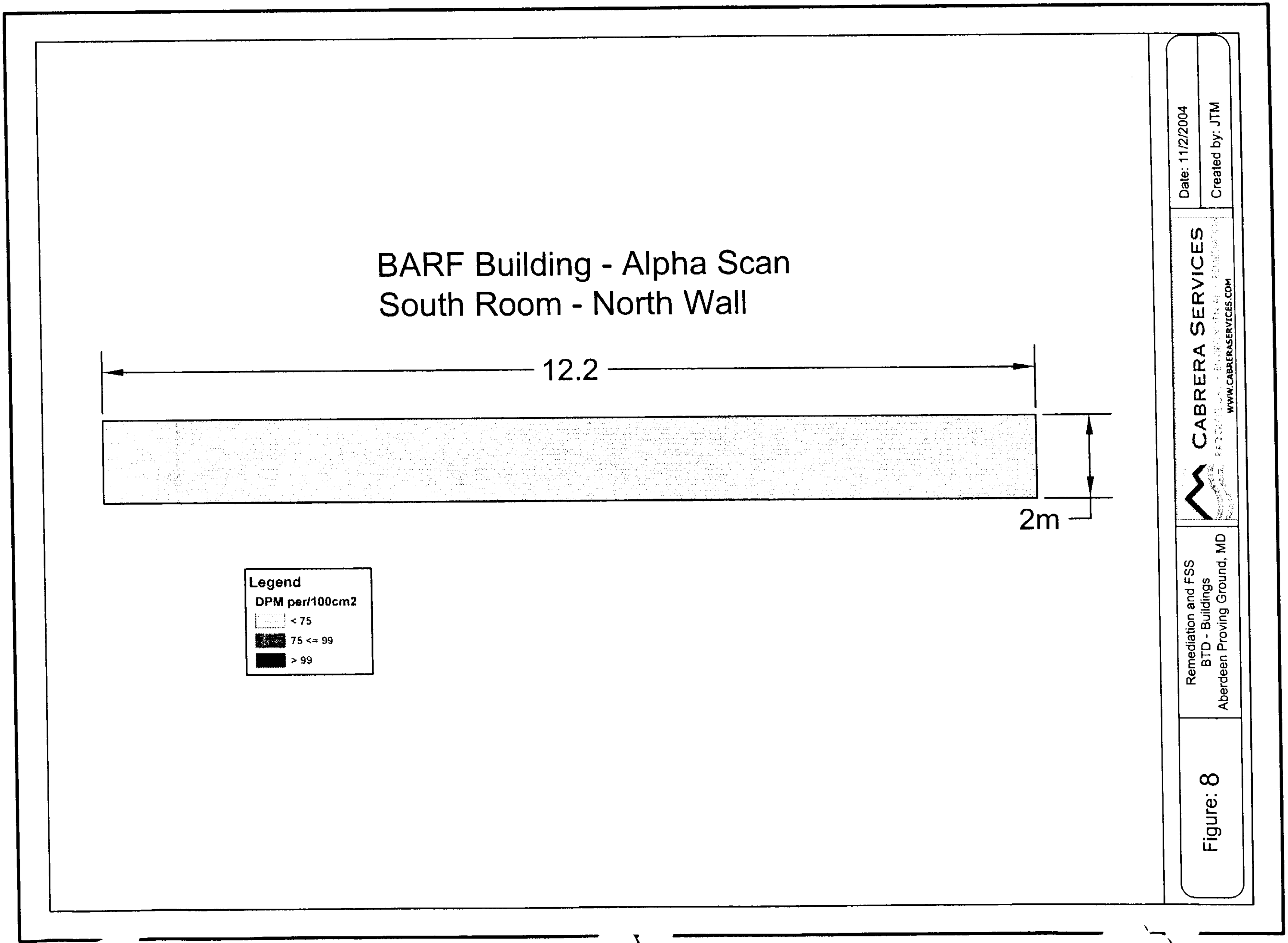
BARF Building - Alpha Scan
South Room - North Wall
12.2
2m
Legend
DPM per/100cm2
< 75
75 <= 99
> 99
Date: 11/2/2004
Created by: JTM
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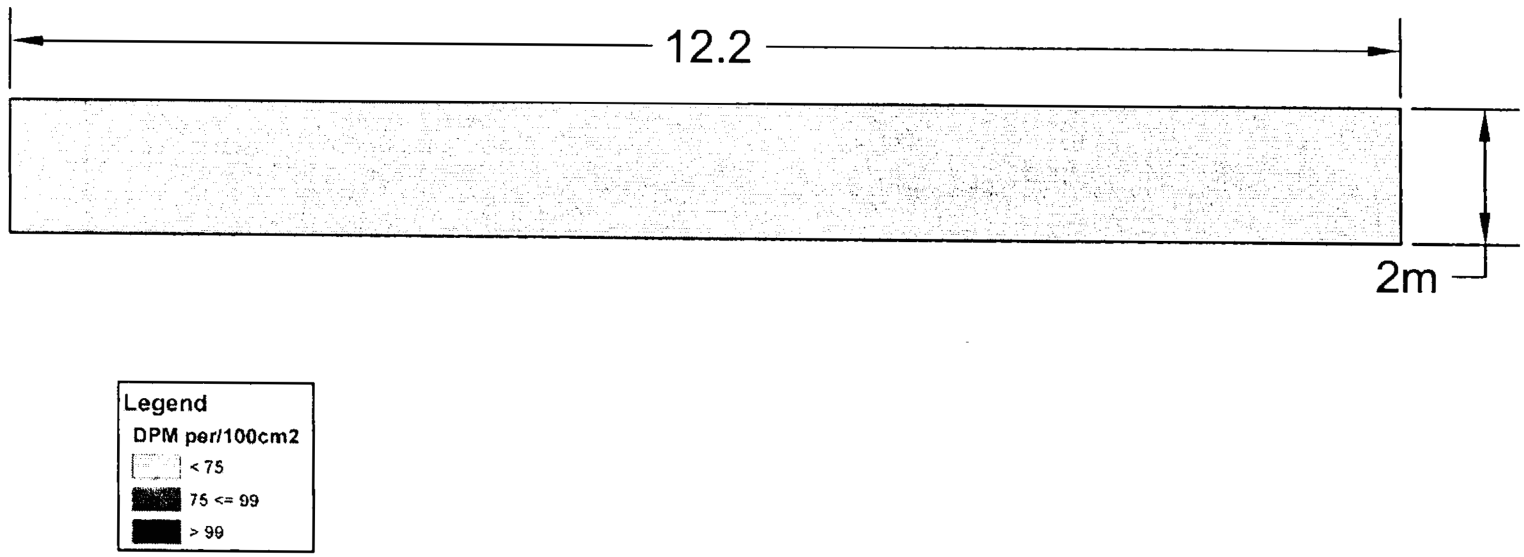
Figure: 8

BARF Building - Alpha Scan
South Room - South Wall



Date: 11/2/2004
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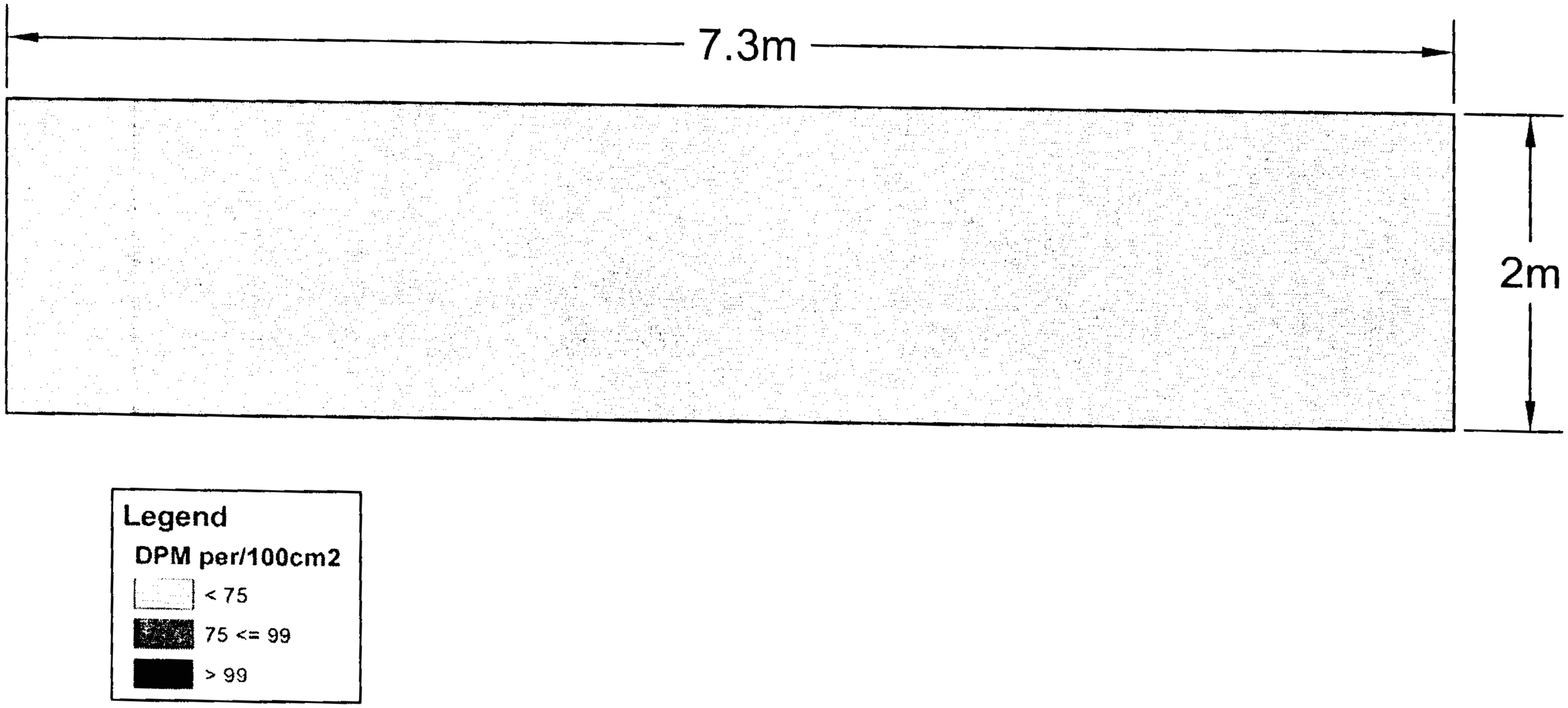
Figure: 9

BARF Building - Alpha Scan
South Room - East Wall



Date: 11/2/2004
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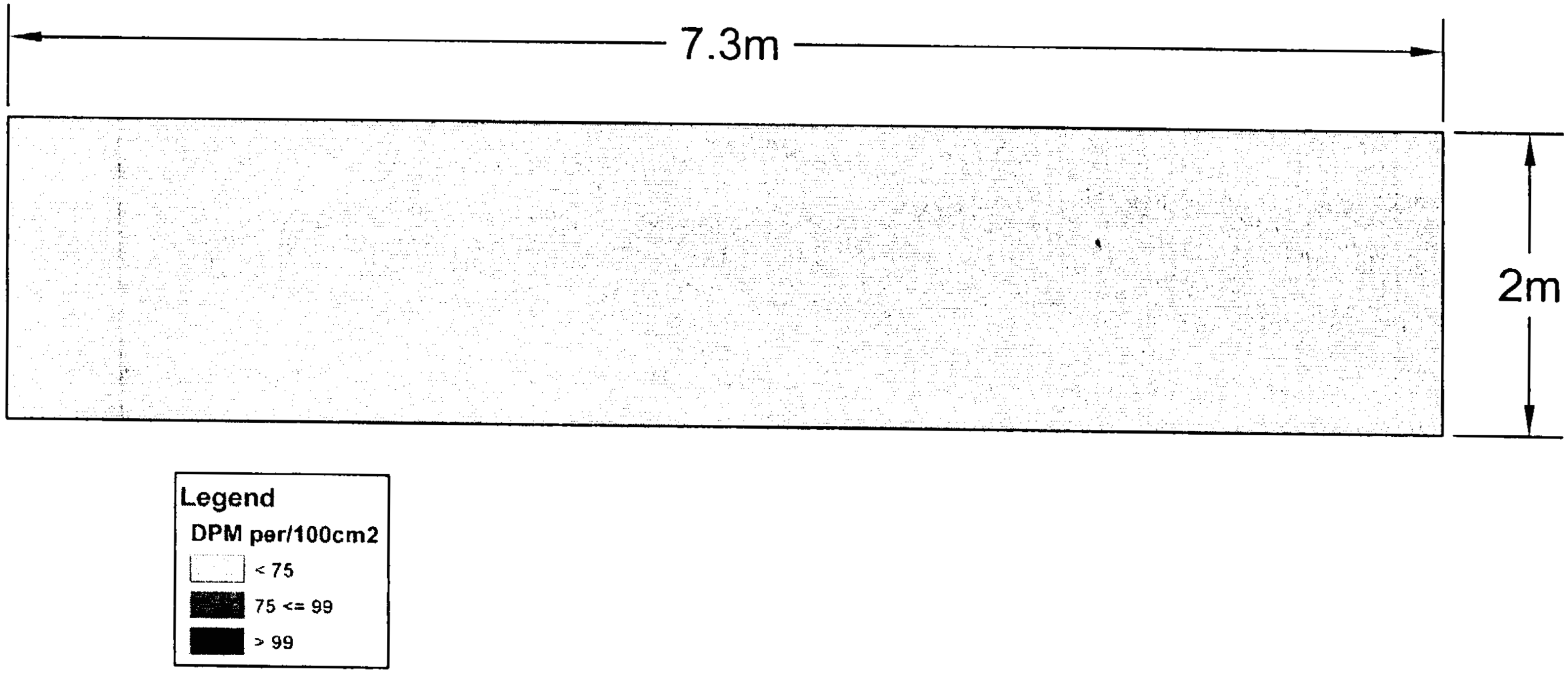
Figure: 10

BARF Building - Alpha Scan
South Room - West Wall



Date: 11/2/2004
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Figure: 11

Wash Rack 2 - Alpha Scan
Interior Floor

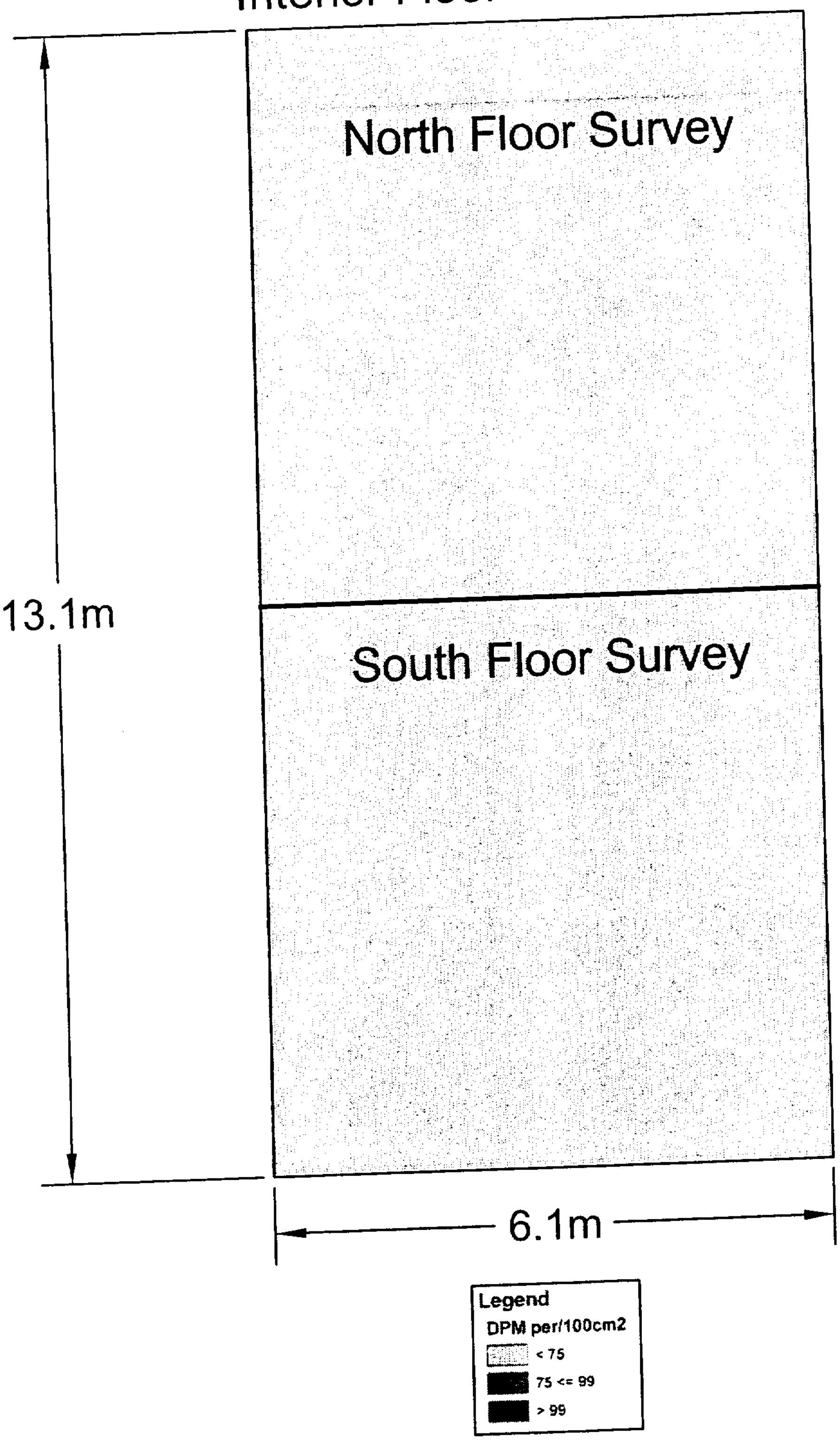
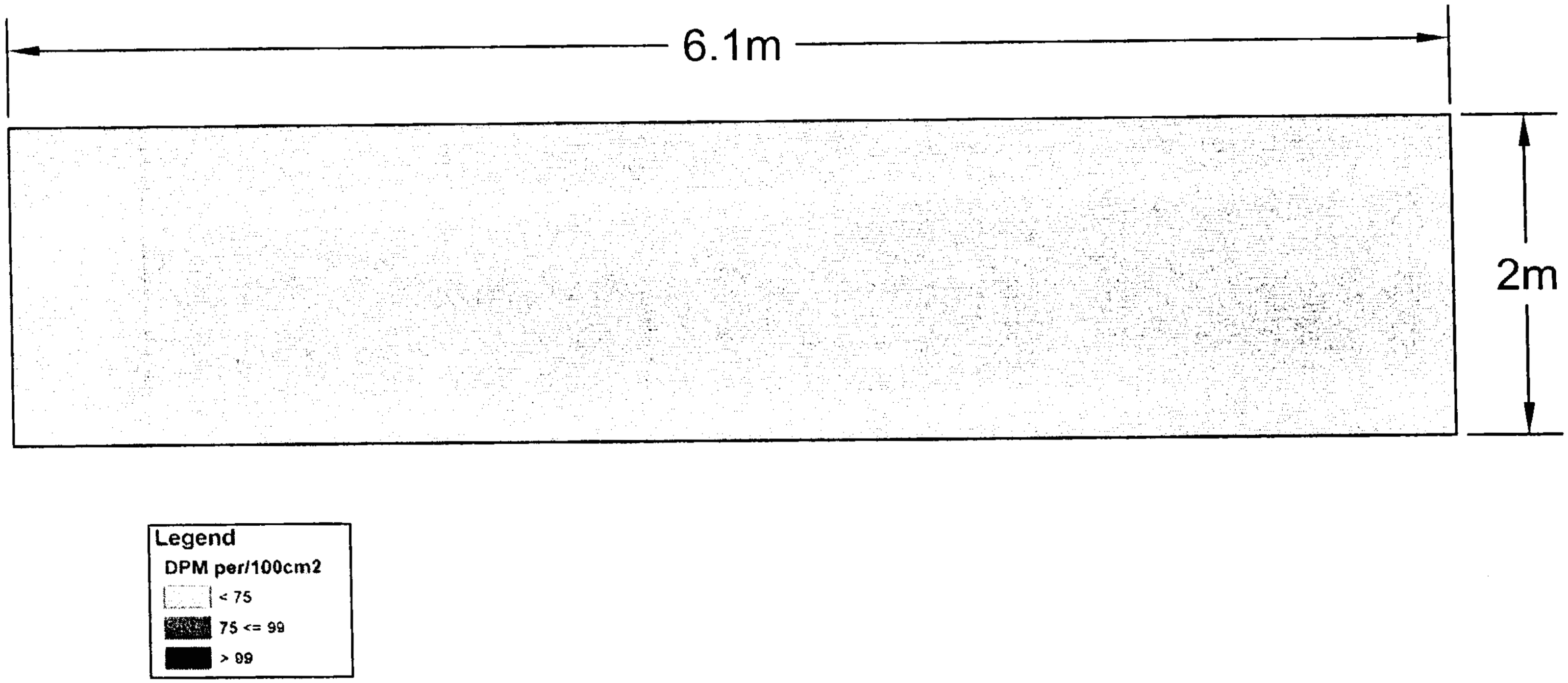


Figure: 12	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Wash Rack 2 - Alpha Scan
North Wall



Date: 11/2/2004

Created by: JTM

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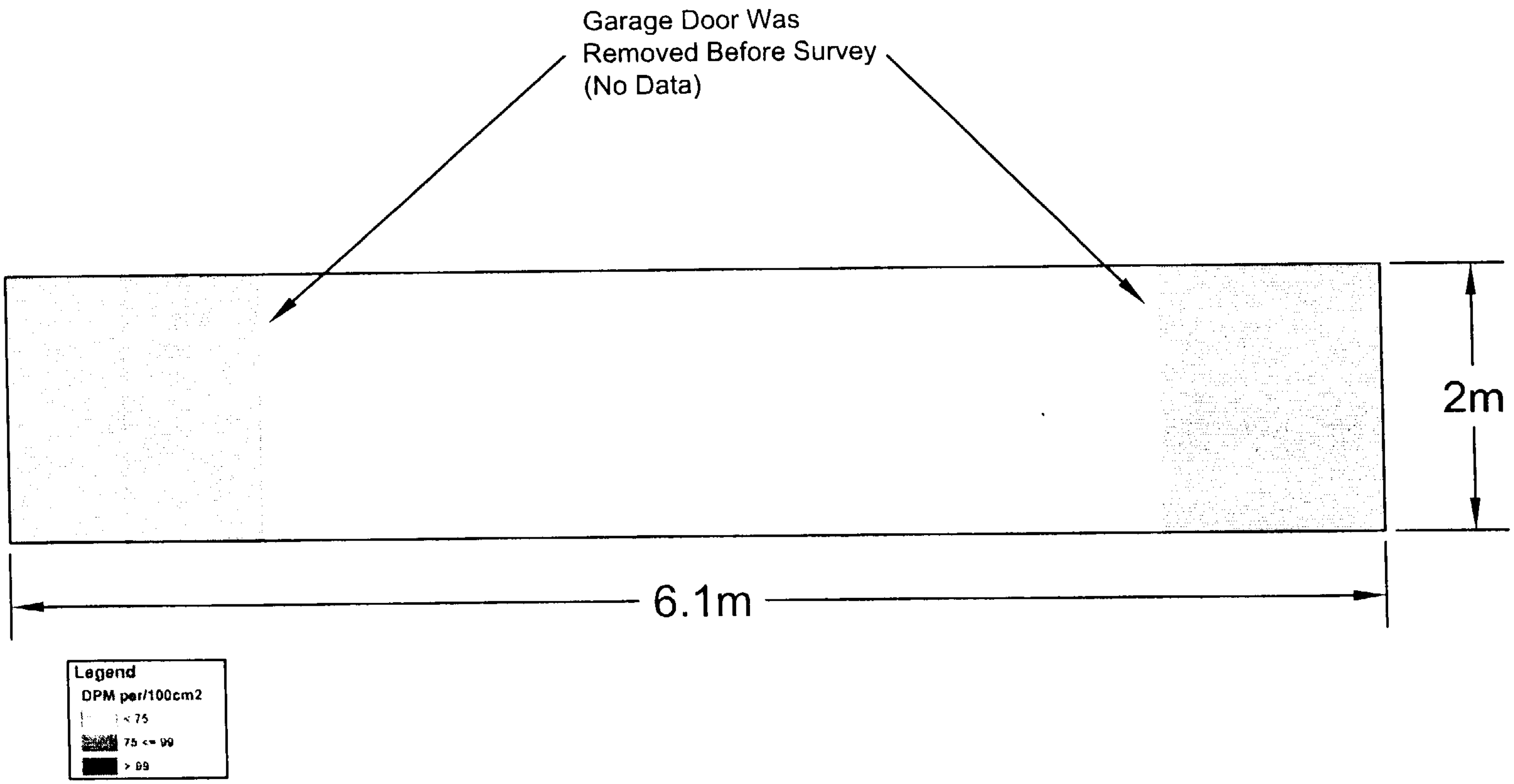
Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 13

Wash Rack 2 - Alpha Scan
South Wall



Date: 11/2/2004
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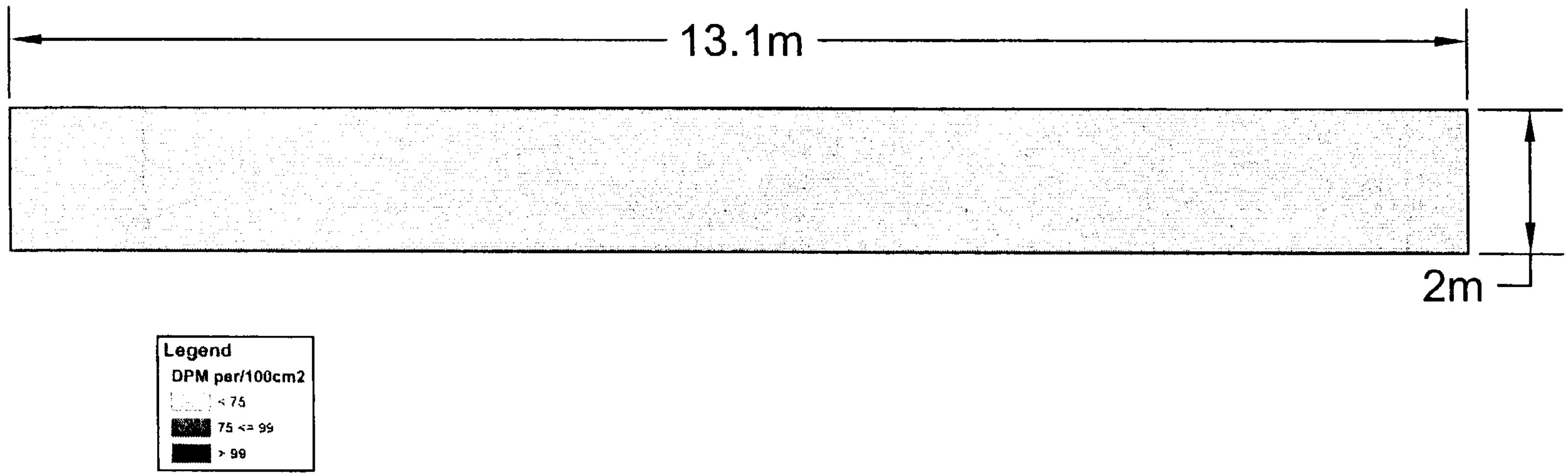
Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure:14

Wash Rack 2 - Alpha Scan
East Wall



Date: 11/2/2004
Created by: JTM

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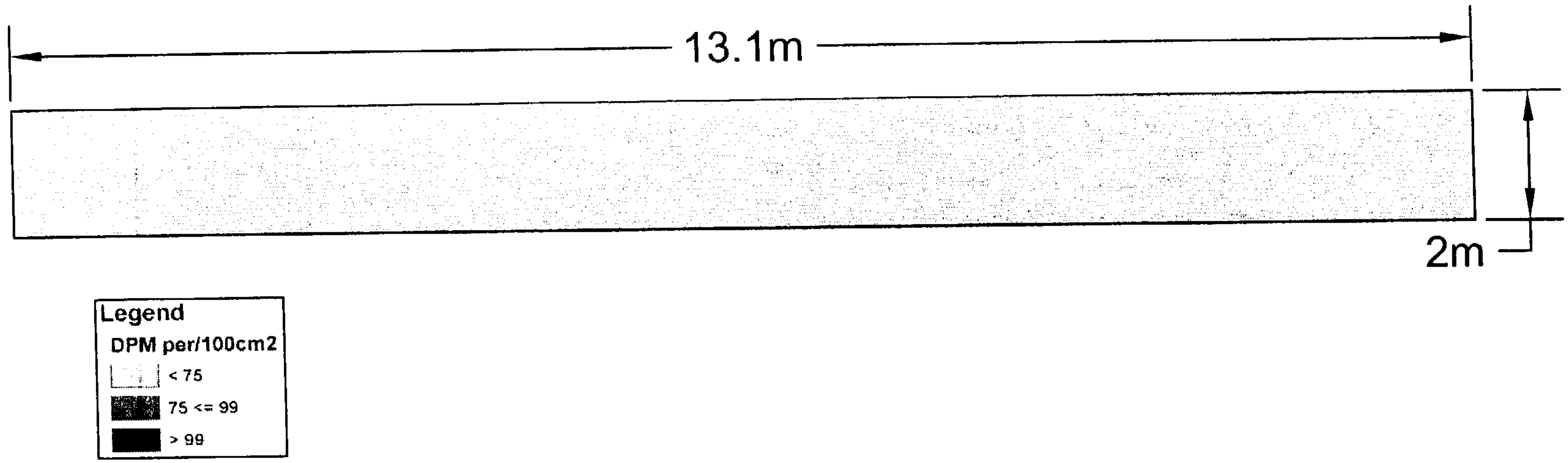
Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure:15

Wash Rack 2 - Alpha Scan
West Wall



Date: 11/2/2004

Created by: JTM

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Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure:16

Wash Rack 3 - Alpha Scan
Interior Floor

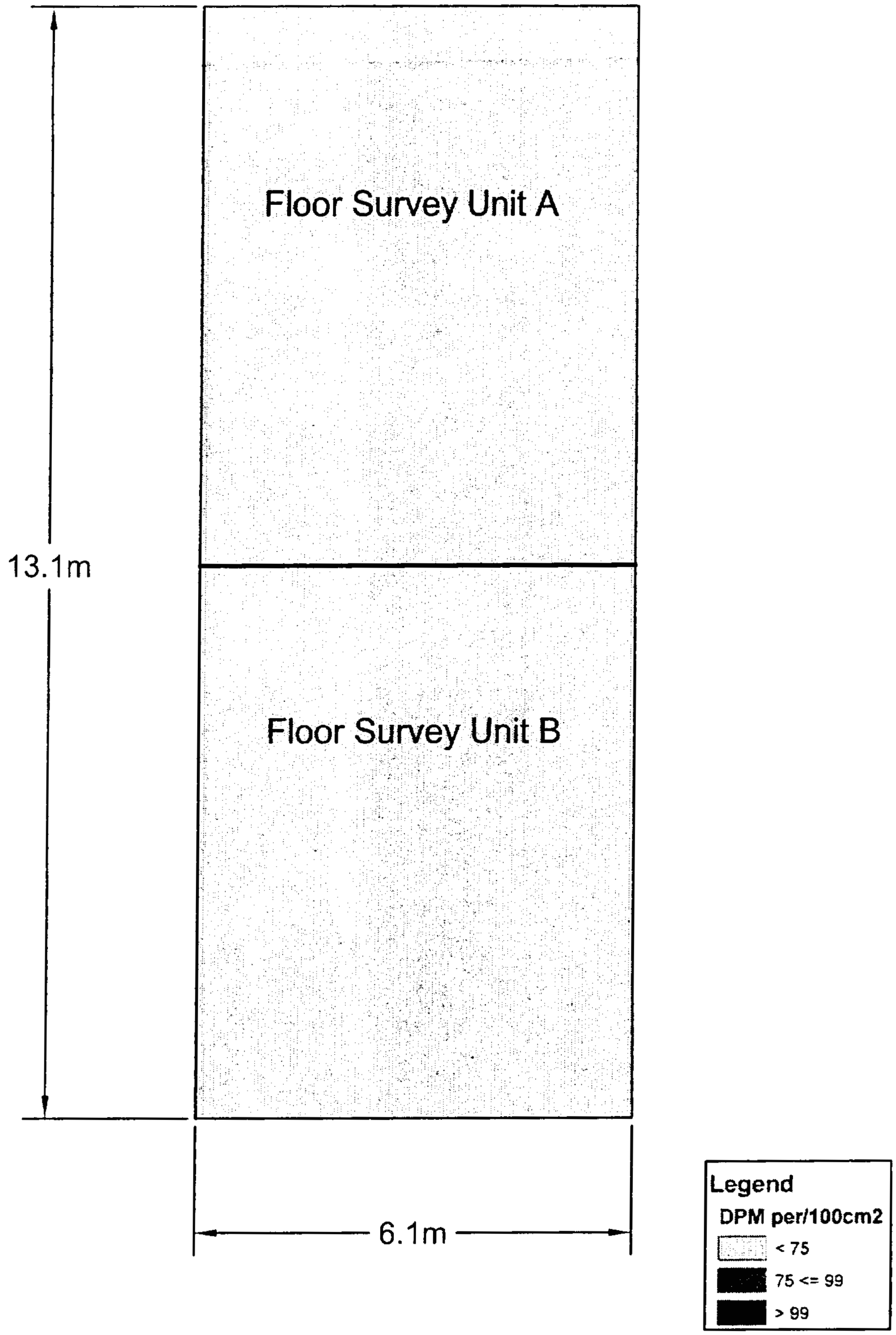
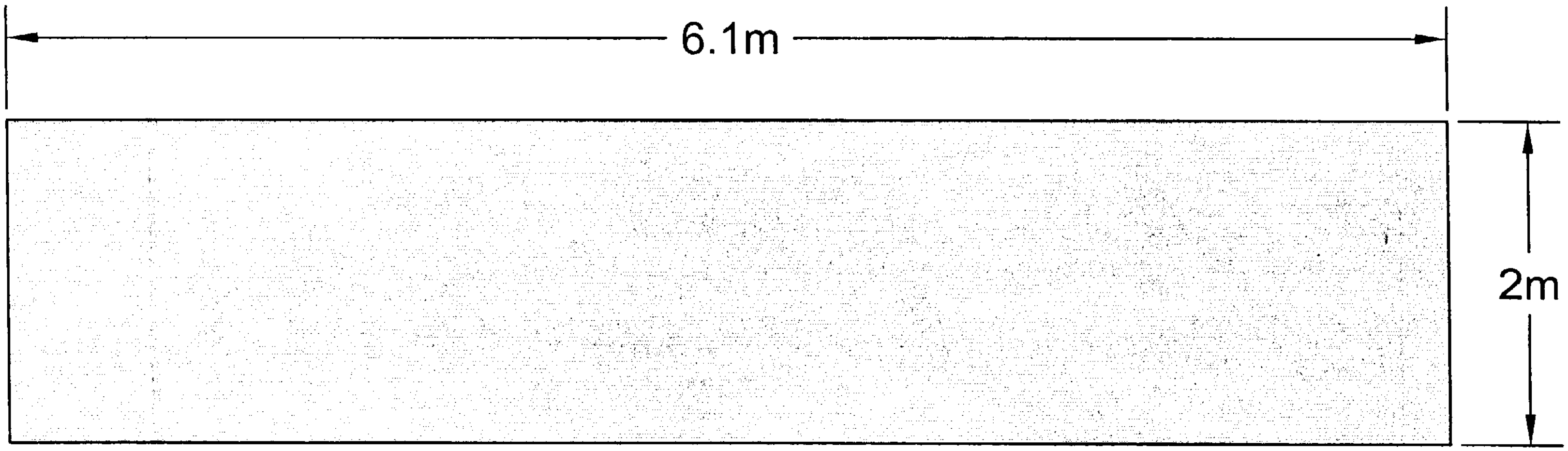


Figure: 17	Remediation and FSS BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES WWW.CABRERASERVICES.COM	Date: 11/2/2004 Created by: JTM

Wash Rack 3 - Alpha Scan
North Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

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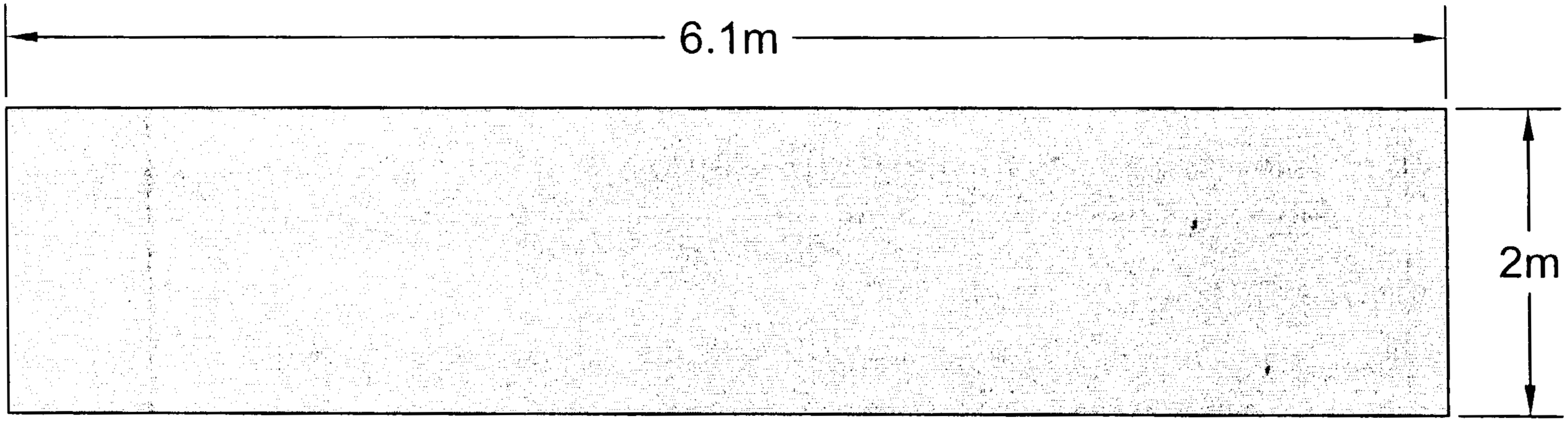
Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure:18

Wash Rack 3 - Alpha Scan
South Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

Created by: JTM

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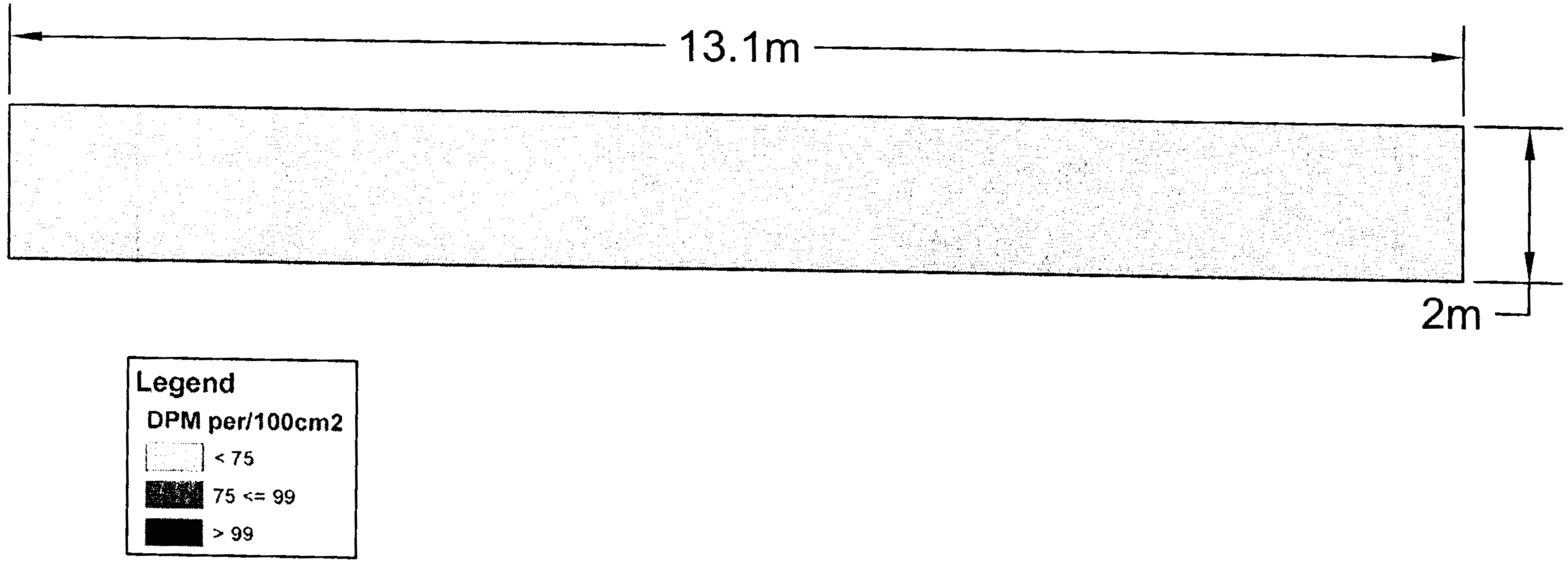
Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 19

Wash Rack 3 - Alpha Scan
East Wall



Date: 11/2/2004

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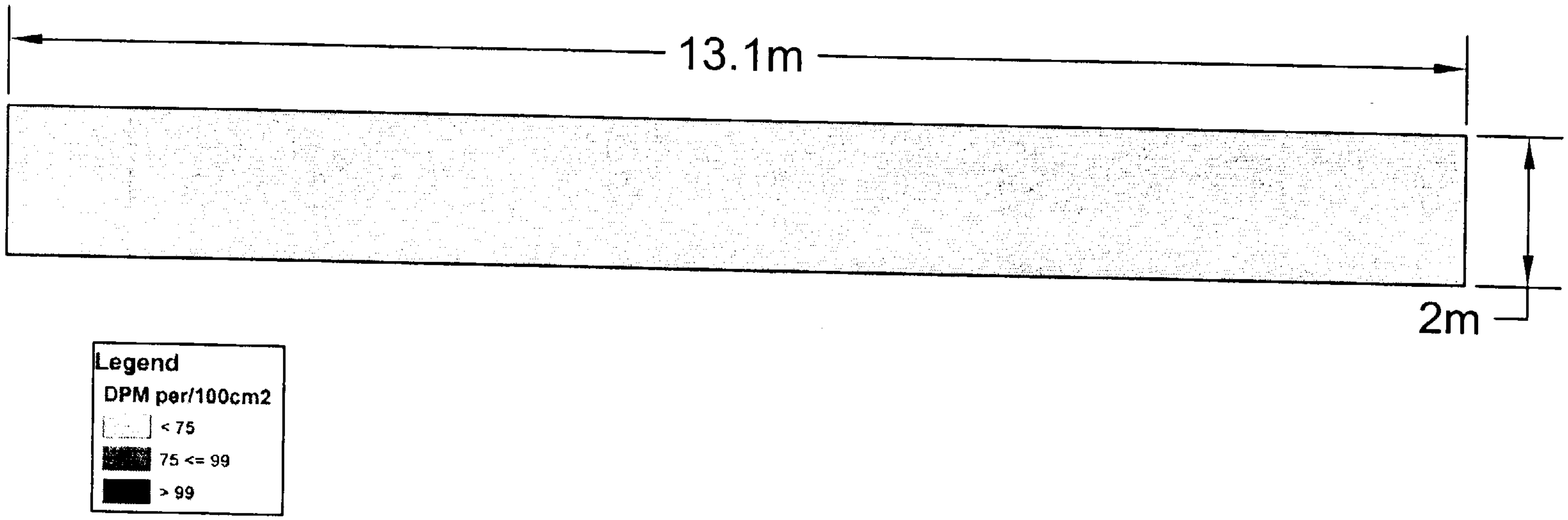
Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 20

Wash Rack 3 - Alpha Scan
West Wall



Date: 11/2/2004

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Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 21

Concrete Pad #1 - Alpha Scan
South Survey Unit

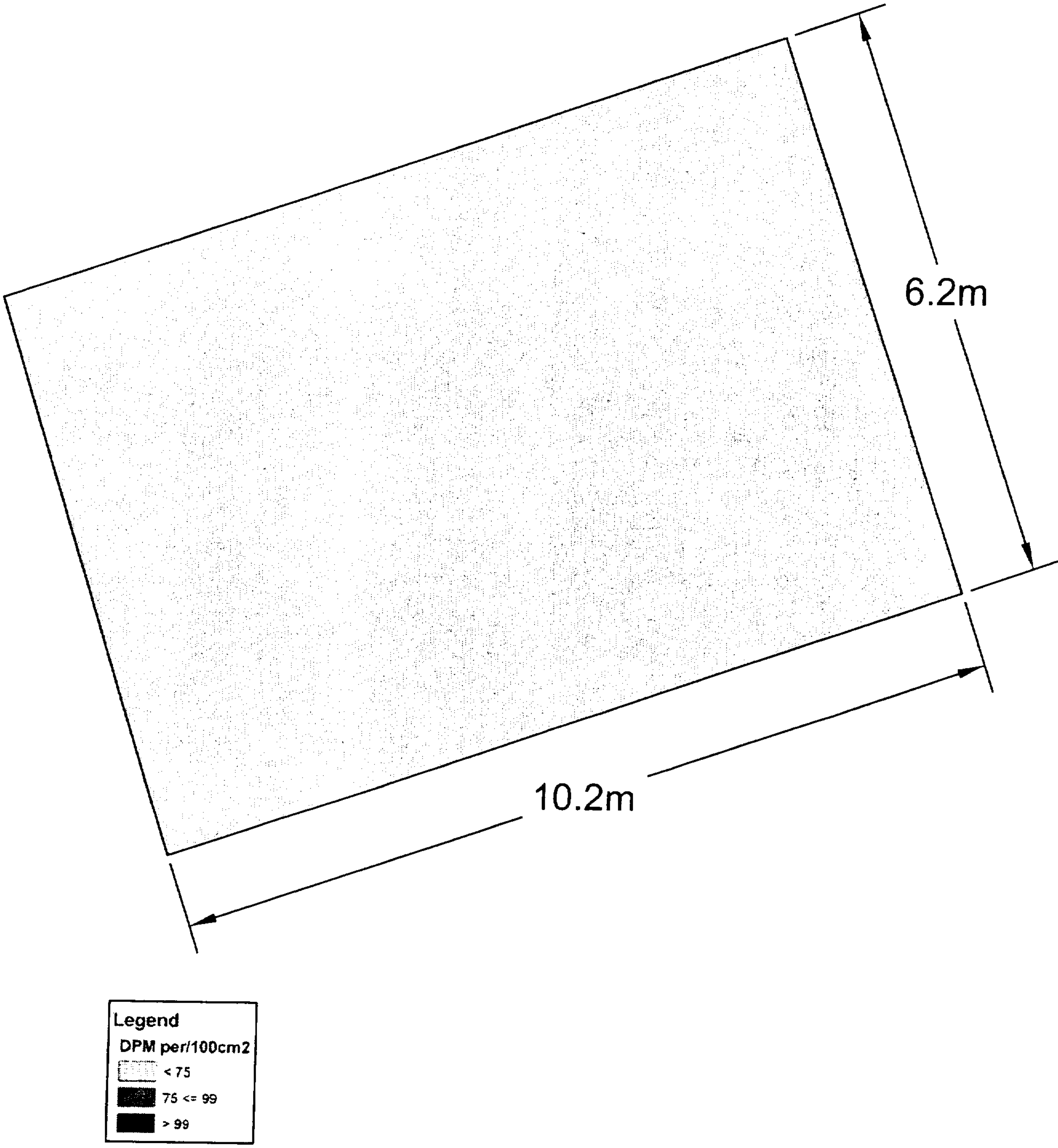

Figure: 22	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Concrete Pad #1 - Alpha Scan
North Survey Unit

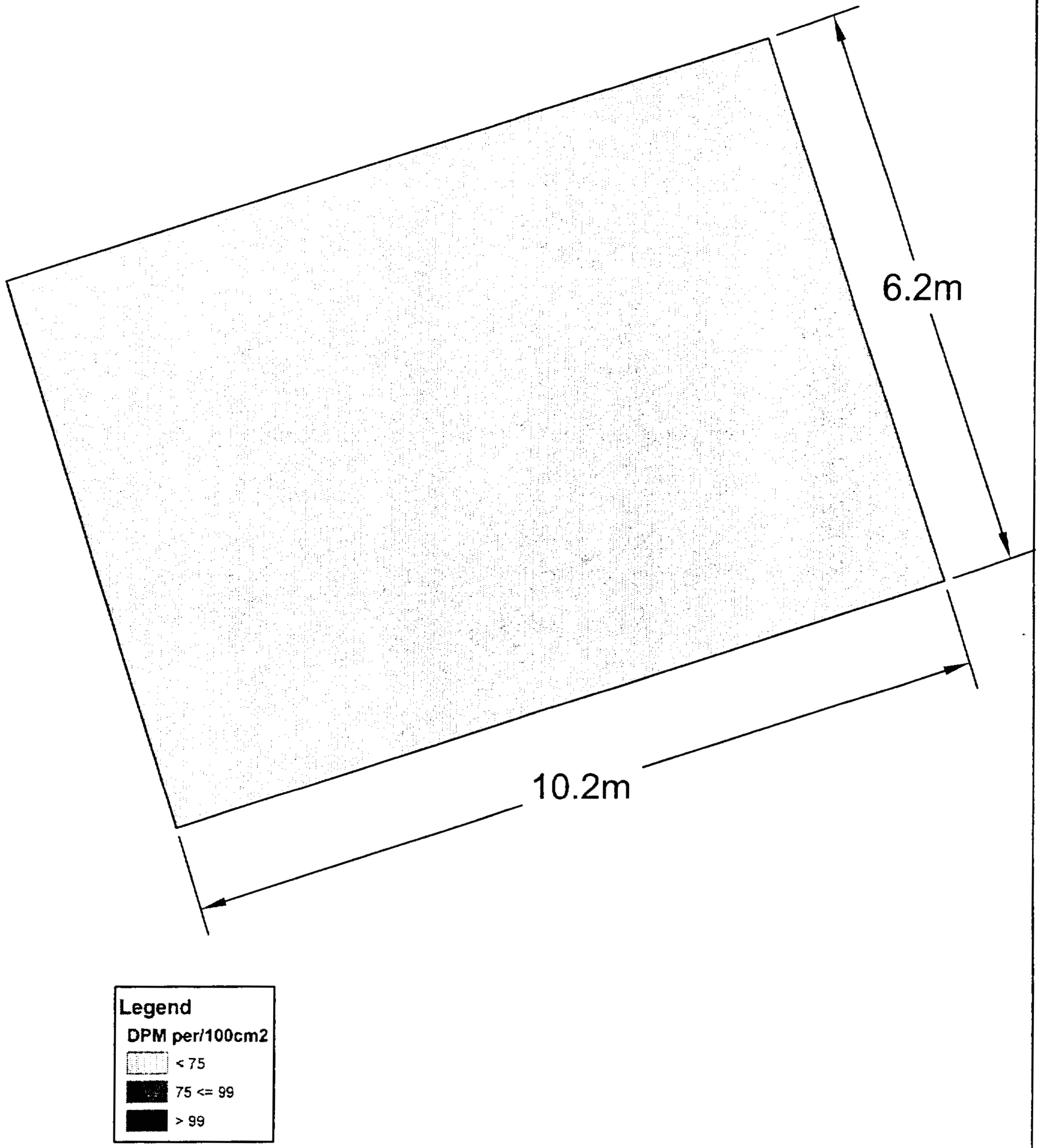

Figure: 23	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Concrete Pad #2 - Alpha Scan
South Survey Unit

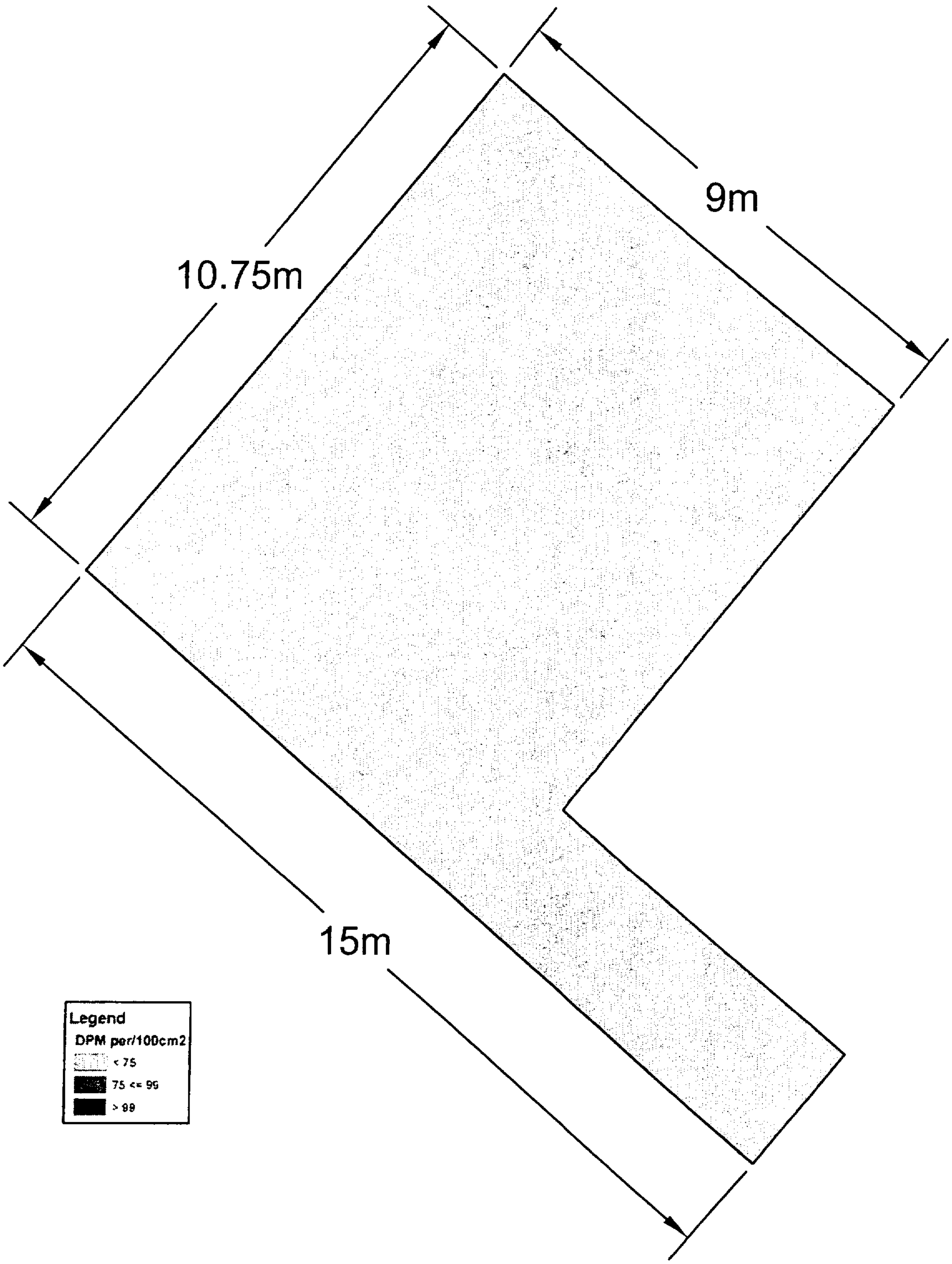

Figure: 24

Remediation and FSS Report
BTD - Buildings
Aberdeen Proving Ground, MD

CABRERA SERVICES
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10/29/2004

Scale: N.T.S.

Concrete Pad #2 - Alpha Scan
North Survey Unit

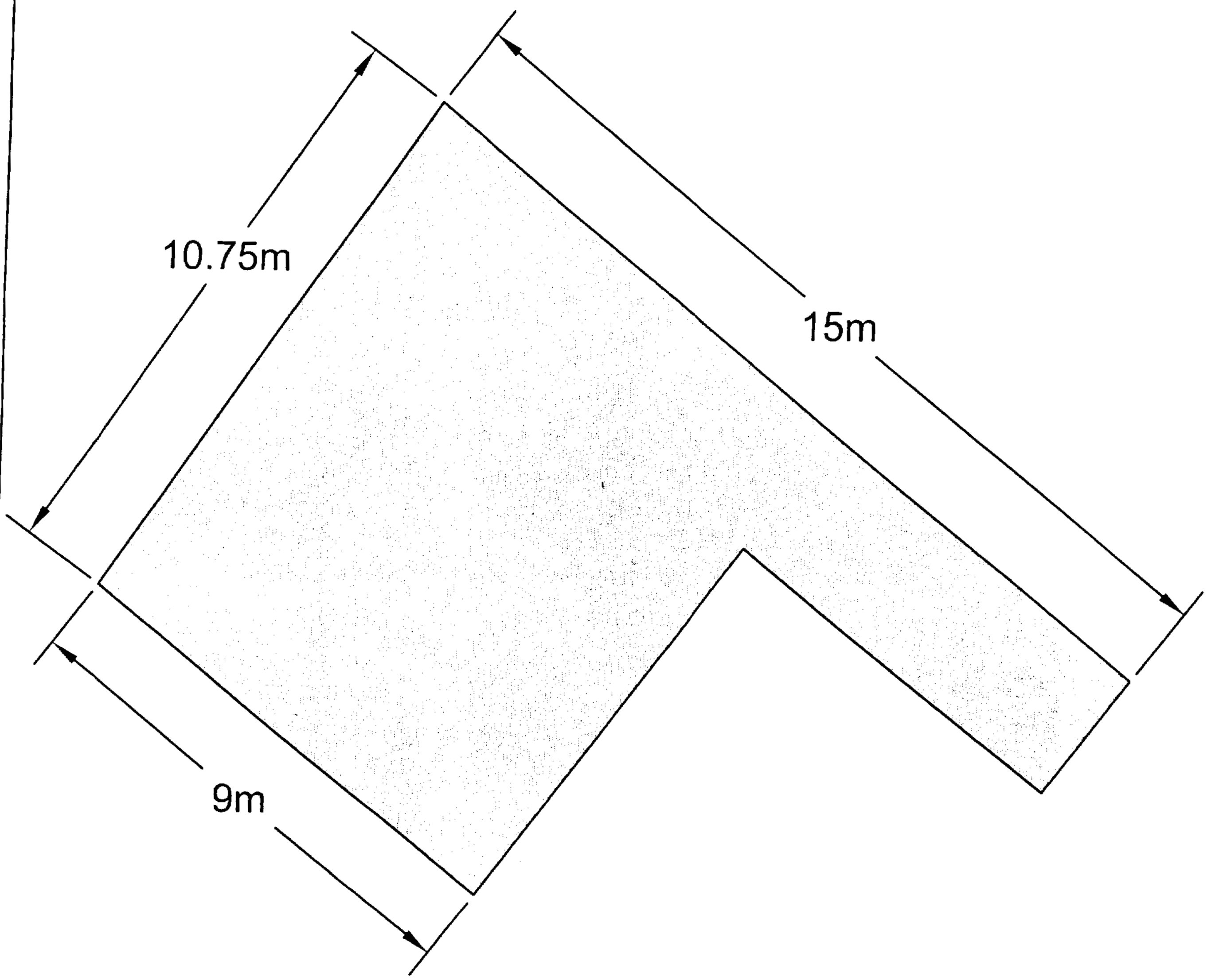
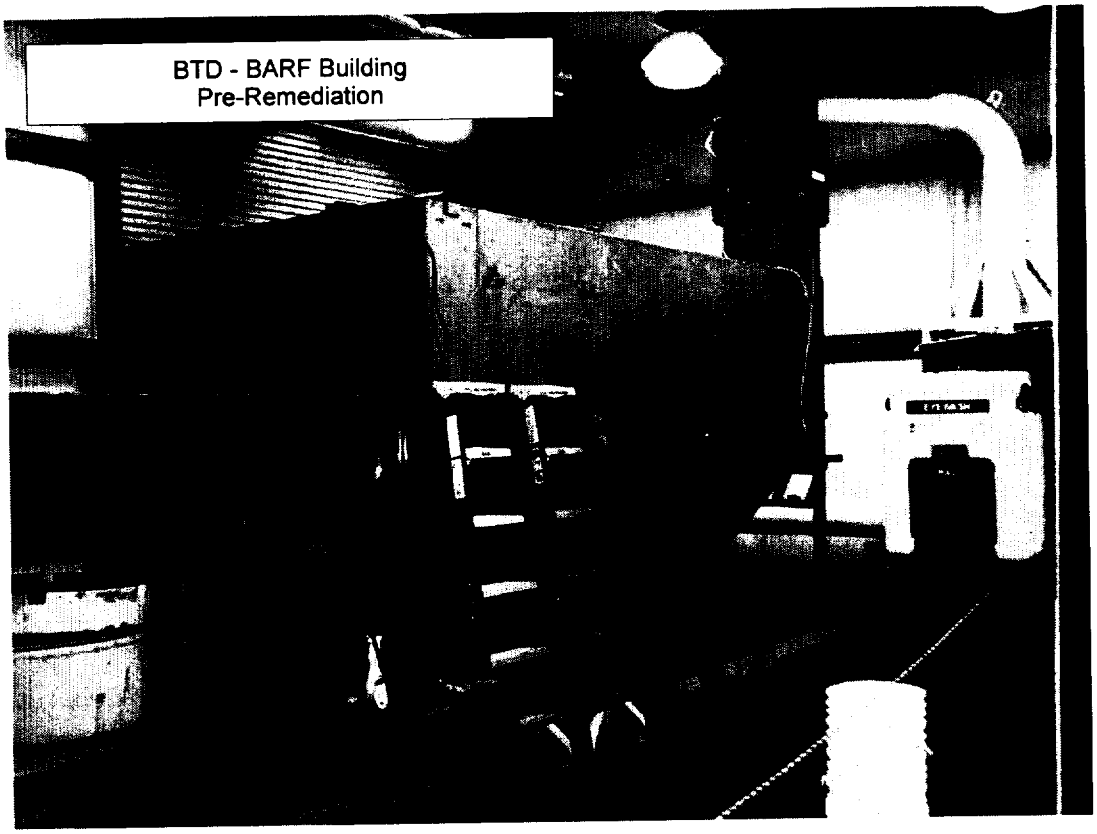


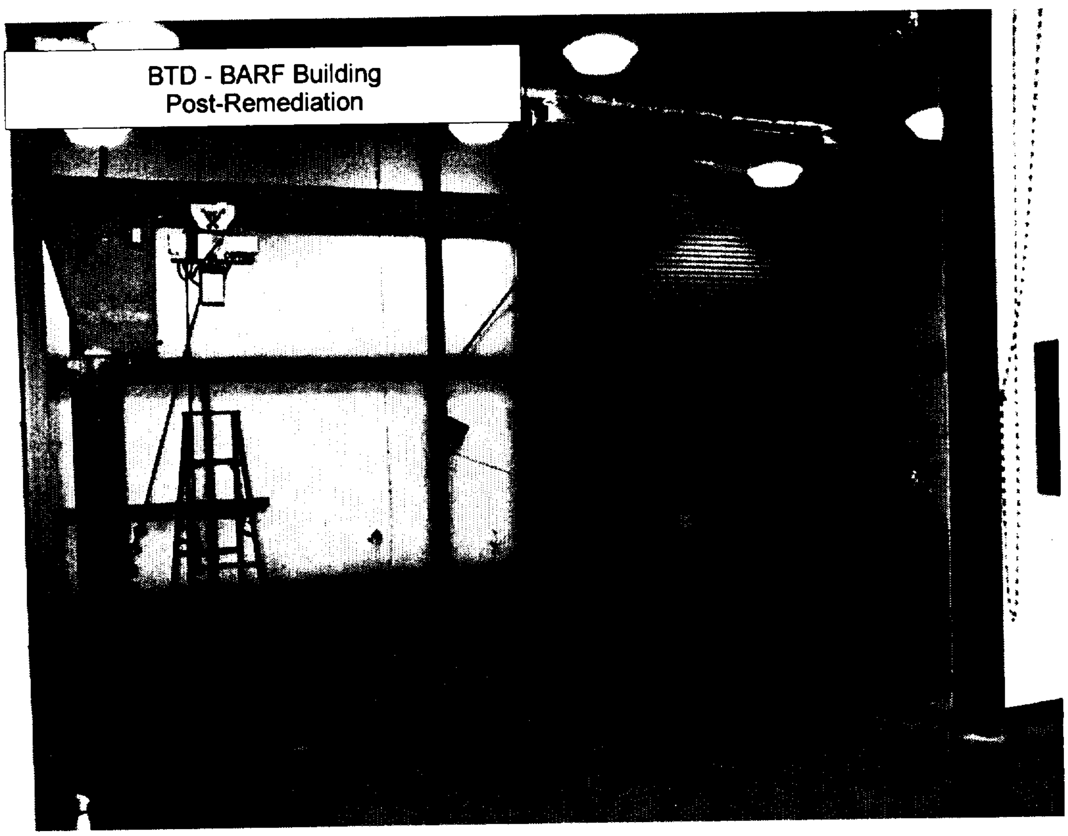
Figure: 25	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

APPENDICES

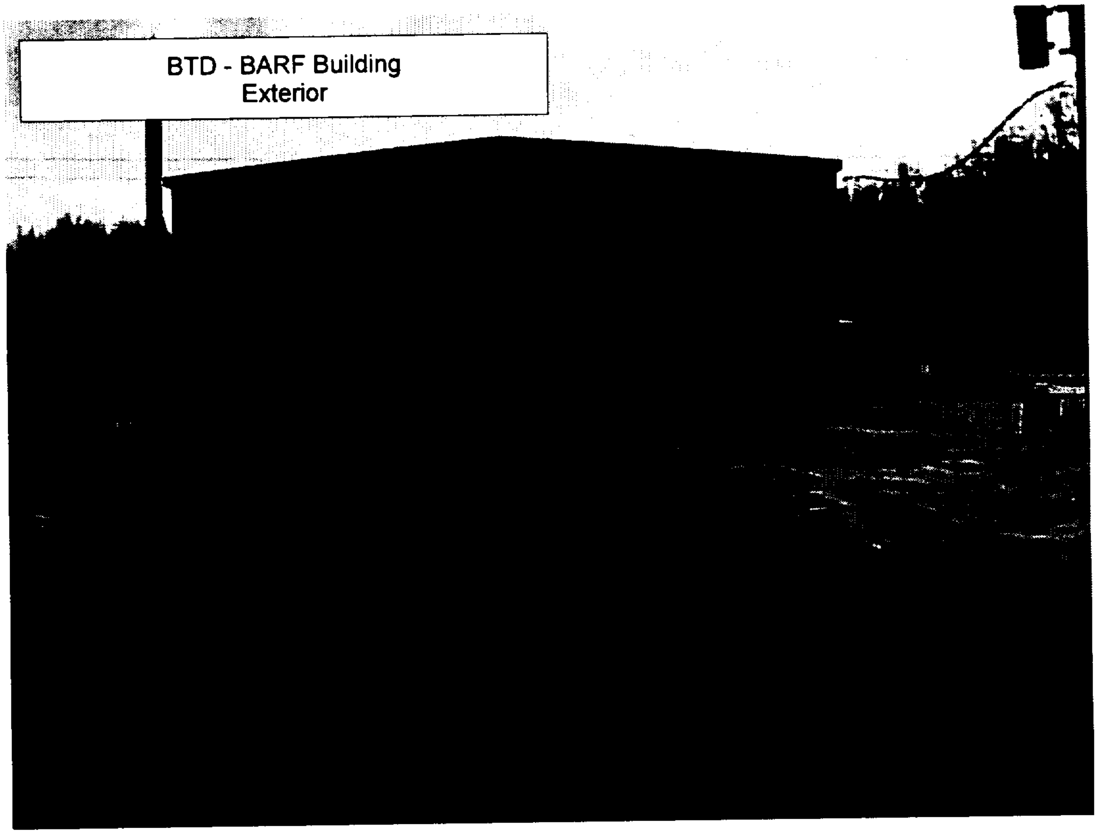
Appendix A: Building Photographs



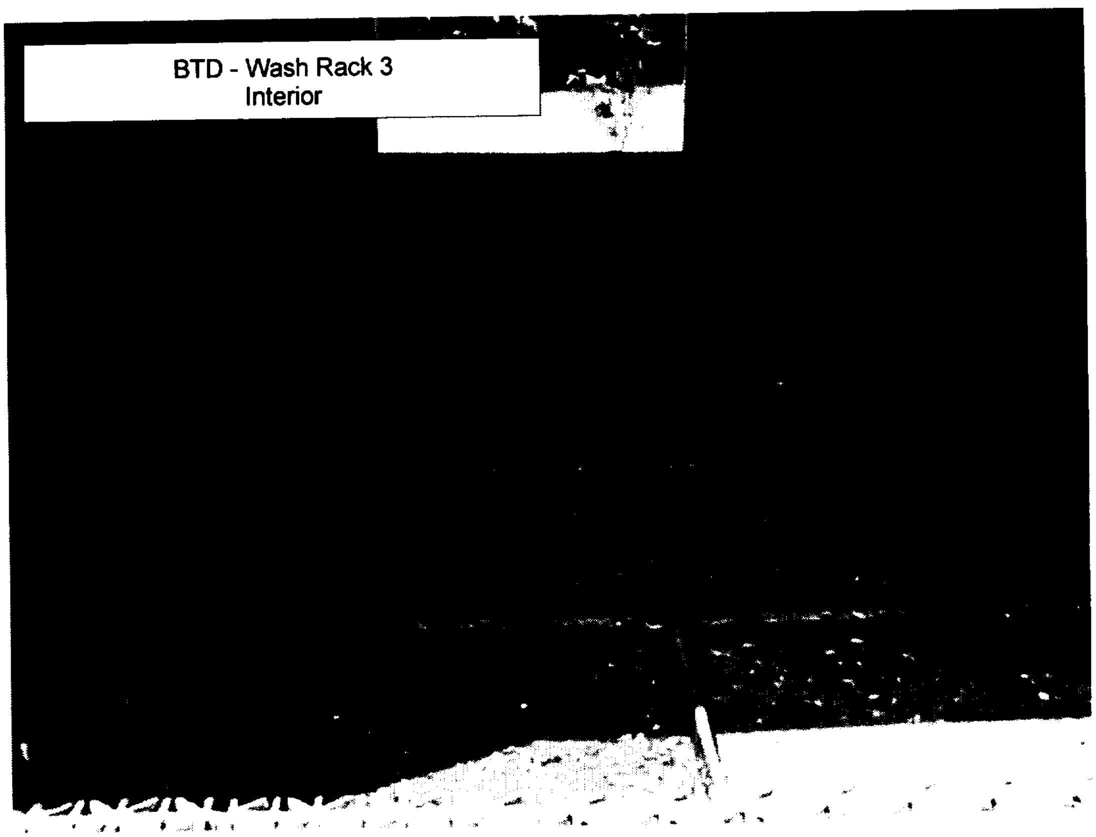
BTD - BARF Building
Pre-Remediation



BTD - BARF Building
Post-Remediation

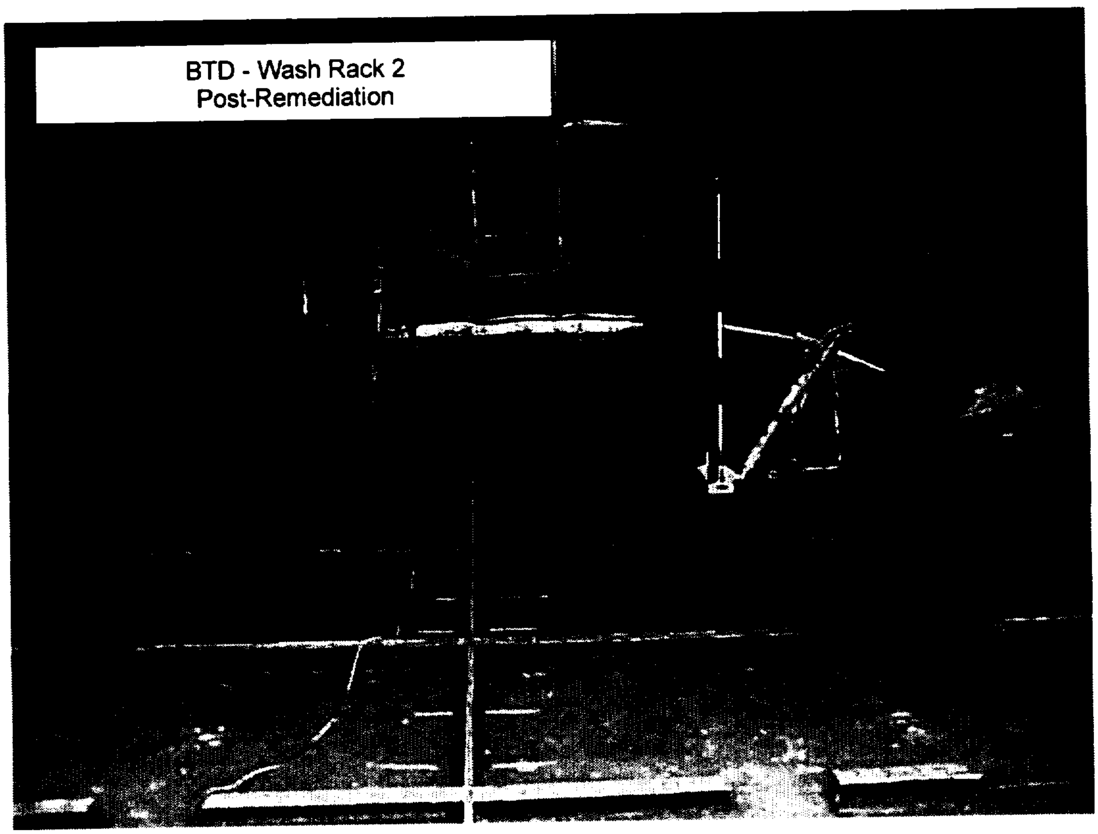


BTD - BARF Building
Exterior

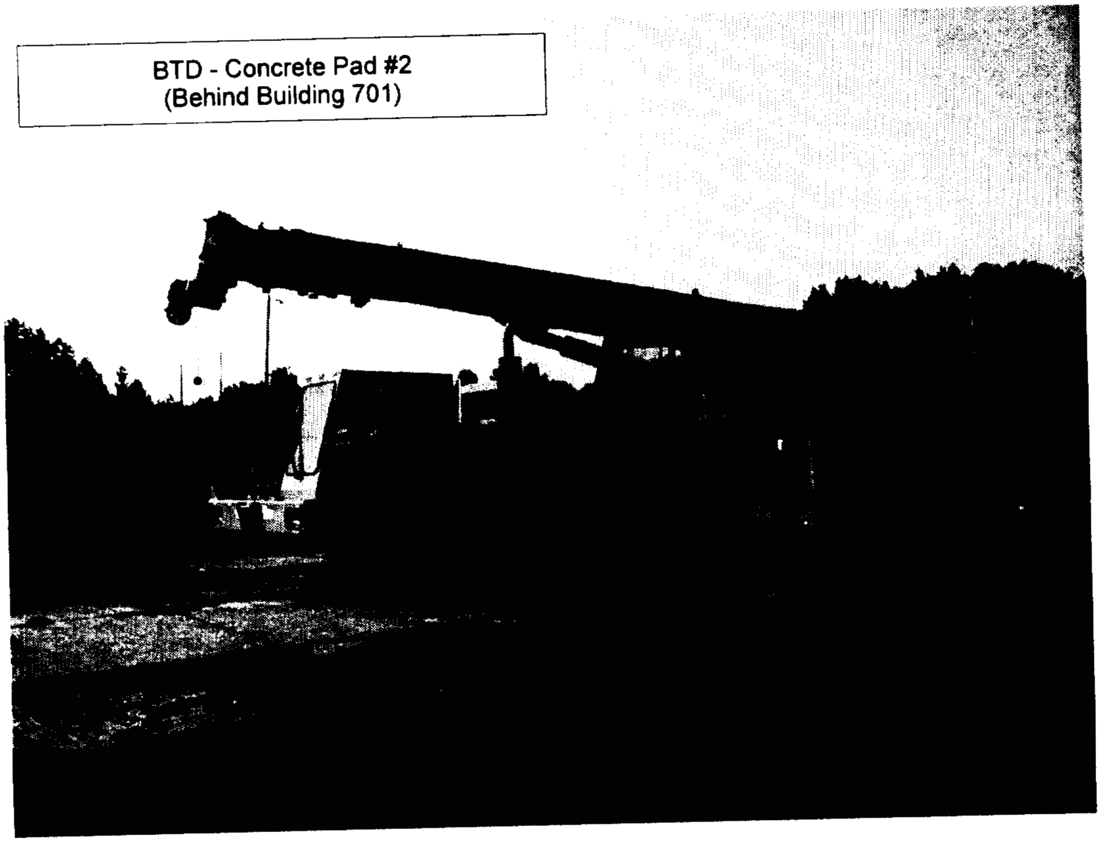


BTD - Wash Rack 3
Interior

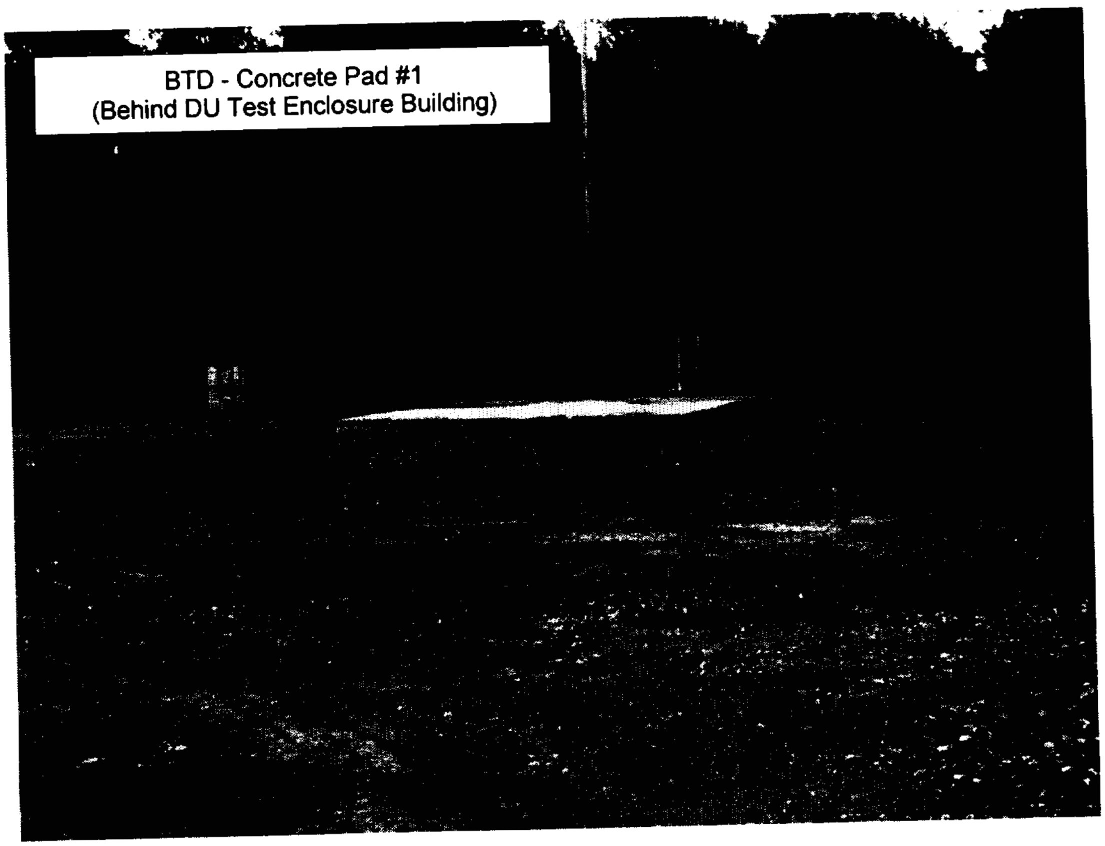
BTD - Wash Rack 2
Pre-Remediation



BTD - Wash Rack 2
Post-Remediation



BTD - Concrete Pad #2
(Behind Building 701)



BTD - Concrete Pad #1
(Behind DU Test Enclosure Building)

Appendix B: Final Status Survey Plan for BTD Armor Reclamation Facility, Aberdeen Proving Ground, Aberdeen, MD

Final Status Survey Plan For Bomb Throwing Device Armor Reclamation Facility Aberdeen Proving Ground, Aberdeen, MD

Contract Number
DAAA09-00G-0002/0039

***Prepared for*:**

U.S. Army Joint Munitions Command
AMSIO-ACE-D Bldg., 350 5th Floor
Rock Island, IL 61299-6000

Prepared by:

Cabrera Services, Inc.
809 Main Street
East Hartford, CT 06108

Cabrera Project No
01-3030.39

April 2003

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Appendix B: Army Regulation 11-9 Army Radiation Safety Program

Appendix C: Survey Unit Maps and Sample Locations

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
APG	Aberdeen Proving Ground
ATC	Army Test Center
BARF	BTD Armor Reclamation Facility
BTD	Bomb Throwing Device
CABRERA	Cabrera Services, Inc.
cpm	Counts Per Minute
DCGL or DCGLw	Derived Concentration Guideline Level
dpm	Disintegrations Per Minute
DU	Depleted Uranium
FSS	Final Status Survey
HSA	Historical Site Assessment
JMC	Joint Munitions Command
LBGR	Lower Bound of the Grey Region
LAB	Liquid Abrasive Blaster
MARSSIM	Multi-Agency Radiation Survey And Site Investigation Manual
MDC	Minimum Detectable Concentration
μR	Microroentgen
mrem	Millirem
NAD	Normalized Absolute Difference
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
QA	Quality Assurance
QC	Quality Control
ROC	Radionuclides of Concern
SU	Survey Unit

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the United States Army Joint Munitions Command (JMC) to provide support to the Army Test Center (ATC) at the Aberdeen Proving Ground (APG) in Aberdeen, MD. The ATC intends to remove equipment used in the decontamination of steel plates within the BTD Armor Reclamation Facility (BARF). The decontamination equipment and ancillary support systems to be removed are part of a Liquid Abrasive Blaster (LAB). This document presents the plans for BARF Final Status Survey (FSS) activities, which are designed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000) guidance. The FSS is a survey of the interior of the BARF. Areas outside the BARF interior walls, floor and ceiling and land areas surrounding the BARF will be addressed under a separate effort.

1.1 General History

APG is a Government-owned and operated testing facility in Aberdeen, MD. The ATC is a tenant activity located at APG. The ATC possesses a Nuclear Regulatory Commission (NRC) license (SUB 834) for the use of depleted uranium (DU) at APG. The ATC utilized the BARF to house the LAB. The LAB was an enclosed system used to decontaminate pieces of steel plate and other small objects with water jets and abrasive. A ventilation system with a pre-filter demister and a HEPA filter removed airborne particulates prior to ventilation release to the environment. A hopper attached to the LAB retained spent abrasive and removed contamination.

Steel plates slated for decontamination were brought to the LAB by fork lift and loaded in the LAB for decontamination. Since the LAB was operated as a closed system with HEPA ventilation the potential for spread of contamination was small. Routine radiation contamination surveys were performed in accordance with license requirements.

In addition, several small boxes of slightly contaminated trash were stored in the southern portion of the building. Several boxes of clean unused HEPA filters were also stored in this area. Routine surveys were performed on all boxes and containers stored in the area.

1.2 General Approach to Building Investigation

The site radiological investigations are designed using the approach outlined in MARSSIM (NRC, 2000).

- Assemble sufficient data to classify areas by contamination potential
- Estimate number of measurement locations
- Identify survey units
- Implement FSS

2.0 SITE ASSESSEMENT

2.1 General Areas for Investigation

The BARF is a steel beam sheet metal constructed building with insulated walls and roof covered with a flexible protective plastic cover. The floor is a concrete pad. The interior of the BARF is approximately 12 meters long by 14.8 meters wide with a ceiling height of 6 meters. The building is bisected by a sheetrock wall with doors leading from one side to the other. There are no drains, sumps, or ventilation system penetrations other than the LAB HEPA ventilation system. A small heating system with insulated ductwork, rollup doors for equipment entry, smaller doorways for personnel entry, and electrical circuit boxes are other general features found in the building.

The northern portion of the BARF contained the LAB decontamination equipment and a small capacity crane used to help lift and load steel plates into the LAB. The southern part of the building was used to store clean unused HEPA filters and small amounts of containerized contaminated trash. Routine radiation contamination surveys were provided on all floor areas within the BARF, on stored boxes and containers, and occasionally on wall surfaces.

No contamination was found on the LAB HEPA filter and areas downstream in the ventilation system ducts during removal of the LAB. Minor contamination was found within the LAB enclosure, the hopper which contained water and abrasive, the HEPA pre-filter, and small areas on the outside of the LAB enclosure near loading points. The lack of activity downstream of the HEPA filter indicates a well-designed system that did not release airborne radioactivity to the environs. Other general surveys do not show contamination on the walls of the BARF. Routine surveys showed only occasional activity on the floor areas surrounding the LAB. Surveys of selected areas in the overhead and on the crane are also negative with respect to contamination.

2.2 Radionuclides of Concern

Site Radionuclides of Concern (ROC) are limited to depleted uranium (DU) and short-lived uranium progeny (Appendix A). The uranium ratios are based on isotopic uranium weight ratios used for shipments of routine DU waste from APG (BARG, 1995). The activity fractions are calculated from the isotopic weight ratios and the specific activity of each uranium isotope. The result is a Uranium-234 (^{234}U):Uranium-235 (^{235}U):Uranium-238 (^{238}U) ratio of 0.084:0.012:0.904. This composition is similar to the 0.190:0.021:0.790 average ratio from three DU soil samples described in the APG report (ANL 1999) entitled "Derived Uranium Guideline for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland", Argonne National Laboratory Environmental Assessment Department, April 1999.

The calculated $DCGL_w$ for the ROC is 100 dpm of total uranium per 100 cm^2 that is calculated using the MARSSIM technique described in section 4.1.

3.0 SURVEY INSTRUMENTATION AND TECHNIQUES

The purpose of this section is to describe radiological survey instruments and techniques to be used for surveys that will be implemented during site radiological investigations. Specific measurement/sampling frequencies and approaches for FSSs are discussed in later sections.

3.1 Surface Alpha Radioactivity Scan Surveys

3.1.1 Eberline FCM4M and Ludlum Model 43-37

Surface scanning for alpha radioactivity will be performed to identify locations, if any, where contaminant concentrations exceed the criterion for unrestricted release. Alpha scanning will be performed on floor surfaces and lower walls using an Eberline FCM4M (active area of 728 cm^2) gas proportional floor monitor, Ludlum Model 43-37 handheld (active area of 582 cm^2) gas proportional detector, or equivalent. Using MARSSIM equation J-7 and the assumptions listed in Table 3.1-1 (scan speeds, background, efficiency, dwell times, etc), the probabilities of two or more counts occurring during the survey of a contaminated area equal to the derived concentration guideline ($DCGL_W$) may be computed from:

$$P(n \geq 2) = 1 - P(n = 0) - P(n = 1) \qquad \text{(MARSSIM Equation J-7)}$$

$$= 1 - \left(e^{-A}\right) \times \left(1 + A\right)$$

$$\text{for } A = \frac{(GE + B)t}{60}$$

where

$P(n \geq 2)$	=	probability of getting 2 or more counts during the time interval t
$P(n = 0)$	=	probability of not getting any counts during the time interval t
$P(n = 1)$	=	probability of getting 1 count during the time interval t
G	=	source activity (dpm)
E	=	detector efficiency (4π)
B	=	background count rate (cpm)
t	=	dwell time over source (seconds)

Alpha scanning will be performed with these instruments by moving the active area of the detector over the surface of interest at or below the given scan speed (Table 3.1-1). If two or more counts occur over the observation interval (Table 3.1-1), a one-minute integrated measurement will be performed at that location prior to scanning being resumed. If the result of the integrated measurement is in excess of the release criteria action level (Section 4.2), the area will be marked for biased measurements and investigated by the Field Supervisor.

3.1.2 Ludlum Model 43-89

Upper wall and ceiling surfaces may not be readily scanned using a Ludlum 43-37 handheld gas proportional counter due to potential long gas delivery tubing lines. These areas are class 3 areas having 10 percent of their areas scanned and may alternatively be scanned with a Ludlum Model 43-89 hand held (active area 126 cm^2) alpha scintillation detector, or equivalent. If the Ludlum Model 43-89 alpha scintillation detector is used, then MARSSIM equation J-5 and the assumptions listed in Table 3.1-1, with a probability of at least one count occurring while surveying an area of contamination equal to the $DCGL_W$ $P(n \geq 1)$, will be implemented instead of MARSSIM equation J-7. Using MARSSIM equation J-5 and the assumptions listed in Table 3.1-1 (scan speeds, background, efficiency, dwell times, etc), the probability that a single count is sufficient to cause a surveyor to stop and investigate further is:

$$P(n \geq 1) = 1 - P(n = 0) = 1 - e^{-A} \qquad \text{(MARSSIM J-5)}$$

$$\text{for } A = \frac{GEd}{60v}$$

where,

$P(n \geq 1)$	=	probability of getting 1 or more counts during the time interval t
$P(n = 0)$	=	probability of not getting any counts during the time interval t
G	=	source activity (dpm)
E	=	detector efficiency (4π)
d	=	width of the detector in the direction of scan (cm)
v	=	scan speed (cm/s)

Alpha scanning will be performed using the Ludlum Model 43-89 detector by moving the active area of the detector over the surface of interest at the given scan speed and assumptions shown in Table 3.1-1. Whenever a count is detected during the scan, the detector will be held in place over the location where the count was detected for approximately for the duration of the pause time (approximately 7-8 seconds). If a second count is detected over this location during the pause time, a two minute integrated count will be performed. If the result of the integrated measurement is in excess of the release criteria (Section 4.1), the area will be marked for biased measurements and investigated by the Field Supervisor. For all instruments, scanning will be performed with the active area of the detector at a height of 0.5 cm above the surface of interest.

To assist in scanning, grids will be marked on surfaces requiring a surface scan. Grids on the floor and lower walls will be one square meter in area. Areas of elevated radioactivity identified during scanning will be physically marked and biased integrated measurements will be performed to quantify surface alpha activity concentrations.

Table 3.1-1: Alpha Scan Assumptions

Model #	Probe Area (cm^2)	Probe Width (cm)	α Efficiency (cpm /dpm)	α Bkgrd (cpm)	Scan Speed (cm/sec)	Pause Time (sec)	P(n>=1)	Dwell Time (sec)	P(n>=2)
FCM4M	728	15	0.15	10	7.5	NA	NA	2.0	0.91
43-37	582	15	0.15	10	6	NA	NA	2.5	0.91
43-89	126	9	0.15	3	1	7.3	0.90	NA	NA

3.2 Integrated Direct Surface Alpha Radioactivity Measurements

Integrated direct measurements (i.e., static measurements) of surface alpha radioactivity will be performed during FSSs to compare contaminant concentrations at discrete sampling locations to the release criterion and facilitate statistical testing. Interior surfaces will be cleaned prior to surveying to remove dirt and grime that could shield alpha emissions from surfaces of interest. The cleaning implements used and the wastes generated during cleaning will be collected and stored on site and disposed in accordance with the contaminants found. Integrated measurements of floors and walls will be performed using a Ludlum Model 43-37 handheld (active area of 582 cm^2) gas proportional detector, Eberline FCM4M (detector surface area of 728 cm^2) gas proportional floor monitor, Ludlum Model 43-89 hand held (active area 126 cm^2) alpha scintillation detector, or equivalent. The estimated detector sensitivities and assumptions used for each of the detectors are presented in Table 3.2-1.

Static measurements will be performed in accordance with CABRERA procedures OP-020 "*Operation of Contamination Survey Meters,*" *Rev 0,* and *OP-021 "Alpha-Beta Counting Instrumentation," Rev 0, and* CABRERA standard radiation instrumentation templates *"Alpha Beta Counting and Smear Worksheet", Rev 1.* Prior to use, FSS instrumentation will be checked for expected response using a Chi-Square distribution utilizing the CABRERA template *"Chi-Square Worksheet", Rev 0.*

The net count rate using the referenced templates will be determined as the difference between the measurement countrate and the daily background countrate measured prior to use.

Table 3.2-1: Detector Sensitivities and Assumptions

Model #	Count Time (min)	Probe Area (cm^2)	α Efficiency (cpm /dpm)	α Background (cpm)	α Static MDC (dpm / 100 cm^2)
FCM4M	1	728	0.15	10	16
43-37	1	582	0.15	10	20
43-89	2	126	0.15	3	30
2929	4	swipe	0.30	0.5	5

3.3 Smear Sample Collection and Analysis

Smear samples for gross transferable alpha contamination will be collected and analyzed to determine if transferable activity is less then 10% of total activity as assumed in the release criterion and to ensure compliance with the equipment release criterion of Army Regulation (AR) 11-9 presented in Appendix B.

Smear samples will be collected over approximately 100 cm^2 areas at biased locations identified during scanning activities, and at other biased locations such as overhead ductwork. Smear samples will be analyzed for alpha radioactivity using a Ludlum 2929 alpha/beta scintillation counter or equivalent in accordance with CABRERA procedure *Alpha Beta Counting Instrumentation, Rev 0.* Based on the assumptions listed in Table 3.2-1, an alpha MDC of 5 dpm/100cm2 will be achieved.

3.4 Gamma Dose Rate Measurements

Gamma dose rate measurements may be qualitatively performed during the FSSs to ensure worker health and safety and to identify unusual dose rate conditions. Measurements will be performed using a Bicron® MicroRem tissue-equivalent scintillation detector, or equivalent, and will be performed in accordance with CABRERA Procedure OP-023, *Operation of micro-R Meters, Rev 0.* Measurements will be performed using the "slow" response time constant setting. The detector will be positioned over the area of interest and allowed to stabilize prior to recording the measurement. The technician will use their judgment to determine when the instrument has stabilized, it is estimated that this will take at least 15 seconds. Such measurements will typically be performed at 1 meter from and/or on contact with the surface being evaluated.

3.5 Volumetric Samples and Analysis

Volumetric samples may be collected from areas of interest (e.g., ventilation) for analysis by alpha spectroscopy for isotopic uranium. If samples are collected to quantify surface activity concentrations, the area over which the sample is collected will be noted so laboratory results can be converted into units of dpm/100cm^2. Volumetric samples will be collected in accordance with CABRERA procedure *OP-005 Volumetric and Material Sampling, rev 0.* Samples will be sent to Paragon Analytics, Inc. for analysis and analyzed in accordance with Paragon's standard operating procedure.

4.0 FINAL STATUS SURVEY DESIGN

The FSS to be performed at the BARF is designed in accordance with Final Status Survey guidance from MARSSIM (NRC, 2000). FSS activities will consist of gross alpha scan surveys and integrated measurements on interior surfaces at frequencies based on MARSSIM guidance. The FSS is designed conservatively in that the radiological background present in survey materials (i.e., concrete floor) will be neglected and the measure of total activity will be used for statistical comparisons to release criteria. Survey activities will also include biased smear sample collection and the performance of gamma dose rate measurements. Biased survey measurements may be performed on building systems (e.g., ventilation) and additional analysis of samples by alpha spectroscopy may be performed. MARSSIM area classifications will be reviewed and possibly revised based on the results of these surveys.

4.1 Residual Radioactivity Limit (DCGL)

As described by MARSSIM, a DCGL is a derived radionuclide activity concentration within a survey unit that corresponds to a release criterion. Per the license requirement of 10CFR20 Subpart E, a release criterion of 25 mrem/yr per year will be used for the BARF. Doses from residual radioactivity will be kept as low as reasonably achievable (ALARA) whenever possible. Using MARSSIM Section 4.3.4, the equation below, and knowing that there is one alpha decay per decay of each uranium isotope, a single total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 was derived for DU. This $DCGL_W$ was calculated using the values provided by the NRC screening guidelines of 90.6 dpm/100cm^2, 97.6 dpm/100cm^2, 101 dpm/100cm^2 and for U^{234}, U^{235}, and U^{238}, respectively, as presented in Table 5.19 of NUREG/CR-5512, volume 3, October 1999 and the DU activity fractions as presented in Section 2.2 of this FSS.

$$DCGL_W = \frac{1}{\left(\frac{f_1}{DCGL_1}\right) + \left(\frac{f_2}{DCGL_2}\right) + \left(\frac{f_3}{DCGL_3}\right)}$$

Where: $DCGL_W$ = Combined gross activity DCGL (i.e., release limit).

f = Activity fraction of radionuclide

DCGL = DCGL of radionuclide

4.2 Action Levels

The total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 will be used conservatively as the action level for both static and scanning measurements. If any survey measurement results in readings above the $DCGL_W$, the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, a follow-up measurement shall be performed at the measurement location to verify the initial result.

4.3 General Area Classification based on contamination potential

Using MARSSIM Section 5.3 as guidance, the BARF will initially be subdivided into four Class 1 Survey Units (SUs) and one Class 3 SU as listed in Table 4.3-1. The initial classifications are

based on contamination potential and area size. MARSSIM recommends that interior Class 1 SUs be less than 100 square meters in size and each of the four Class 1 SU range from 77.6 m^2 to 88.8 m^2. The floor and lower walls of the northern room of the BARF share similar contamination potential because this area housed the LAB decontamination equipment and was where the decontamination process was performed. Although the lab system was self-contained and surveys did not routinely identify transferable contamination on the floor or walls, contaminated materials were moved through this room via the south rollup door to be loaded in and out of the LAB system. In accordance with MARSSIM guidance, the south room floor and lower walls will initially be considered Class 1 SUs as well because this area was once used to store containerized contaminated trash.

MARSSIM does not specify area limits on Class 3 SUs. Since the upper wall and ceiling surfaces of the north and south rooms share similar potential for contamination, these areas were combined into one Class 3 SU. The potential for contamination on the upper walls and ceiling surface in the north room is small because no contamination was identified on the LAB HEPA filter or at downstream areas in the ventilation system. The lack of activity downstream of the HEPA filter indicates a well-designed system that did not release airborne radioactivity to the environs. In addition, transferable contamination was not identified during routine surveys in the BARF and the primary mechanism for transport (i.e., ventilation system) was not contaminated.

Maps presenting the BARF SU delineations and the reference coordinate system are presented in Appendix C.

Table 4.3-1: Survey Units

SU #	Description	Area (m^2)	Material	Class
SU 1	North Room Floor	88.8	Concrete	1
SU 2	South Room Floor	88.8	Concrete	1
SU 3	North Room Lower Wall	76.6	Foam / Sheet Metal	1
SU 4	South Room Lower Wall	76.6	Foam / Sheet Metal	1
SU 5	Ceilings and Upper Walls	488	Foam / Sheet Metal	3

4.4 Number of Static Measurements

MARSSIM discusses a method to determine the number of measurement locations required in a given survey unit. A minimum number of measurement locations are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The following subsections describe the bases for and derivation of the minimum required measurement locations per survey unit.

4.4.1 Estimation of Relative Shift

The minimum number of measurement locations required is dependent on the distribution of site residual radionuclide concentrations relative to the $DCGL_W$ and acceptable decision error limits (α and β).

The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated using the following equation, found in Section 5.5.2.3 of MARSSIM. The relative shift is calculated as follows:

$$\Delta/\sigma = \frac{DCGL_w - LBGR}{\sigma}$$

Where: $DCGL_W$= the DCGL (i.e., release limit).

LBGR = concentration at the lower bound of the gray region. The Lower Bound of the Grey Region (LBGR) is the concentration to which the survey unit must be cleaned in order to have an acceptable probability of passing the statistical tests.

σ = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system).

As previously stated, the $DCGL_w$ for surface alpha radioactivity is 100 dpm/100cm^2. The LBGR was conservatively estimated at 70 dpm alpha/100 cm^2 based on previous studies with similar instruments on concrete. Without prior survey, it is reasonable to assume a coefficient of variation on the order of 30 percent (MARSSIM Section 5.5.2.2). Using a coefficient of variation of 30 percent and the LBGR as an estimate of the sample mean, a sigma value of 21 dpm/100cm^2 is obtained. Using the parameters discussed above, the relative shift is calculated as 1.4.

4.4.2 Determination of N (Number of Required Measurement Locations)

The final number of required measurement locations per survey unit is 20 as per MARSSIM (Table 5.5) given a relative shift of 1.4 and an error rate for both Type I and Type II errors of five percent (i.e., $\alpha = \beta = 0.05$). The actual number of measurements to be performed in each survey unit ranges from 20 to 24 samples based on the size of the survey area (Section 4.6).

4.5 Elevated Measurement Criterion ($DCGL_{EMC}$)

MARSSIM states that, for Class 1 survey units, a dose area factor should be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion. For the purpose of ALARA, the $DCGL_W$ will be used as the $DCGL_{EMC}$ which corresponds to an area factor of one. Since the scan MDC of the instrumentation is sensitive enough to identify the $DCGL_W$ at least ninety percent of the time, it is unlikely that small areas of elevated activity exceeding the release criterion would be missed during scanning.

4.6 Static Measurement Locations

Measurement locations in Class 1 survey units have been established using a random start point in a systematic rectangular grid. The grid spacing for Class 1 survey units will be determined, based on the measured area of the survey unit, using the following equation (Equation 5-7 from MARSSIM).

$$L = \sqrt{\frac{A}{N}}$$

Where: L = rectangular grid spacing for survey unit
A = area of survey unit
N = number measurement locations

Measurement spacing results (L) using the equation above, 20 systematic static measurement locations, and the area of the Class 1 survey units presented in Section 4.3 ($77.6m^2$ and $88.8m^2$) results in a measurement spacing of approximately 2m. Maps presenting the BARF SU delineations and the reference coordinate system are presented in Appendix C.

In accordance with MARSSIM, static measurement spacing for the Class 3 SU will be performed at random locations. Maps presenting the BARF SU delineations and the reference coordinate system are presented in Appendix C.

4.7 Surface Alpha Radioactivity Scan Surveys

Class 1 SU scan surveys will be performed as described in Section 4.1 and will cover 100% of reasonably accessible surfaces. Areas of elevated radioactivity identified during scanning will be physically marked and biased integrated measurements will be performed to quantify surface alpha activity concentrations for direct comparison to the $DCGL_W$. Survey areas in excess of the $DCGL_W$ will be investigated by the Field Supervisor and flagged for additional biased sampling (e.g. smear sampling, alpha spectroscopy).

Scan surveys in Class 3 SUs will cover at least 10% of surface areas and, when possible, will be biased toward areas with high potential for the presence of contamination. Examples of areas with potentially higher concentrations of contamination include ventilation intake and exhaust ports and areas where DU contamination may have settled from the air, such as ceiling trusses and joints. Areas of elevated radioactivity identified during scanning will be physically marked and biased integrated measurements will be performed to quantify surface alpha activity concentrations for direct comparison to the $DCGL_W$. Since contamination is not expected in Class 3 areas, any biased measurements confirmed to be in excess of the $DCGL_W$ will trigger investigation by the Field Supervisor and a re-evaluation of the area classification.

4.8 Integrated Direct Surface Alpha Radioactivity Measurements

Measurements of surface alpha radioactivity will be performed in SUs at locations selected for MARSSIM statistical testing and at biased locations identified prior to and during scanning activities. Such measurements will be performed as described in Section 3.2.

4.9 Smear Sample Collection and Analysis

Smear samples will be collected at biased survey locations and at least 10% of systematic survey locations. Smear samples will be collected as described in Section 3.3.

4.10 Gamma Exposure Rate Measurements

Gamma exposure rate measurements may be performed to ensure worker safety and to identify unusual exposure rate conditions. Gamma exposure rate measurements will be performed as described in Section 3.4.

5.0 EQUIPMENT RELEASE

5.1 Survey of Equipment for Release without Restriction

Certain equipment present inside the BARF may need to be surveyed for consideration of release without restriction. If necessary, CABRERA will follow the surface release limits of 1,000 dpm/100 cm^2 of DU alpha activity per Army Regulation 11-9 *The Army Radiation Safety Program*. It is expected that all final release surveys of equipment will be performed by the licensee and these surveys will follow APG procedures. If CABRERA performs these release surveys for APG, then CABRERA will follow the APG procedures.

6.0 DATA PROCESSING

For this FFS, it is essential that all significant events be documented and retained for future reference. While many types of project events have specific forms on which they are documented, many events occur on a routine basis during survey field activities that must be documented as they occur. Additionally, project data transactions must also be recorded as they occur. To provide a practical means of capturing this information, a project logbook will be initiated upon project commencement.

Significant project events, including data transactions involving project electronic data, shall be recorded in the Project Logbook. Data transactions are defined as any transfer, download, export, copy, differential correction, sort, or other manipulation performed on project electronic data. Project Logbook records shall be sufficient to allow data transactions to be reconstructed after the project is completed. The Field Supervisor shall be responsible for maintaining the Project Data Logbook and will review the Project Data Logbook at least daily to report significant issues.

The Project Logbook is considered a legal record and will be permanently bound and the pages will be pre-numbered. Pages may not be removed from the logbook under any circumstances. Entries shall be legible, factual, detailed, and complete and shall be signed and dated by the individual(s) making the entries. If a mistake is made, the individual making the entry shall place a single line through the erroneous entry and shall initial and date the deletion. Under no circumstances shall any previously entered information be completely obliterated. Use of whiteout in the Project Logbook is not permitted for any reason. Only one Project Logbook will be maintained. If a Project Logbook is completely filled, another volume shall be initiated. In this case, each volume shall be sequentially numbered.

6.1 Project Electronic Data

Much of this FSS will rely on data collected and stored electronically. Electronic data is subject to damage and/or loss if not properly protected. As such, all project electronic data shall be downloaded from its collection device (e.g., laptop computers, data loggers, etc.) on at least a daily basis. At the conclusion of each day's survey activities, the Field Supervisor shall back up all electronic data collected that day to appropriate removable media (e.g., CD, zip disk, or equivalent) and shall ensure the backup is removed from site. Under no circumstances shall the backup be stored in the same building in which the original project electronic data is stored.

Data files shall be named according to a naming protocol designated by the field supervisor. No variations from this protocol shall occur without the prior concurrence of the field supervisor. During data download and transfer transactions, the applicable data file name(s) shall be included in project data logbook entries.

7.0 SURVEY QUALITY ASSURANCE/QUALITY CONTROL

Activities associated with this work plan shall be performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Topics covered in project procedures and protocols may include proper use of instrumentation, Quality Control (QC) requirements, equipment limitation, etc. Quality Assurance (QA) measures for this FSS are described herein.

7.1 Instrumentation Requirements

The Field Supervisor is responsible for determining the instrumentation required to complete the requirements of this work plan. Only instrumentation approved by the Field Supervisor will be used to collect radiological data. The Field Supervisor is responsible for ensuring individuals are appropriately trained to use project instrumentation and other equipment, and that instrumentation meets the required detection sensitivities. Instrumentation shall be operated in accordance with either a written procedure or manufacturers' manual, as determined by the Field Supervisor. The procedure and/or manual will provide guidance to field personnel on the proper use and limitations of the instrument.

7.1.1 Calibration Requirements

Instruments used during the FSS shall have current calibration/maintenance records kept on site for review and inspection. The records will include, at a minimum, the following:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

Instrumentation shall be maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments are maintained. Instruments will be calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using National Institute of Standards and Technology (NIST) traceable sources.

7.1.2 Instrument QC Source and Background Checks

Prior to and after daily use, alpha and gamma measuring instruments will be QC checked by comparing the instruments' response to a designated alpha or gamma radiation source and to ambient background. QC source checks will be performed with the designated source positioned in a reproducible geometry. Background checks will be performed in an identical fashion with the source removed. During QC checks, instruments will be inspected for physical damage, current calibration and erroneous responses. The individual performing these tasks shall document the results in accordance with the associated instrument procedure and/or protocols. Instrumentation that does not meet the specified requirements of calibration, inspection, or response check will be removed from service. If an instrument is removed from service, any data obtained after the last successful QC check will be considered suspect due to faulty instrumentation.

Quality control source checks for the Eberline FCM4M, Ludlum 43-37, Ludlum 43-89 will consist of a one-minute integrated count with the designated Thorium–230 (^{230}Th) and Technetium-99 (^{99}Tc) sources. QC source checks for the Bicron® MicroRem meter will consist of observing needle deflection and estimating an average dose rate once the instrument readings have stabilized (approximately 22 seconds) using a ^{137}Cs source. The acceptance criterion for these instrument response checks is within +/- 20% of the average response generated using ten initial source checks and ten measurements of ambient background performed at the beginning of the project. A response check outside these criteria will be cause for evaluation of conditions (e.g., instrument operation, source/detector geometry). The response check will be repeated once prior to field use of that instrument. Instruments that fail the second successive response check will be removed from service. Only Field Supervisors can return a failed instrument back to service after proper corrective actions are taken.

Quality control source response checks for the Ludlum 2929 will be checked daily by evaluating response to designated ^{230}Th (Alpha) and ^{99}Tc (Beta) sources and ambient background. Response checks will consist of one-minute counts of a ^{230}Th, ^{99}Tc source, and a 20 minute count of ambient background. The acceptance criteria for instrument response will be set to two and three-sigma of the average response generated using ten initial source checks and ten measurements of ambient background. A daily response check outside the two-sigma, but within the three-sigma criteria will be cause for a recount prior to use. A response check outside two sigma on the second count will be cause for further evaluation and or re-performance of QC control values prior to continued use. Response checks falling outside acceptance criteria will be cause for notification of the Field Supervisor and evaluation of conditions (e.g., instrument operation, source/detector geometry) prior to further counts and/or removal of the instrument from service. Instruments must pass a response check prior to field use. Only Field Supervisors can return a failed instrument back to service after proper corrective actions are taken.

Quality control for volumetric sample analysis will be performed in accordance with applicable Paragon standard operating procedures.

7.2 Direct Alpha, Smear, and Exposure Rate Measurements

Instrumentation will be operated in accordance with standard operating procedures and/or protocols.

7.2.1 Duplicate Measurements

Duplicate measurements will be required for 10% of the static measurement locations for each survey unit. Duplicate measurements will be compared to the initial analytical results by determining a Normalized Absolute Difference (NAD) value and comparing it against the performance criteria specified as follows:

Analyses of field and laboratory duplicates will be compared to the initial analytical results by determining a NAD value for each data set by the following equation (PROB, 1993):

$$NAD = \frac{|\text{Sample - Duplicate}|}{\sqrt{\sigma^2_{\text{Sample}} + \sigma^2_{\text{Duplicate}}}}$$

Where: Sample = first sample value (original),
Duplicate = second sample value (duplicate),
$\sigma_{\text{Sample}} = 2\sigma$ counting uncertainty of the sample, and,
$\sigma_{\text{Duplicate}} = 2\sigma$ counting uncertainty of the duplicate

The calculated NAD results will be compared to a performance criteria of less than or equal to 1.96. Calculated NAD values less than 1.96 will be considered acceptable and values greater than 1.96 will be investigated for possible discrepancies in analytical precision, or for sources of disagreement with the following assumptions of the test:

- the sample measurement and duplicate or replicate measurement are of the same normally distributed population

- the standard deviations, σ_{Sample} and $\sigma_{\text{Duplicate}}$, represent the true standard deviation of the measured population

8.0 REFERENCES

(ANL, 1999) ANL Environmental Assessment Department Health Risk Report, "*Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland*", M. Picel and S. Kamboj, Argonne National Laboratory, April 1999

(BARG, 1995) Specific Manufacturing Capability Program, *Depleted Uranium Constituents and Decay Heating*, Lockheed, Idaho presentation, dated October 3, 1995.

(CABRERA, 2000a) CABRERA OP-020, "*Operation of Contamination Survey Meters", Rev 0*

(CABRERA, 2000b) CABRERA OP-021, "*Alpha-Beta Counting Instrumentation", Rev 0*

(CABRERA, 2000c) Cabrera OP-023, "*Operation of micro-R Meters", Rev 0*

(NRC, 1999) NUREG/CR-5512, Volume 3 *Residual Radioactive Contamination from Decommissioning, Parameter Analysis*, Draft Report for Comment, U.S. Nuclear Regulatory Commission, dated October, 1999.

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

Appendix A: Uranium 238 Decay Series

Uranium 238 Decay Series

(Excerpted from Radioactive Decay Data Tables, David Kocher, 1981)

Radionuclide	Half-Life	Emissions	Energy (MeV)	Percent Yield
U-238	4.5 x 109 y	α	4.2	75
		α	4.15	25
Th-234	24.1 d	β	0.193	79
		β	0.1	21
		γ	0.093	4
		γ	0.063	3.5
Pa-234m	1.17 min	β	2.29	98
Pa-234	6.75 h	β	0.53	<1
		β	1.13	<1
U-234	2.47 x105 y	α	4.72	28
		α	4.77	72
Th-230	8.0 x 104 y	α	4.62	24
		α	4.68	76
Ra-226	1602 y	α	4.60	6
		α	4.78	95
		γ	0.186	4
Rn-222	3.82 d	α	5.49	100
Po-218	3.05 min	α	6.0	100
Pb-214	26.8 min	β	0.65	50
		β	0.71	40
		γ	0.3	19
		γ	0.35	36
Bi-214	19.7 min	β	1.0	23
		β	1.51	40
		β	3.26	19
		γ	0.609	47

Appendix B:
Army Regulation 11-9
Army Radiation Safety Program

Army Regulation 11-9

Army Programs

The Army Radiation Safety Program

Headquarters
Department of the Army
Washington, DC
28 May 1999

Headquarters
Department of the Army
Washington, DC
28 May 1999

*Army Regulation 11-9

Effective 29 June 1999

Army Programs

The Army Radiation Safety Program

Louis Caldera
Secretary of the Army

History. This is a new regulation.

Summary. This regulation prescribes Army radiation safety policy. It is a consolidation of several regulations that partially covered this policy. It implements DODI 6055.8 and DODI 6055.11. It includes Army policy for the use, licensing, disposal, transportation, dosimetry, accident reporting, safety design, and inventory control of and radiation exposure standards for ionizing and nonionizing radiation sources. This regulation updates policy to be consistent with current Federal radiation safety regulations; simplifies Army radiation authorization, Army radiation permit, and Nuclear Regulatory Commission license application procedures; requires Army radiation authorizations for the use of machine-produced ionizing radiation; and strengthens MACOM and installation radiation safety authority.

Applicability. This regulation applies to the Active Army, the Army National Guard of the United States, the Army Reserve, and Army contractors. This regulation does not apply to nuclear weapons (AR 50-5).

Proponent and exception authority. The proponent of this Army regulation is the Director of the Army Staff (DAS). The DAS has the authority to approve exceptions to this regulation that are consistent with controlling law and regulation. The DAS may delegate this authority, in writing, to a division chief within the proponent agency in the grade of colonel or civilian equivalent.

Army management control process. This regulation contains management control provisions and identifies key management controls that must be evaluated.

Supplementation. Supplementation of this regulation is prohibited without prior approval from HQDA (DACS-SF), WASH DC 20310-0200.

Suggested improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to HQDA (DACS-SF), WASH DC 20310-0200.

Distribution. This publication is available in electronic media only and is intended for command level C for Active Army and D for Army National Guard of the United States.

*This regulation supersedes AR 40-14, 30 June 1995; AR 40-46, 15 November 1974; AR 385-9, 1 April 1982; and AR 385-11, dated 1 May 1980

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Chapter 1
Introduction

1-1. Purpose
This regulation establishes policies and procedures for the use of, licensing, disposal, transportation, safety design, and inventory control of ionizing and nonionizing radiation sources. It also provides radiation exposure standards and dosimetry and accident reporting instructions. Its objective is to assure safe use of radiation sources and compliance with all applicable Federal and DOD rules and regulations.

1-2. References
Required and related publications are listed in appendix A.

1-3. Explanation of terms
Abbreviations and special terms used in this regulation are explained in the glossary.

1-4. Responsibilities
a. The Assistant Secretary of the Army (Installations and Environment) (ASA(I&E)) establishes overall Army environment, safety, and occupational health policy and maintains general oversight of and serves as advocate for the Army Radiation Safety Program.

b. The Assistant Secretary of the Army (Manpower and Reserve Affairs) establishes overall Army health and preventive medicine policy and maintains oversight of medical and health aspects of the Army Radiation Safety Program.

c. The Director of Army Safety (DASAF), Office of the Chief of Staff, Army, will-

(1) Provide Army Staff oversight of the Army Radiation Safety Program.

(2) Administer, direct, and integrate Army Force Protection risk management (AR 385-10).

(3) Chair the Army Radiation Safety Council (ARSC).

(4) In coordination with the ASA (I&E), designate, in writing, a qualified nuclear medical science officer (SSI 72A67C) colonel to serve as Army Radiation Safety Officer (Army RSO).

d. The Commanding General, Army Materiel Command (AMC) will—

(1) Control NRC (Nuclear Regulatory Commission) licenses and Army radiation authorizations for Army radioactive commodities.

(2) Provide ionizing radiation dosimetry services (at the Army Ionizing Radiation Dosimetry Center (AIRDC)) that meet the requirements of 10 CFR 20.1501(c). The Chief, AIRDC, will—

(a) Publish instructions for starting, maintaining, and ending personnel dosimetry services (SB 11-206).

(b) Maintain the Army's Central Dosimetry Records Repository (CDRR). The CDRR will archive comprehensive dosimetry records for all Army personnel and for other personnel who use Army dosimetry services. Records will meet the requirements of 10 CFR 20.2106 and 20.2110. Records will include results of bioassays, administrative dose assignments (including copies of documents that make the assignments), and supplementary occupational dose equivalent information (for example, dosimetry information resulting from off-duty employment, "moonlighting") that any radiation safety officer (RSO) reports. In particular, the AIRDC will meet the requirements of 10 CFR 20.2106(f) for long-term retention of these records.

(c) Provide quarterly personnel dosimetry reports (automated dosimetry record (ADR)) to RSOs for all personnel who received dosimetry services during the previous calendar quarter. These reports will enable supported RSOs to meet all recordkeeping requirements in 10 CFR 20.2106.

(3) Survey each installation and each NRC license, Army reactor permit, or Army radiation authorization (ARA) holder at least once every three years for compliance with applicable radiation safety and health regulations and guidance (AR 40-5).

(4) Establish appropriate occupational health surveillance for personnel occupationally exposed to radiation (AR 40-5).

(5) Perform health hazards assessments (HHAs) of commodities and systems that emit radiation or contain RAM as early as practical in development and before fielding (AR 40-10).

(6) Provide radiation bioassay services (AR 40-5) that comply with criteria of the American National Standards Institute (ANSI) (see ANSI N13.30). Such services are available from the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM) on a cost-reimbursable basis.

(7) Provide medical support for investigations of alleged excessive radiation exposures (DODI 6055.11 and DA PAM 40-18).

h. The Assistant Chief of Staff for Installation Management (ACSIM) will provide oversight for all radioactive contamination surveys conducted in support of base closure or installation restoration activities.

i. Each MACOM commanding general will—

(1) Assure installation and subordinate command compliance with conditions of AMC-held radioactive commodity NRC licenses and ARAs. (See para 2-1b.)

(2) Designate, in writing, a person to be the MACOM RSSO.

(3) Issue ARAs as necessary (para 2-3).

(4) As necessary, establish and employ procedures to assure that captured, purchased, borrowed, or otherwise obtained foreign equipment and materiel are surveyed for RAM and that appropriate actions are taken following discovery of any RAM in those items.

(5) Concerning the MACOM radiation safety program:

(a) Establish review and approval procedures for conducting risk management in accordance with established doctrine (DODI 6055.1).

(b) Maintain a central register of risk decisions regarding deviations from the Army standards of this regulation and DA PAM 40-18 within the command.

(c) Assure that the complete risk management process is executed before the conduct of all operations.

(6) Report excess military-exempt lasers to the Defense Reutilization and Marketing Service for utilization screening within DOD (DOD 4160.21-M-1). (See para 3-2c.)

(a) Maintain accountability during the screening period.

(b) Losing and gaining organizations will transfer excess directly between themselves.

(c) After utilization screening is completed, identify supply system requirements for usable parts. Return required parts to the supply system.

j. Each installation commander—

(1) Will designate, in writing, a qualified individual to be Installation RSO.

(2) May establish an Installation Radiation Safety Committee (RSC). (See para 1-6.)

(3) Will prepare and maintain historical records of location of use or storage of RAM on the installation and the responsible activity for that use or storage (para 2-5).

(4) Will maintain documentation listing locations categorized as "RF controlled" and "RF uncontrolled" environments as necessary (DODI 6055.11).

(5) Issue Army radiation permits as necessary (para 2-4).

k. Each commander will—

(1) Designate, in writing, a person to be the RSO when any of the following is true.

(4) Provide radiation safety consultation to the MACOM commanding general and staff and to subordinate commanders and staffs.

(5) Serve as MACOM radiation safety point-of-contact.

n. Each Installation RSO will—

(1) Direct the installation radiation safety program.

(2) Assist TOE (Table of Organization and Equipment) units on the installation to meet requirements of NRC licenses and ARAs for radioactive commodities. In particular, the installation RSO will—

(a) Assure that TOE unit personnel receive appropriate radiation safety training as necessary.

(b) Meet all reporting requirements for accidents or incidents (para 6-2).

(c) Assure appropriate inventory control per applicable technical publications and logistics regulations.

(3) Notify the AMC RSSO when a building or area that currently or formerly contained radioactive commodities is scheduled for demolition or will no longer contain radioactive commodities. This is to provide AMC radioactive commodity license holders appropriate notice so that they can take decommissioning actions as necessary.

o. Each RSO (or LSO), including the installation RSO, will—

(1) Perform or be responsible for the performance of all radiation safety functions that applicable Federal, DOD, and Army regulations and NRC license, Army reactor permit, and ARA conditions require.

(2) Establish plans and procedures for handling credible emergencies involving radiation and radioactive materials. This includes coordination with civilian and military emergency response organizations as necessary.

(3) Coordinate with supporting medical personnel to help assure that personnel receive appropriate occupational health surveillance (AR 40-5).

(4) For an RSO with laser safety responsibilities, assume the responsibilities of an LSO as listed in section 1.3.2, ANSI Z136.1, except for occupational health responsibilities. (The RSO or LSO will assist the occupational health physician as necessary in meeting laser occupational health responsibilities.)

1-5. Army Radiation Safety Council

a. The ARSC is the Chief of Staff, Army's advisory body to provide recommendations for Army radiation safety directives and to gather and disseminate information about the status of the Army radiation safety program.

b. Membership includes the DASAF as chair (para 1-4c(3)), the Army RSO as recorder, the Radiological Hygiene Consultant to TSG, a representative of the ACSIM (Assistant Chief of Staff for Installation Management), a representative of the Army Reactor Office (AR 50-7), and the RSSO from each MACOM, the National Guard Bureau, and the Office, Chief Army Reserve.

c. The ARSC will meet at least once each 6 month period and at the call of the chair.

1-6. Installation Radiation Safety Committee

a. The installation RSC is the installation commander's advisory body to gather and disseminate information about the status of the installation radiation safety program.

b. Membership includes a chair that the commander designates, the installation RSO (recorder), and all tenant RSOs. Installations with large numbers of TOE unit personnel that use radioactive commodities will include military representatives knowledgeable about the TOE units' radiation safety programs.

c. Each installation RSC will meet at least once each calendar year and at the call of the chair.

f. Forward requests through command channels to HQDA (DACS-SF), WASH DC 20310-0200, for waivers and exceptions to Federal or DOD radiation safety regulations. Prior approval from HQDA (DACS-SF), WASH DC 20310-0200, is required before such requests are sent to a Federal agency or to DOD. Prior approval of TSG is also required before requests for waivers or exceptions to Federal or DOD personnel radiation exposure standards are sent to a Federal agency or to DOD.

Chapter 2
Ionizing Radiation Sources

2-1. General

a. Materiel. AR 70-1 applies to developmental and non-developmental materiel containing radiation sources.

b. Compliance with NRC regulations and NRC license, Army reactor permit, and ARA conditions.

(1) All Army personnel using RAM will comply with all applicable NRC regulations and conditions of NRC licenses, Army reactor permits, and ARAs held by their own or by another command (paras 2-2a(2) and 2-3b(2)).

(2) Holders of NRC licenses, Army reactor permits, and ARAs will assure that all personnel using RAM are aware of applicable regulations and conditions as appropriate.

c. Shielding and control designs. A qualified expert will design, review, and test shielding of and controls for access to radiation areas, high radiation areas, and very high radiation areas. Perform these procedures per applicable regulations and guidelines before routinely using radiation sources within the area. Each design for high radiation and very high radiation areas will receive an additional independent review by a qualified expert that the MACOM RSSO designates.

d. Environmental requirements. See 10 CFR 51, 40 CFR, AR 200-1, and AR 200-2 for RAM environmental requirements.

2-2. Nuclear Regulatory Commission licenses

The NRC licenses special, source, and byproduct material in the U.S. and its possessions.

a. Send applications for new licenses, license renewals, and license amendments through command channels to the MACOM headquarters for forwarding to the NRC.

(1) The MACOM commanding general may allow subordinate commanders to forward applications directly to the NRC without MACOM review.

(2) When compliance with conditions proposed in the application requires efforts of personnel of another command, obtain a letter of agreement from an authorized representative of that command (paras 1-4l(5) and 2-1b).

(3) The applicant or MACOM RSSO will provide a copy of all correspondence relating to applications to Commander, CHPPM, Aberdeen Proving Ground, MD 21010-5422.

(4) Tenant commanders will provide a copy of each NRC license, including all amendments, to the installation commander.

b. Except as specified in paragraphs 1-9f and 2-2a, all Army personnel may communicate directly with the NRC without restriction. However, a person considering such communication should also consider whether information to be requested is obtainable from Army sources and whether information provided or obtained is of interest to the chain of command or other Army organizations.

2-3. Army radiation authorizations

a. The Army uses ARAs to control specific Army ionizing radiation sources (including machines that emit ionizing radiation) that the NRC does not license. An ARA is required for all such sources except

b. The ARP application will specify start and stop dates for the ARP and describe for what purposes the applicant needs the ARP. The installation commander will approve the application only if the applicant provides evidence to show that one of the following is true.

(1) The applicant possesses a valid NRC license or Department of Energy (DOE) radiological work permit that allows the applicant to use the source as specified in the ARP application.

(2) The applicant possesses a valid Agreement State license that allows the applicant to use RAM as specified in the ARP application, and the applicant has filed NRC Form-241, Report of Proposed Activities in Non-Agreement States, with the NRC in accordance with 10 CFR 150.20. An ARP issued under this circumstance will be valid for no more than 180 days in any calendar year.

(3) For NARM and machine-produced ionizing radiation sources, the applicant has an appropriate State authorization that allows the applicant to use the source as specified in the ARP application or has in place a radiation safety program that complies with Army regulations.

(4) For overseas installations, the applicant has an appropriate host-nation authorization as necessary that allows the applicant to use the source as specified in the ARP application and has in place a radiation safety program that complies with Army regulations. (Applicants will comply with applicable status-of-forces agreements [SOFAs] and other international agreements.)

c. All ARPs will require applicants to remove all permitted sources from Army property by the end of the permitted time.

d. Disposal of RAM by non-Army agencies on Army property is prohibited. However, the installation commander may authorize radioactive releases to the atmosphere or to the sanitary sewerage system that are in compliance with all applicable Federal, DOD, and Army regulations. (The installation commander also will give appropriate consideration to State or local restrictions on such releases.)

e. A sample ARP is in figure 2-2.

2-5. Decommissioning records

a. Holders of NRC licenses will establish and maintain decommissioning records in accordance with 10 CFR 30.35(g), 40.36(f), and 70.25(g), as applicable.

b. Holders of ARAs will establish and maintain decommissioning records similar to those that the NRC requires.

c. Holders of NRC licenses and ARAs will provide information about the location of use and storage of RAM to the installation commander for the installation RAM history records (para 1-4j(3)).

2-6. Transfer and transport

a. Transfer radioactive material only to persons authorized to receive and possess it.

(1) The holder of the commodity license or ARA will in accordance with technical publications and applicable instructions establish transfer of Army radioactive commodities.

(2) For all other RAM, the shipper will obtain and retain appropriate evidence (for example, a copy of the recipient's ARA or NRC or Agreement State license) before shipping the RAM.

b. Domestic shipments of RAM will be in accordance with applicable NRC (10 CFR 71), Department of Transportation (DOT) (49 CFR), and U.S. Postal Service (39 CFR) regulations and per DOD 4500.9-R (Part II). International shipments of RAM will be per applicable U.S. and International Atomic Energy Agency (IAEA) transportation regulations.

c. Do not transfer radium and items containing radium to non-DOD agencies or activities (except for disposal as radioactive waste).

DEPARTMENT OF THE ARMY

HQ, MACOM

CITY, STATE, AND ZIP CODE

REPLY TO ATTENTION OF

XXXX-XX (11-XXm) 15 January 2000

MEMORANDUM FOR Commander, U.S. Army Activity, Installation, City, State XXXXX-XXXX

SUBJECT: Army Radiation Authorization (ARA) No. XXX-XX

1. Reference memorandum, HQ, U.S. Army Activity, XXXX-XX-X, 15 November 1999, subject: Application for Renewal of Army Radiation Authorization No. XXX-XX, and enclosures thereto.

2. In accordance with referenced memorandum ARA No. XXX-XX is amended in its entirety to read as follows:

a. Expiration date: 31 January 2002.

b. Description of machine-produced ionizing radiation source and of radioactive material, its chemical and/or physical form, and maximum amount at any one time authorized under this ARA: See enclosure.

c. Authorized use: See enclosure.

d. Radiation Safety Officer: CPT Dan Hamilton.

e. Conditions: See enclosure.

3. Except as specifically provided otherwise in this ARA, conduct your program in accordance with the statements, representations, and procedures in the documents, including any enclosures, listed: referenced memorandum.

4. Our point of contact is Mr. John A. Manfre, MACOM Radiation Safety Staff Officer, DSN XXX-XXXX.

FOR THE COMMANDER:

Encl RUPERT K. THORNE

as LTC, GS

Adjutant

Figure 2-1. Sample Army radiation authorization

Chapter 3
Lasers

3-1. General

a. The design of Army laser safety programs will follow applicable guidelines in ANSI Z136.1 and ANSI Z136.3. Military-exempt laser users will comply with laser safety requirements in applicable technical publications.

b. Army laser range safety guidance is in AR 385-63 and MIL-HBK 828.

c. Use a type-classified or commercial class IIIb or class IV laser on an Army range only if the DOD Laser Systems Safety Working Group or CHPPM has performed a prior laser hazard evaluation for that specific kind of laser.

(1) A list of approved lasers is in MIL-HDBK-828. Send requests for approval of an unlisted laser through command channels to Commander, CHPPM, ATTN: MCHB-DC-OLO, Aberdeen Proving Ground, MD 21010-5422.

(2) Use an unlisted class IIIb and class IV laser on an Army range for RDTE purposes only. Users of such lasers will comply with paragraph a.

d. Only a qualified expert will design, review, and test controls for access to a class IIIb or IV laser facility. Meet this requirement in accordance with applicable directives before routinely using class IIIb or IV lasers within such a facility. A qualified expert will design or review for adequacy all radiation safety SOPs (standing operating procedures) for each such facility.

e. Use only class I, class II, and class IIIa lasers indoors on Army installations as hand-held laser pointing devices. Do not use class IIIb or class IV lasers for such purposes.

3-2. Military-exempt lasers

a. Although exempt, military-exempt lasers will meet as many of the laser safety standards in 21 CFR 1040 as practical.

b. Proponents of military-exempt lasers will include laser safety requirements in technical publications about siting, operation, and maintenance of these lasers and laser systems.

c. Dispose of unwanted military-exempt lasers in accordance with DOD 4160.21-M-1. Do not dispose of potentially usable lasers or laser parts through utilization outside DOD, donation, or sale without the prior approval of the Deputy Undersecretary of Defense (Environmental Security) or designee. Send requests for such disposition through supply channels to the commanding general of the appropriate materiel readiness command.

d. Military-exempt lasers will not include lasers intended primarily for indoor classroom training and demonstration, industrial operations, scientific investigations, or medical applications.

e. Commanding General, USACHPPM, will maintain records for all military-exempt lasers that indicate types of laser products and manufacturers.

Chapter 4
Radiofrequency electromagnetic radiation

4-1. General

a. The Army will comply with RF (radiofrequency) radiation safety program elements in DODI 6055.11. Type-classified RF EMR (electromagnetic radiation) emitting system users will comply with radiation safety requirements in applicable technical publications.

b. Adopt no practice and conduct no operation involving planned exposure of personnel to RF levels in excess of the applicable maximum permissible exposures in DODI 6055.11.

c. Do not use radiofrequency protective clothing for routine use to protect personnel. Protective equipment, such as electrically insulated gloves and shoes for protection against RF shock and burn or for insulation from the ground plane is permissible where necessary for compliance with induced current limits in DODI 6055.11.

(2) Personnel at Army government-owned contractor-operated (GOCO) facilities and contractor personnel who are working in Army facilities and require dosimetry will use AIRDC-supplied dosimeters unless a written contract specifically exempts them. (Non-GOCO contractor personnel working under provisions of an ARP may use contractor-supplied dosimetry.)

(3) AIRDC dosimeters may be used to monitor the exposure of other personnel and for area monitoring. Evaluate requirements for continued use of AIRDC dosimetry for such purposes periodically (at least annually).

(4) DA PAM 40-18 contains instructions for wearing supplemental dosimeters.

c. Bioassay.

(1) Monitor occupational intake of RAM and, as necessary, assess the committed effective dose equivalent (CEDE) for:

(a) Adults likely to receive, in 1 year, an intake in excess of 10 percent of applicable annual limits of intake (ALI). The ALIs for NRC-licensed RAM are in table 1, columns 1 and 2, 10 CFR 20, appendix B. The Surgeon General will provide, as necessary, ALIs and related air and water concentrations for radioisotopes used under ARA authority and not listed in 10 CFR 20, appendix B to the Army RSO for promulgation.

(b) Minors and declared pregnant women likely to receive, in 1 year, a CEDE in excess of 0.05 rem (0.5 mSv).

(2) Intake of RAM may be monitored and the CEDE assessed for other individuals. Evaluate the requirement for continued intake monitoring periodically (at least annually).

(3) All Government- and contractor-provided bioassay will be in accordance with procedures in ANSI N13.30.

d. Dosimetry and bioassay records.

(1) All personnel will complete DD Form 1952, Dosimeter Application and Record of Occupational Radiation Exposure, before receiving AIRDC dosimetry or participating in a routine bioassay program.

(2) The RSO will provide a copy of determinations of administrative doses (para e), determinations of non-Army occupational dose histories (obtained from somewhere other than AIRDC), bioassay results, and results of assessing CEDE by bioassay or by determination of the time-weighted air concentrations to which an individual has been exposed [that is, derived air concentration (DAC)-hours] to the AIRDC for archiving.

(3) The RSO will provide a copy of each DD Form 1952 and calendar year ADR for routinely monitored personnel to the supporting medical treatment facility or occupational health clinic (AR 40-66). (Examples: A visitor monitored only during a short-term visit of a few days is not routinely monitored. A student or intern monitored over a period of a few months is routinely monitored.)

e. Administrative doses.

(1) Only TSG may approve assigning an administrative dose in place of any AIRDC-recorded occupational dose equivalent that exceeds a value in table 5-1.

(2) RSOs will estimate TEDE (total effective dose equivalent) or CEDE when they cannot determine it from dosimetry or bioassay (for example, if a dosimeter was lost, damaged, or believed to be deliberately exposed). The estimate of the administrative dose may be based on any of the following.

(a) Occupancy or workload information and radiation dose levels at the radiation source operator location.

(b) Data supplied by a supplemental dosimeter.

(c) Average of the individual's previous occupational dose for the preceding 6 to 12 months if conditions prevailed similar to those during the period for which the dose is being estimated.

1. From 10 CFR 20. Refer to 10 CFR 20 for detailed standards.
2. Abbreviations: TEDE = total effective dose equivalent; DDE = deep dose equivalent; ED = effective dose; EDE = effective dose equivalent; CDE = committed dose equivalent; SDE = shallow dose equivalent.
3. OSHA standard for occupational exposure of adults and for the lens of the eye is 1¼ rem in calendar quarter. OSHA standard for skin of whole body is 7½ rem in calendar quarter. OSHA standard for hands and forearms; feet and ankles is 18¾ rem in calendar quarter.
4. The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with applicable regulations, will not exceed 2 mrem (0.02 mSv) in any one hour.

Table 5—3.
Electromagnetic Radiation.

REGION	*WAVELENGTH*	*FREQUENCY*	*AUTHORITY*
Ionizing (gamma and x rays)	< 100 nm	> 3 PHz (E > 12.4 eV)	NRC and OSHA
Ultraviolet (UV)	100 to 380-400 nm	0.75-0.79 to 3 PHz	ACGIH
Visible (light)	380-400 to 760-780 nm	380-390 to 750-790 THz	ACGIH
Infrared (IR)	760-780 nm to 1 mm	300 GHz to 380-390 THz	ACGIH
Radiofrequency	1 mm to 100 km	3 kHz to 300 GHz	DOD
Extremely low frequency	> 100 km	< 3 kHz	ACGIH
Static electric fields	NA	NA	ACGIH
Static magnetic fields	NA	NA	ICNIRP

Notes.
1. Unit abbreviations: nm = nanometer (10^{-9} m); mm = millimeter (10^{-3} m); km = kilometer (10^{3} m); PHz = petahertz (10^{15} Hz); THz = terahertz (10^{12} Hz); GHz = gigahertz (10^{9} Hz); kHz = kilohertz (10^{3} Hz); and eV = electron volt (1 eV = 1.6 □10 $^{-19}$ J).
2. Wavelength x frequency = speed of light = 3 x 10^{8} m s^{-1}.
3. Authority = The regulating authority for personnel exposure for the purposes of this regulation (para 5-4).

Chapter 6
Special reporting requirements

6-1. General

a. Reporting requirements of AR 40-5, AR 385-40, and DA PAM 40-18 apply for radiation accidents, incidents, and over-exposures. Additional requirements are in paras b and 6-2.

b. IMMEDIATELY EVACUATE PERSONNEL SUSPECTED OF EXPERIENCING POTENTIALLY DAMAGING EYE EXPOSURE FROM LASER RADIATION TO THE NEAREST MEDICAL FACILITY FOR AN EYE EXAMINATION (See FM 8-50). LASER EYE INJURIES REQUIRE IMMEDIATE SPECIALIZED OPHTHALMOLOGIC CARE TO MINIMIZE LONG-TERM VISUAL ACUITY LOSS. MEDICAL PERSONNEL SHOULD OBTAIN MEDICAL GUIDANCE FOR SUCH EMERGENCIES FROM THE WALTER REED ARMY INSTITUTE OF RESEARCH DETACHMENT AT BROOKS AFB (Commercial [800] 473-3549).

c. Notify the installation or activity public affairs officer at the onset of the accident or incident in order to activate public affairs contingency measures (AR 360-5). Radiation accidents or incidents attract the attention of local and national media quickly. Early disclosure of accurate information is vital to maintaining the confidence of both the internal and external public.

6-2. Ionizing radiation

Federal reporting requirements for accidents, incidents, and over-exposures are in 10 CFR 20, subpart M and in 29 CFR 1910.1096(m) and 1926.53(o).

a. Send information copies of all reports required by 10 CFR 20.2201 through 20.2205, 29 CFR 1910.1096(m), or 29 CFR 1926.53(o) and of any other accident or incident report to the NRC or OSHA through command channels to HQDA (DACS-SF), WASH DC 20310-0200.

b. Reports through command channels will meet the same time requirements, as do required reports to the NRC and OSHA. For example, if the NRC requires immediate telephonic notification, follow it with immediate telephonic notification through the chain of command to HQDA (DACS-SF), WASH DC 20310-0200.

DA PAM 40-18
Personnel Dosimetry Guidance and Dose Recording Procedures for Personnel Occupationally Exposed to Ionizing Radiation. (Cited in paras 1-4g(7), 1-4i(5)(b), 5-2b(4), and 6-1a.)

DOD 4160.21-M-1
Defense Demilitarization Manual. (Cited in para 3-2c.)

DOD 4500.9-R (Part II)
Defense Transportation Regulation - Cargo Movement. (Cited in para 2-6b.)

DODI 6055.1
DOD Occupational Safety and Health Program (Cited in para 1-4i(5)(a).)

DODI 6055.11
Protection of DOD Personnel from Exposure to Radiofrequency Radiation and Military Exempt Lasers. (Cited in paras 4-1a through c, 1-4g(7), 1-4j(4), and 5-4c.)

FM 8-50
Prevention and Medical Management of Laser Injuries. (Cited in para 6-1b.)

FM 25-101
Battle Focused Training. (Cited in para 1-8f.)

FM 101-5
Staff Organization and Operations. (Cited in paras 1-8f and 1-9c.)

IEEE C95.3
Institute of Electrical and Electronics Engineers, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields RF and Microwave. (Cited in para 4-2.) (This publication may be obtained from the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th St., New York, NY 10017.)

MIL-HDBK-828
Laser Range Safety. (Cited in paras 3-1b and 3-1c(1).) (This publication may be obtained from the Standardization Documents Order Desk, Building 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094.)

SB 11-206
Personnel Dosimetry Supply and Service for Technical Ionizing Radiation Exposure Control. (Cited in para 1-4d(2)(a).)

TB 750-43
Army Test, Measurement, and Diagnostic Equipment (TMDE) Calibration and Repair Support Program. (Cited in paras 1-4d(4) and 2-8.)

Title 10, CFR, Chapter I
Nuclear Regulatory Commission. (Cited in paras 1-4d(2), 1-4d(2)(b) through (e); 2-1d; 2-3a(1) and (4); 2-3c(2); 2-4b(2); 2-5a; 5-2a(1), c(1)(a), and f; 6-2; and 6-2a.)

Title 21, CFR, Subchapter J
Radiological Health. (Cited in paras 3-2a.)

Title 29, CFR, Part 1910
Occupational Safety and Health Standards. (Cited in paras 1-4d(2)(d), 5-2a(2) and f, 6-2, and 6-2a.)

Title 32, CFR, Part 655
Radiation Sources on Army Land. (Cited in para 2-4.)

Title 39, CFR
U.S. Postal Service. (Cited in para 2-6b.)

Title 40, CFR
Environmental Protection Agency. (Cited in para 2-1d.)

DODI 6055.8
Occupational Radiation Protection Program

IEEE C95.1
Institute of Electrical and Electronics Engineers, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz (This publication may be obtained from the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th St., New York, NY 10017.)

NBS Handbook 107
Radiological Safety in the Design and Operation of Particle Accelerators (The National Bureau of Standards is now known as the National Institute of Standards and Technology) (This publication may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, or from the National Technical Information Service, 5258 Port Royal Rd., Springfield, VA 22161.)

NBS Handbook 111
Radiation Safety for x-ray Diffraction and Fluorescence Analysis Equipment (This publication may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, or from the National Technical Information Service, 5258 Port Royal Rd., Springfield, VA 22161.)

NBS Handbook 114
General Safety Standards for Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV (This publication may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, or from the National Technical Information Service, 5258 Port Royal Rd., Springfield, VA 22161.)

NCRP Reports
Approximately 100 numbered reports on a variety of radiation safety topics (These publications may be obtained from the National Council on Radiation Protection and Measurements, 7910 Woodmont Ave., Suite 1016, Bethesda, MD 20814.)

NRC Regulatory Guide 8.13
Instruction Concerning Prenatal Radiation Exposure (This publication may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, or from the National Technical Information Service, 5258 Port Royal Rd., Springfield, VA 22161.)

NRC Regulatory Guide 8.29
Instruction Concerning Risks from Occupational Radiation Exposure (This publication may be obtained from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, or from the National Technical Information Service, 5258 Port Royal Rd., Springfield, VA 22161.)

TB 43-0116
Identification of Radioactive Items in the Army

TB 43-0121
Inspection and Certification of RADIAC Meters (Dosimeters)

TB 43-0122
Instructions for the Safe Handling and Identification of U.S. Army Communications-Electronics Command-Managed Radioactive Items in the Army Inventory

TB 43-0216
Safety and Hazard Warnings for Operation and Maintenance of TACOM Equipment

TB 43-0133
Hazard Criteria for CECOM Radiofrequency and Optical Radiation Producing Equipment

TB 43-0137
Transportation Information for CECOM Radioactive Commodities (Use this bulletin for general guidance only; refer to 10 CFR 71 and 49 CFR for current NRC and DOT regulations.)

Appendix B
Sample application for Army Radiation Authorization (DA Form 3337)

APPLICATION FOR ARMY RADIATION AUTHORIZATION

For use of this form, see AR 11-9; the proponent agency is DAS

1. THIS IS AN APPLICATION FOR *(Check appropriate item)* ☐ NEW ARA ☐ AMENDMENT TO ARA NUMBER ________ ☐ RENEWAL OF ARA NUMBER	2. NAME, MAILING ADDRESS, AND E-MAIL ADDRESS OF APPLICANT *(Include ZIP Code)*
3. ADDRESS(ES) WHERE AUTHORIZED IONIZING RADIATION SOURCE(S) WILL BE USED OR POSSESSED	
4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION	5. TELEPHONE NUMBER AND FAX NUMBER

Items 6 through 12 may be continued on the following page or on 8 1/2 x 11 paper. The type and scope of information to be provided should be adequate to show complete compliance with applicable regulations and guidance. *(If you are ask use of radioactive material to a valid Nuclear Regulatory Commission (NRC) license, provide number and expiration date of the license and only supplements that differ from the NRC license application and associated documents.)*

6. RADIATION SOURCE(S)

a. RADIOACTIVE MATERIAL *(Element and mass number, chemical and/or physical form, and maximum amount that you will possess at any one time.)*	b. ACCELERATOR(S) AND X-RAY SYSTEM(S) CAPABLE OF PRODUCING HIGH RADIATION AREA OR VERY HIGH RADIATION AREA *(Describe)*
7. PURPOSE(S) FOR WHICH IONIZING RADIATION SOURCE(S) WILL BE USED	8. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE
9. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS	10. FACILITIES AND EQUIPMENT *(Describe rooms or areas, shielding, safety devices, monitoring equipment, and so on.)*
11. RADIATION SAFETY PROGRAM	12. WASTE MANAGEMENT

13. CERTIFICATION

The applicant understands that all statements and representations made in this application are binding upon the applicant. The applicant and any official executing this certification on behalf of the applicant named in Item 2, certify that all information contained in this application is true and correct to the best of their knowledge and belief.

14. NAME, RANK, AND TITLE OF CERTIFYING OFFICER	15. SIGNATURE
	16. DATE (YYYYMMDD)

SAMPLE

DA FORM 3337, MAY 1999 — DA FORM 3337, MAR 80 IS OBSOLETE — USAPA V1.00

Appendix C
Management Control Evaluation Checklist

C-1. Function
The function covered by this checklist is radiation safety.

C-2. Purpose
The purpose of this checklist is to assist commanders and radiation safety officers in evaluating the key management controls listed below. It is not intended to cover all controls.

C-3. Instructions
Answers must be based on the actual testing of key management controls (for example, document analysis, direct observation, sampling, simulation, other). Answers that indicate deficiencies must be explained and corrective action indicated in supporting documentation. These management controls must be evaluated at least once every five years. Certification that this evaluation has been conducted must be accomplished on DA Form 11-2-R (Management Control Evaluation Certification Statement).

C-4. Test questions
a. If required (para 1-4k(1)), has a person been designated to be radiation safety officer?

b. If required (para 1-4k(2)), has a written radiation safety SOP been established?

c. Are all personnel occupationally exposed to radiation receiving appropriate radiation safety training?

d. Are all radiation sources secured against unauthorized use and removal?

e. If the unit possesses radioactive commodities, has a written SOP been established to assure compliance with radiation safety requirements of applicable technical publications?

f. Are all controllable quantities of radioactive material and radiation-producing sources held by the unit under appropriate authority (for example, a Nuclear Regulatory Commission license, an Army radiation authorization, or as part of a radioactive commodity)?

g. Is all radioactive waste disposed of properly?

h. Are all radiation survey instruments used for health and safety appropriately calibrated?

i. For Army laser ranges have all type-classified or commercial class IIIb or class IV lasers received appropriate evaluation before their use?

j. Are all unwanted military-exempt lasers disposed of properly?

k. Are all accidents and incidents involving excessive personnel radiation exposure or excessive radioactive contamination of facilities, equipment, or the environment promptly reported through appropriate channels?

l. Do all personnel occupationally exposed to ionizing radiation or radioactive material above applicable levels (paras 5-2b(1) and c(1)) participate in an appropriate dosimetry or bioassay program?

m. Is the dose in all unrestricted areas less than 2 millirems (0.02 millisieverts) in any one hour?

C-5. Supersession
This is a new checklist.

C-6. Comments
Help make this a better tool for evaluating management controls. Submit comments to HQDA (DACS-SF), WASH DC 20310-0200.

CHPPM
U.S. Army Center for Health Promotion and Preventive Medicine

cm
centimeter

DA
Department of the Army

DAC
derived air concentration

DASAF
Director of Army Safety

DOD
Department of Defense

DODI
Department of Defense Instruction

DOE
Department of Energy

dpm
disintegrations per minute

DOT
Department of Transportation

DSN
Defense Switching Network

EMR
electromagnetic radiation

EPA
U.S. Environmental Protection Agency

eV
electron volt

FY
fiscal year

GHz
gigahertz

GOCO
Government-owned contractor-operated

Gy
gray

h
hour

HHA
health hazard assessment

HQDA
Headquarters, Department of the Army

Hz
hertz

NBS
National Bureau of Standards (now named the National Institute of Standards and Technology)

NCRP
National Council on Radiation Protection and Measurements

NGB
National Guard Bureau

NIST
National Institute of Standards and Technology

nm
nanometer

NORM
naturally occurring radioactive material

NRC
U.S. Nuclear Regulatory Commission

NSN
National stock number

NVLAP
National Voluntary Laboratory Accreditation Program

OSHA
Occupational Safety and Health Administration

PHz
petahertz

RAM
radioactive material

RDTE
research, development, testing, and evaluation

RF
radiofrequency

RSC
radiation safety committee

RSO
radiation safety officer

RSSO
radiation safety staff officer

SB
supply bulletin

SI
Systemé Internationale (International System)

SOFA
status of forces agreement

SOP
standing operating procedure

SSI
specialty skill identifier

ALARA
Acronym for "as low as is reasonably achievable" means making every reasonable effort to maintain exposures to radiation as far below applicable dose limits as is practical consistent with the purpose for which the activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations and in relation to utilization of nuclear energy, radioactive materials, and ionizing radiation in the public interest.

Annual limit of intake (ALI)
The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any organ or tissue.

Army regulation
A directive that sets forth missions, responsibilities, and policies, and establishes procedures to ensure uniform compliance with those policies.

Army Reserve facilities
Pertains to those facilities normally employed for the administration and training of Army Reserve units, in any entire structure or part thereof, including any interest in land, Army Reserve Center, and storage and other use areas.

Background radiation
Radiation from cosmic sources; naturally occurring radioactive material, including radon (except as a decay product of source or special nuclear material); and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation. Background radiation does not include radiation from source, byproduct, or special nuclear materials that the NRC regulates or from NARM that the Army regulates.

Becquerel (Bq)
The SI unit of radioactivity equivalent to one nuclear transformation per second.

Bioassay (radiobioassay)
The determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (*in vivo* counting) or by analysis and evaluation of materials excreted or removed from the human body (*in vitro* counting).

Byproduct material
Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Committed dose equivalent
The dose equivalent to organs or tissue of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed effective dose equivalent
The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Commodity, radioactive
See Radioactive commodity

Condition
The status of personnel and equipment (readiness) as they interact with the operational environment during mission planning and execution.

Control
Action taken to eliminate hazards or reduce their risk.

Curie (Ci)
A unit of radioactivity equal to 37 billion becquerels.

Gray (Gy)
The SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule/kilogram (100 rads).

Hazard
Any real or potential condition that can cause injury, illness, death of personnel, damage to or loss of equipment or property, or mission degradation.

Hertz (Hz)
The SI unit of frequency equivalent to one vibration (cycle) per second.

High radiation area
An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Infrared (IR) electromagnetic radiation
Electromagnetic radiation with a wavelength between 760-780 nm and 1 mm.

Installation
A grouping of facilities located in the same vicinity, which support particular functions. Installations may be elements of a base. Land and improvements permanently affixed thereto which are under the control of the Department of the Army and used by Army organizations. Where installations are located contiguously, the combined property is designated as one installation and the separate functions are designated as activities of that installation. In addition to those used primarily by troops, the term installation applies to real properties such as depots, arsenals, ammunition plants (both contractor and Government operated), hospitals, terminals, and other special mission installations. For the purposes of this regulation, United States Army Regional Support Commands are installations.

Ionizing radiation
Charged subatomic particles and ionized atoms with kinetic energies greater than 12.4 eV, electromagnetic radiation with photon energies greater than 12.4 eV, and all free neutrons and other uncharged subatomic particles (except neutrinos and antineutrinos).

Kilo- (k)
An SI unit prefix indicating a factor of 1000.

Laser
A device that produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for light amplification by stimulated emission of radiation. Lasers are classified by degree of potential hazard (see 21 CFR 1040.10 and ANSI Z136.1 for comprehensive definitions of laser hazard classes).

a. Class I lasers emit at levels that are not hazardous under any viewing or maintenance conditions. They are exempt from control measures. (However, as a matter of good safety practice avoid intrabeam viewing in case the laser is mislabeled.)

b. Class II lasers (low-power) emit in the visible light portion of the electromagnetic spectrum. They are a potential eye hazard only for prolonged intrabeam viewing. Eye protection is normally afforded by the aversion response including the blink reflex.

c. Class III (medium-power) lasers emit in the infrared, visible, or ultraviolet portions of the electromagnetic spectrum. They are a hazard for direct intrabeam and specular reflection viewing. Diffuse reflection is not normally a hazard.

   (1) Class IIIa lasers, even though they emit at class III power levels, have special beam characteristics that make them eye-safe except when viewed through magnifying optics.

   (2) Class IIIb lasers are all other class III lasers.

d. Class IV (high-power) lasers emit in the infrared, visible, or ultraviolet portions of the electromagnetic spectrum. They are hazardous for direct intrabeam exposure and sometimes diffuse reflection exposure to the eyes or skin. They may also produce fire, material damage, laser-generated air contaminants, and hazardous plasma radiation.

Qualified expert
A person who, by virtue of training and experience, can provide competent authoritative guidance about certain aspects of radiation safety. Being a qualified expert in one aspect of radiation safety does not necessarily mean that a person is a qualified expert in a different aspect. Forward requests for determination of whether a certain individual is a qualified expert through command channels to the MACOM RSSO as necessary. Forward these requests to HQDA (DACS-SF), WASH DC 20310-0200, for further evaluation as necessary.

Quality factor
The modifying factor [listed in 10 CFR 20.1004, tables 1004(b).1 and 1004(b).2] that is used to derive dose equivalent from absorbed dose.

Rad
A unit of absorbed dose. One rad is equal to an absorbed dose of 0.01 joule/kilogram (0.01 gray).

Radiation
For the purposes of this regulation, unless otherwise specified, radiation includes both ionizing and nonionizing radiation.

Radiation area
An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radiation safety
For the purposes of this regulation, a scientific discipline whose objective is the protection of people and the environment from unnecessary exposure to radiation. Radiation safety is concerned with understanding, evaluating, and controlling the risks from radiation exposure relative to the benefits derived. Same as *health physics and radiation protection.*

Radiation safety committee
An advisory committee for the commander to assess the adequacy of the command's radiation safety program. Same as *radiation control committee and radiation protection committee.*

Radiation Safety Officer
The person that the commander designates, in writing, as the executive agent for the command's radiation safety program. Same as *radiation protection officer or health physics officer.*

Radiation safety program
A program to implement the objective of radiation safety.

a. The Army's radiation safety program includes all aspects of:
   (1) Measurement and evaluation of radiation and radioactive material pertaining to protection of personnel and the environment.
   (2) Army compliance with Federal and DOD radiation safety regulations.
   (3) The Army's radiation dosimetry, radiation bioassay, radioactive waste disposal, radiation safety training, and radiation instrument TMDE and calibration programs.

b. A command's radiation safety program includes all aspects of:
   (1) Measurement and evaluation of radiation and radioactive material within the command as they pertain to protection of personnel and the environment.
   (2) Compliance with Federal, DOD, and Army radiation safety regulations.

Radioactive commodity
An item of Government property made up in whole or in part of radioactive material. A national stock number (NSN) or part number is assigned to commodities containing radioactive material greater than 0.01 Ci.

Severity
The expected consequence of an event in terms of degree of injury, property damage, or other mission impairing factors (loss of combat power, adverse publicity, and so on), that should occur.

Shallow dose equivalent
Applies to the external exposure of the skin or an extremity and is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg cm^{-2}) averaged over an area of 1 square centimeter.

Sievert (Sv)
The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rem).

Source material
Uranium or thorium, or any combination thereof, in any physical or chemical form or ores that contain by weight one-twentieth of one percent (0.05%) or more of uranium, thorium, or any combination thereof. Source material does not include special nuclear material.

Special nuclear material
Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, or any material artificially enriched by any of the foregoing.

Sustain the Force
One of the Army's four core capabilities. This capability includes the processes of acquiring, maintaining and sustaining equipment; maintaining and sustaining land operations; acquiring and sustaining infrastructure and operating installations.

Tera- (T)
An SI unit prefix indicating a factor of one trillion (10^{12}).

Total effective dose equivalent
The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Type classification
A designation the Army uses to indicate acceptability for service use (AR 70-61).

Ultraviolet (UV) electromagnetic radiation
Electromagnetic radiation with wavelengths between 100 nm and 380-400 nm.

United States Army Reserve Center
A home station facility, activity, or installation utilized for administration and training of United States Army Reserve units and personnel.

Unrestricted area
An area, access to which in neither limited nor controlled (for the purposes of ionizing radiation safety).

Very high radiation area
An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

Visible light
Electromagnetic radiation with wavelengths between 380-400 nm and 760-780 nm.

Weighting factor
For an organ or tissue, the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly.

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Army Radiation Safety Officer (Army RSO), 1-4l, 1-5b, 1-9f
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Assistant Secretary of the Army (Installations, Logistics, and Environment) [ASA(IL&E)], 1-4a
Assistant Secretary of the Army (Manpower and Reserve Affairs), 1-4b, 1-5b
Chief, Army Ionizing Radiation Dosimetry Center (AIRDC), 1-4d(2), 5-2d(2), 5-2e(3)(b)
Chief, Army Reserve, 1-5b
Chief, National Guard Bureau, 1-5b, 1-9b(3)
Commander, 1-4k, 2-2a(4), 2-2b(3)
Commanding General,
Center for Health Promotion and Preventive Medicine (CG, CHPPM), 1-4g(6), 2-2a(3), 2-3d, 3-1c, 3-2d, 4-2a
Commanding General, U.S. Army Materiel Command (CG, AMC), 1-4d
Commanding General, U.S. Army Medical Command (CG, MEDCOM), 1-4g
Commanding General, U.S. Army Training and Doctrine Command (CG, TRADOC), 1-4f
Director of Army Safety (DASAF), 1-4c, 1-5b, 1-9f
Installation commander, 1-4j
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Radiation Safety Officer (RSO), 1-4d(2)(c) and (d), 1-4o, 1-6b, 1-7b and c, 1-8a, 5-2d(2) and (3), 5-2e(2) and (3)
Radiation Safety Staff Officer (RSSO), 1-4m, 1-5b, 2-1c, 2-2d, 2-3b, 2-3d
Radiological Hygiene Consultant to The Surgeon General, 1-5b
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Appendix C: Survey Unit Maps and Sample Locations

Appendix C: Final Status Survey Plan For Wash Rack Facilities #2 and #3, Aberdeen Proving Ground, Aberdeen, MD

Final Status Survey Plan
For Wash Rack Facilities #2 and #3
Aberdeen Proving Ground, Aberdeen, MD

Contract Number
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Prepared for:

U.S. Army Joint Munitions Command
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ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
APG	Aberdeen Proving Ground
ATC	Army Test Center
CABRERA	Cabrera Services, Inc.
cpm	Counts Per Minute
DCGL or DCGLw	Derived Concentration Guideline Level
dpm	Disintegrations Per Minute
DU	Depleted Uranium
FSS	Final Status Survey
HSA	Historical Site Assessment
JMC	Joint Munitions Command
LBGR	Lower Bound of the Grey Region
MARSSIM	Multi-Agency Radiation Survey And Site Investigation Manual
MDC	Minimum Detectable Concentration
μR	Microroentgen
mrem	Millirem
NAD	Normalized Absolute Difference
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
QA	Quality Assurance
QC	Quality Control
ROC	Radionuclides of Concern
SU	Survey Unit

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the United States Army Joint Munitions Command (JMC) to provide support to the Army Test Center (ATC) at the Aberdeen Proving Ground (APG) in Aberdeen, MD. The ATC intends to survey two Wash Rack Facilities (WRFs) for unrestricted release. This document presents the plans for WRF #2 and WRF #3 Final Status Survey (FSS) activities, which are designed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000) guidance. The FSS is a survey of the interior of both WRFs. Areas outside the WRFs interior walls, floors and ceilings as well as the surrounding land areas will be addressed under a separate effort.

1.1 General History

APG is a Government-owned and operated testing facility in Aberdeen, MD. The ATC is a tenant activity located at APG. The ATC possesses a Nuclear Regulatory Commission (NRC) license (SUB 834) for the use of depleted uranium (DU) at APG. Since the construction of WRF #2 and WRF #3 in 1992, the ATC has utilized these facilities as warehouses. The WRFs have never been used as wash racks. The WRFs were used to store items and equipment, some of which were contaminated with DU. WRF #2 housed DU in the form of penetrators, floor sweepings, liquid abrasive residue from previous decontamination activities, and range debris (e.g., paper, plastic, wood). WRF #3 was used for the storage of uncontaminated Navy accelerator parts and the temporary housing of a cutting table contaminated with DU.

1.2 General Approach to Building Investigation

The site radiological investigations are designed using the approach outlined in MARSSIM (NRC, 2000).

- Select instrumentation and measurement techniques (Section 3.0)
- Develop a Derived Concentrations Guideline Level (Section 2.2 and Section 4.1)
- Classify areas by contamination potential (Section 4.3)
- Estimate number of measurement locations (Section 4.4)
- Identify survey units (Table 4.3-1)
- Collect Data (Sections 4.7, 4.8, 4.9, 4.10)
- Evaluate Data (Section 7.1)

2.0 SITE ASSESSEMENT

2.1 General Areas for Investigation

The WRFs are similar in construction and consist of steel beam frame and sheet metal walls with no interior insulation or wallboard. The interior of the WRFs are approximately 56' long by 26' wide with a ceiling height of 20'. The floors consist of steel plate with a recessed trough running the length of the facilities. The trough area is approximately 20' wide by 4" deep. The trough area contains multiple raised (~3") steel beams which were used to support steel floor grating. The grating, which was removed prior to this FFS, was flush with the surrounding floor plate. There are no drains, sumps, heating, cooling, or ventilation systems in these facilities. Steel rollup doors for equipment entry are located at both ends of these facilities.

Since the WRFs were used as storage facilities for contaminated materials, the primary area of investigation is the floor, trough area, and lower wall surfaces (6' and below). WRF #2 housed DU in the form of penetrators, floor sweepings, liquid abrasive residue from previous decontamination activities, and range debris (e.g., paper, plastic, wood). Some of these contaminated materials may have been spilled prior to packaging and loose contamination could be transferred to the facility. WRF #3 was used for the storage of uncontaminated Navy accelerator parts and the temporary housing of a cutting table contaminated DU. Contamination left by the cutting table was identified in the southwest corner of the facility. This contamination was removed though decontamination activities prior to the initiation of the FSS. Past routine surveys of the WRFs have identified minor levels of DU contamination on the floor areas of these facilities.

2.2 Radionuclides of Concern

Site Radionuclides of Concern (ROC) are limited to depleted uranium (DU) and short-lived uranium progeny (Appendix A). The uranium ratios are based on isotopic uranium weight ratios used for shipments of routine DU waste from APG (BARG, 1995). The activity fractions are calculated from the isotopic weight ratios and the specific activity of each uranium isotope. The result is a Uranium-234 (^{234}U):Uranium-235 (^{235}U):Uranium-238 (^{238}U) ratio of 0.084:0.012:0.904. This composition is similar to the 0.190:0.021:0.790 average ratio from three DU soil samples described in the APG report (ANL 1999) entitled "Derived Uranium Guideline for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland".

3.0 SURVEY INSTRUMENTATION AND TECHNIQUES

The purpose of this section is to describe radiological survey instruments and techniques to be used for surveys that will be implemented during site radiological investigations. For this FSS, scanning and integrated direct measurements performed to measure surface radioactivity concentrations will be based solely on alpha emissions. Beta measurements will be collected in tandem with alpha measurements and presented for qualitative review in an appendix of the FSS report. Specific measurement/sampling frequencies and approaches for the FSS are discussed in later sections.

Prior to the initiation of survey activities, interior surfaces will be cleaned to remove dirt and grime that could shield alpha emissions from detection. The cleaning implements used and the wastes generated during cleaning will be collected and stored on site and disposed in accordance with the contaminants found.

3.1 Surface Alpha Radioactivity Scan Surveys

Surface scanning will be performed to identify locations, if any, where contaminant concentrations exceed the criterion for unrestricted release. Scanning will be performed with the active area of the detector at a height of 0.5 cm above the surface of interest using the detector specific assumptions listed in Table 3.1-1. Scanning measurements will be performed in accordance with CABRERA procedures OP-020 "*Operation of Contamination Survey Meters,*" *Rev 0.*

3.1.1 Ludlum Model 43-37 and Eberline FCM4M

Scanning will be performed on floor surfaces and lower walls using an Eberline FCM4M (active area of 728 cm^2) gas proportional floor monitor, Ludlum Model 43-37 handheld (active area of 582 cm^2) gas proportional detector, or equivalent. Using MARSSIM equation J-7 and the instrument specific assumptions listed in Table 3.1-1, the Scan MDC is determined to be equal to $DCGL_W$. Using the detector specific assumptions presented in Table 3.1-1, the chance of detecting a concentration equal to the $DCGL_W$ would be 91% and signified by the incidence of two alpha counts occurring within the dwell time of that instrument.

$$P(n \geq 2) = 1 - P(n = 0) - P(n = 1) \qquad \text{(MARSSIM Equation J-7)}$$

$$= 1 - \left(e^{-A}\right) \times \left(1 + A\right)$$

$$A = \frac{(GE + B)t}{60}$$

where

$P(n \geq 2)$ = probability of getting 2 or more counts during the time interval t
$P(n = 0)$ = probability of not getting any counts during the time interval t
$P(n = 1)$ = probability of getting 1 count during the time interval t
G = source activity (dpm)
E = detector efficiency (4π)
B = background count rate (cpm)
t = dwell time over source (seconds)
A = detector area (cm^2)

If two or more alpha counts occur during the dwell time, a one-minute integrated measurement will be performed at that location. If the result of the integrated alpha measurement is in excess of the release criteria action level (Section 4.2), the area will be marked for biased measurements and investigated by the Field Supervisor.

3.1.2 Ludlum Model 43-89 and Ludlum Model 43-93

Upper wall and ceiling surfaces may not be readily scanned using a Ludlum 43-37 handheld gas proportional counter due to potential long gas delivery tubing lines. These areas may alternatively be scanned with a Ludlum Model 43-89 (active area 126 cm^2) or Ludlum Model 43-93 (100 cm^2) active area scintillation detectors, or equivalent.

Using MARSSIM equation J-5 and the instrument specific assumptions listed in Table 3.1-1, the Scan MDC is determined to be equal to derived concentration guideline ($DCGL_W$). The chance of detecting a concentration equal to the $DCGL_W$ would be 90% and signified by the incidence of one alpha count occurring within the pause time of that stationary instrument.

$$P(n \geq 1) = 1 - P(n = 0) = 1 - e^{-A} \qquad \text{(MARSSIM J-5)}$$

$$\text{for } A = \frac{GEd}{60v}$$

where,

$P(n \geq 1)$ = probability of getting 1 or more counts during the time interval t
$P(n = 0)$ = probability of not getting any counts during the time interval t
G = source activity (dpm)
E = detector efficiency (4π)
d = width of the detector in the direction of scan (cm)
v = scan speed (cm/s)
A = detector area (cm^2)

Whenever an alpha count is detected during the scan, the detector will be held in place over the location where the count was detected for approximately for the duration of the pause time (approximately 7-8 seconds). If a second alpha count is detected over this location during the

pause time, a two minute integrated count will be performed. If the result of the integrated measurement is in excess of the release criteria (Section 4.1), the area will be marked for biased measurements and investigated by the Field Supervisor.

Table 3.1-1: Alpha Scan Assumptions

Model #	Probe Area (cm^2)	Probe Width (cm)	α Efficiency (cpm /dpm)	α Bkgd (cpm)	Scan Speed (cm/sec)	Pause Time (sec)	P(n>=1)	Dwell Time (sec)	P(n>=2)
FCM4M	728	15	0.15	10	7.5	NA	NA	2.0	0.91
43-37	582	15	0.15	10	6	NA	NA	2.5	0.91
43-89	125	9	0.15	3	1	7.3	0.90	NA	NA
43-93	100	9	0.15	3	1	7.3	0.90	NA	NA

3.2 Integrated Direct Surface Alpha Radioactivity Measurements

Integrated direct measurements (i.e., static measurements) of surface alpha radioactivity will be performed during FSSs to compare contaminant concentrations at discrete sampling locations to the release criterion and facilitate statistical testing. Integrated measurements of floors and walls will be performed using a Ludlum Model 43-37 handheld (active area of 582 cm^2) gas proportional detector, Eberline FCM4M (detector surface area of 728 cm^2) gas proportional floor monitor, Ludlum Model 43-89 hand held (active area 126 cm^2) alpha scintillation detector, Ludlum Model 43-93 hand held (active area 100 cm^2) alpha scintillation detector or equivalent. The estimated detector sensitivities and assumptions used for each of the detectors are presented in Table 3.2-1.

Static measurements will be performed in accordance with CABRERA procedures OP-020 "*Operation of Contamination Survey Meters,*" *Rev 0,* and OP-021 "*Alpha-Beta Counting Instrumentation,*" *Rev 0, and* CABRERA standard radiation instrumentation templates "*Alpha Beta Counting and Smear Worksheet*", *Rev 1.* Prior to use, FSS instrumentation will be checked for expected response using a Chi-Square distribution utilizing the CABRERA template "*Chi-Square Worksheet*", *Rev 0.*

The net count rate using the referenced templates will be determined as the difference between the measurement count rate and the daily background count rate measured prior to use.

Table 3.2-1: Detector Sensitivities and Assumptions

Model #	Count Time (min)	Probe Area (cm^2)	α Efficiency (cpm /dpm)	α Background (cpm)	α Static MDC (dpm / 100 cm^2)
FCM4M	1	728	0.15	10	16
43-37	1	582	0.15	10	20
43-89	2	126	0.15	3	38
43-93	2	126	0.15	3	48
2929	4	swipe	0.30	0.5	5

3.3 Smear Sample Collection and Analysis

Smear samples for gross transferable alpha contamination will be collected and analyzed to determine if transferable activity is less than or equal to 10% of total activity as assumed in the $DCGL_W$ (Section 4.1) and to ensure compliance with the equipment release criterion of Army Regulation (AR) 11-9 presented in Appendix B. Smear results for beta activity will be collected in tandem with alpha activity measurements and recorded for qualitative assessment.

Smear samples will be collected over approximately 100 cm^2 areas at biased locations identified during scanning activities. Smear samples will be analyzed for alpha and beta radioactivity using a Ludlum 2929 alpha/beta scintillation counter or equivalent in accordance with CABRERA procedure OP-021 *"Alpha-Beta Counting Instrumentation," Rev 0*. Based on the assumptions listed in Table 3.1-1, an alpha MDC of 5 dpm/100cm^2 will be achieved.

3.4 Gamma Dose Rate Measurements

Gamma dose rate measurements may be qualitatively performed during the FSSs to ensure worker health and safety and to identify unusual dose rate conditions. Measurements will be performed using a Bicron® MicroRem tissue-equivalent scintillation detector, or equivalent, and will be performed in accordance with CABRERA Procedure OP-023, *Operation of micro-R Meters, Rev 0*. Measurements will be performed using the "slow" response time constant setting. The detector will be positioned over the area of interest and allowed to stabilize prior to recording the measurement. The technician will use their judgment to determine when the instrument has stabilized, it is estimated that this will take at least 15 seconds. Such measurements will typically be performed at 3' from and/or on contact with the surface being evaluated.

4.0 FINAL STATUS SURVEY DESIGN

The FSS to be performed at the WRFs are designed in accordance with Final Status Survey guidance from MARSSIM (NRC, 2000). FSS activities will consist of gross alpha and beta scan surveys and integrated measurements on interior surfaces at frequencies based on MARSSIM guidance. The FSS is designed conservatively in that the radiological background present in survey materials (i.e., floor and walls) will be neglected and the measure of total activity will be used for statistical comparisons to release criteria. Survey activities will also include biased smear sample collection and the performance of gamma dose rate measurements. MARSSIM area classifications will be reviewed and possibly revised based on the results of these surveys.

4.1 Residual Radioactivity Limit (DCGL)

As described by MARSSIM, a DCGL is a derived radionuclide activity concentration within a survey unit that corresponds to a release criterion. Per the license requirement of 10CFR20 Subpart E, a release criterion of 25 mrem/yr per year will be used for the WRF. Doses from residual radioactivity will be kept as low as reasonably achievable (ALARA) whenever possible. Using MARSSIM Section 4.3.4, the equation below, and knowing that there is one alpha decay per decay of each uranium isotope, a single total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 was derived for DU. This $DCGL_W$ was calculated using the values provided by the NRC screening guidelines of 90.6 dpm/100cm^2, 97.6 dpm/100cm^2, 101 dpm/100cm^2 and for U^{234}, U^{235}, and U^{238}, respectively, as presented in Table 5.19 of NUREG/CR-5512, volume 3, October 1999 and the DU activity fractions as presented in Section 2.2 of this FSS. As noted in the NUREG/CR-5512 document, screening level guidelines are based on the assumption that the fraction of removable surface contamination is ten percent.

$$DCGL_W = \frac{1}{\left(\frac{f_1}{DCGL_1}\right) + \left(\frac{f_2}{DCGL_2}\right) + \left(\frac{f_3}{DCGL_3}\right)}$$

Where: $DCGL_W$ = Combined gross activity DCGL (i.e., release limit).

f = Activity fraction of radionuclide

DCGL = DCGL of radionuclide

4.2 Action Levels

The total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 will be used as the action level for both static and scanning measurements. If any survey measurement results in readings above the $DCGL_W$, the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, a follow-up measurement shall be performed at the measurement location to verify the initial result.

4.3 General Area Classification Based on Contamination Potential

Using MARSSIM Section 5.3 as guidance, the WRFs will be divided into individual survey units and classified by contamination potential. Initially, WRF #2 will be divided into three Class 1

Survey Units (SUs) and one Class 2 SU as listed in Table 4.3-1. WRF #3 also be divided into three Class 1 SUs and one Class 2 SU as listed in Table 4.3-1.

The initial classifications are based on contamination potential and area size. MARSSIM identifies Class 1 areas as having, or had prior to remediation, a potential for radioactive contamination or known contamination. MARSSIM suggests that interior Class 1 SUs be less than 100 square meters in size. The floor and lower walls of the WRFs share a similar history of contamination and contamination potential because these facilities were used to store DU waste. DU contamination has been identified previously on the floors of these facilities during past routine surveys. The floor area in WRF #2 was remediated for DU contamination prior to the initiation of the FFS.

MARSSIM identifies Class 2 areas as having, or had prior to remediation, a potential for radioactive contamination or known contamination but are not expected to exceed the $DCGL_W$. MARSSIM suggests that interior Class 2 SUs be less than 1000 square meters in size. The ceiling and upper walls of WRFs are initially classified as Class 2 due to remediation activities being performed previously on the floor of these facilities.

Maps presenting the WRFs SU delineations and the reference coordinate system are presented in Appendix C.

Table 4.3-1: Survey Units

SU #	Description	Material	Class	Area (m^2)	# of Samples	L (ft)
1	WRF #2 Floor South Side	Metal	1	68	20	6.1
2	WRF #2 Floor North Side	Metal	1	68	20	6.1
3	WRF #2 Lower Walls	Metal	1	90	24	7.0
4	WRF #2 Ceiling and Upper Walls	Metal	2	346	20	13.7
1	WRF #3 Floor South Side	Metal	1	68	20	6.1
2	WRF #3 Floor North Side	Metal	1	68	20	6.1
3	WRF #3 Lower Walls	Metal	1	90	24	7.0
4	WRF #3 Ceiling and Upper Walls	Metal	2	346	20	13.7

4.4 Number of Static Measurements

MARSSIM provides a method to determine the number of measurement locations required in a given survey unit. A minimum number of measurement locations are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The following subsections describe the bases for and derivation of the minimum required measurement locations per survey unit.

4.4.1 Estimation of Relative Shift

The minimum number of measurement locations required is dependent on the distribution of site residual radionuclide concentrations relative to the $DCGL_w$ and acceptable decision error limits (α and β).

The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated using the guidance found in Section 5.5.2.3 of MARSSIM. The relative shift is calculated as follows:

$$\Delta/\sigma = \frac{DCGL_w - LBGR}{\sigma}$$

Where: $DCGL_w$ = Derived Concentration Guideline Level

LBGR = concentration at the lower bound of the gray region. The Lower Bound of the Grey Region (LBGR) is the concentration at which the survey unit has an acceptable probability of passing the statistical tests.

σ = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system).

As previously stated, the $DCGL_w$ for surface alpha radioactivity is 100 dpm/100cm^2. The LBGR was conservatively estimated at 70 dpm alpha/100 cm^2 based on previous studies with similar instruments on concrete. Without prior survey, it is reasonable to assume a coefficient of variation on the order of 30 percent (MARSSIM Section 5.5.2.2). Using a coefficient of variation of 30 percent and the LBGR as an estimate of the sample mean, a sigma value of 21 dpm/100cm^2 is estimated. Using the parameters discussed above, the relative shift is calculated as 1.4.

4.4.2 Determination of N (Number of Required Measurement Locations)

The final number of required measurement locations per survey unit is 20 as per MARSSIM (Table 5.5) given a relative shift of 1.4 and an error rate for both Type I and Type II errors of five percent (i.e., $\alpha = \beta = 0.05$). The actual number of measurements to be performed in each survey unit ranges from 20 to 24 samples based on the size of the survey area (Section 4.6).

4.5 Elevated Measurement Criterion ($DCGL_{EMC}$)

MARSSIM states that, for Class 1 survey units, a dose area factor should be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion. For the purpose of ALARA, the $DCGL_W$ will be used as the $DCGL_{EMC}$, which corresponds to an area factor of one. Since the scan MDC of the instrumentation is sensitive enough to identify the $DCGL_W$ at least ninety percent of the time (see Section 3.1), it is unlikely that small areas of elevated activity exceeding the release criterion would be missed during scanning.

4.6 Static Measurement Locations

Measurement locations in Class 1 and Class 2 survey units have been established using a random start point in a systematic rectangular grid. The grid spacing for Class 1 and Class 2 survey units will be determined, based on the measured area of the survey unit, using the following equation (Equation 5-7 from MARSSIM).

$$L = \sqrt{\frac{A}{N}}$$

Where: L = rectangular grid spacing for survey unit
A = area of survey unit
N = number measurement locations

Measurement spacing results (L) using the equation above are presented in Table 4.3-1. Maps presenting the WRFs SU delineations and the reference coordinate system are presented in Appendix C.

4.7 Surface Alpha Radioactivity Scan Surveys

Class 1 SU scan surveys will be performed as described in Section 4.1 and will cover 100% of reasonably accessible surfaces. Areas of elevated radioactivity identified during scanning will be physically marked, and biased integrated measurements will be performed to quantify surface alpha activity concentrations for direct comparison to the $DCGL_W$. Survey areas in excess of the $DCGL_W$ will be investigated by the Field Supervisor and flagged for additional biased sampling (e.g., smear sampling). Beta scans will be performed in tandem with alpha measurements and recorded for qualitative purposes.

Scan surveys in Class 2 SUs will cover at least 10% of accessible surface areas and, when possible, will be biased toward areas with high potential for the presence of contamination. Examples of areas with potentially higher concentrations of contamination include horizontal and difficult to access areas where DU contamination may have accumulated, such as trusses and floor joints. Areas of elevated radioactivity identified during scanning will be physically marked, and biased integrated measurements will be performed to quantify surface alpha activity concentrations for direct comparison to the $DCGL_W$. Since contamination in excess of the $DCGL_W$ is not expected in Class 2 areas, any biased measurements confirmed to be in excess of the $DCGL_W$ will trigger investigation by the Field Supervisor and a re-evaluation of the area classification. Beta scans will be performed in tandem with alpha measurements and recorded for qualitative purposes.

4.8 Integrated Direct Surface Alpha Radioactivity Measurements

Measurements of surface alpha radioactivity will be performed in SUs at locations selected for MARSSIM statistical testing and at biased locations identified prior to and during scanning activities. Such measurements will be performed as described in Section 3.2. Beta measurements will be performed in tandem with alpha measurements and recorded for qualitative purposes.

4.9 Smear Sample Collection and Analysis

Smear samples will be collected at biased survey locations and at least 10% of systematic survey locations. Smear samples will be collected as described in Section 3.3. Beta measurements will be performed in tandem with alpha measurements and recorded for qualitative purposes.

4.10 Gamma Exposure Rate Measurements

Gamma exposure rate measurements may be performed to ensure worker safety and to identify unusual exposure rate conditions. Gamma exposure rate measurements will be performed as described in Section 3.4.

5.0 EQUIPMENT RELEASE

5.1 Survey of Equipment for Release Without Restriction

All equipment inside the WRFs should have been removed prior to FFS. If equipment is present that requires survey for unrestricted release, CABRERA will follow the surface release limits of 1,000 dpm/100 cm^2 of DU alpha activity per Army Regulation 11-9 *The Army Radiation Safety Program*. It is expected that all final release surveys of equipment will be performed by the licensee and these surveys will follow APG procedures. If CABRERA performs these release surveys for APG, then CABRERA will follow the APG procedures.

6.0 DATA PROCESSING

This section describes how project events and data will be retained for this FSS.

6.1 Project Log Book

All significant events which occur during this FSS be documented and retained for future reference. While many types of project events have specific forms on which they are documented, many events occur on a routine basis during survey field activities that must be documented as they occur. Additionally, project data transactions must also be recorded as they occur. To provide a practical means of capturing this information, a project logbook will be initiated upon project commencement.

Significant project events, including data transactions involving project electronic data, shall be recorded in the Project Logbook. Data transactions are defined as any transfer, download, export, copy, differential correction, sort, or other manipulation performed on project electronic data. Project Logbook records shall be sufficient to allow data transactions to be reconstructed after the project is completed. The Field Supervisor shall be responsible for maintaining the Project Data Logbook and will review the Project Data Logbook at least daily to report significant issues.

The Project Logbook is considered a legal record and will be permanently bound and the pages will be pre-numbered. Pages may not be removed from the logbook under any circumstances. Entries shall be legible, factual, detailed, and complete and shall be signed and dated by the individual(s) making the entries. If a mistake is made, the individual making the entry shall place a single line through the erroneous entry and shall initial and date the deletion. Under no circumstances shall any previously entered information be completely obliterated. Use of whiteout in the Project Logbook is not permitted for any reason. Only one Project Logbook will be maintained. If a Project Logbook is completely filled, another volume shall be initiated. In this case, each volume shall be sequentially numbered.

6.2 Project Electronic Data

Much of this FSS will rely on data collected and stored electronically. Electronic data is subject to damage and/or loss if not properly protected. As such, all project electronic data shall be downloaded from its collection device (e.g., laptop computers, data loggers, etc.) on at least a daily basis. At the conclusion of each day's survey activities, the Field Supervisor shall back up all electronic data collected that day to appropriate removable media (e.g., CD, zip disk, or equivalent) and shall ensure the backup is removed from site. Under no circumstances shall the backup be stored in the same building in which the original project electronic data is stored.

Data files shall be named according to a naming protocol designated by the field supervisor. No variations from this protocol shall occur without the prior concurrence of the field supervisor. During data download and transfer transactions, the applicable data file name(s) shall be included in project data logbook entries.

7.0 INTERPRETATION OF SURVEY RESULTS

The results of individual integrated static measurements performed for this FSS will be evaluated to compare the residual radioactivity present in the WRFs SU's to the release criteria ($DCGL_W$). This comparison will determine if the WRFs can be considered for release without radiological restriction. If all of the SU's of a WRF meet the criteria for unrestricted release, the WRF as a whole will be considered a viable candidate for unrestricted release.

In accordance with MARSSIM guidance, a preliminary data review will be performed to identify patterns, relationships, and potential anomalies present in the survey data. In this review, basic statistics including the mean, median, standard deviation, maximum and minimum values will be calculated for each SU. A graphical review of the alpha data will be performed consisting of posting plots and histograms. Posting plots will be used to review the spatial independence of measurements within survey units, while histograms will be employed to review the overall symmetry of the data.

Once the data have been reviewed, all of the static alpha measurements for each SU will be compared to the $DCGL_W$. If all of the static alpha measurements for a SU are below the $DCGL_W$, the survey unit meets the release criteria. If the average residual radioactivity in an individual SU is greater than the $DCGL_W$, the SU does not meet the release criteria. If any alpha measurements in a SU are greater than the $DCGL_W$ and the average residual radioactivity in that survey unit is below the $DCGL_W$, the Sign test will be performed as described in MARSSIM to compare the median concentration of residual radioactivity in individual survey units to the $DCGL_W$. If the results of that survey unit pass the Sign test, that SU meets the release criteria. Finally, a retrospective power curve will be computed to measure the power of the Sign test based on the results of the measurements performed. The results of all of these statistical processes will be provided in the FSS Report.

8.0 SURVEY QUALITY ASSURANCE/QUALITY CONTROL

Activities associated with this work plan shall be performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Topics covered in project procedures and protocols may include proper use of instrumentation, Quality Control (QC) requirements, equipment limitation, etc. Quality Assurance (QA) measures for this FSS are described herein.

8.1 Instrumentation Requirements

The Field Supervisor is responsible for selecting the instrumentation required to complete the requirements of this work plan. Only instrumentation approved by the Field Supervisor will be used to collect radiological data. The Field Supervisor is responsible for ensuring individuals are appropriately trained to use project instrumentation and other equipment, and that instrumentation meets the required detection sensitivities. Instrumentation shall be operated in accordance with either a written procedure or manufacturers' manual, as determined by the Field Supervisor. The procedure and/or manual will provide guidance to field personnel on the proper use and limitations of the instrument.

8.1.1 Calibration Requirements

Instruments used during the FSS shall have current calibration/maintenance records kept on site for review and inspection. The records will include, at a minimum, the following:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

Instrumentation shall be maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments are maintained. Instruments will be calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using National Institute of Standards and Technology (NIST) traceable sources.

8.1.2 Instrument QC Source and Background Checks

Prior to and after daily use, alpha and gamma measuring instruments will be QC checked by comparing the instruments' response to a designated alpha or gamma radiation source and to ambient background. QC source checks will be performed with the designated source positioned in a reproducible geometry. Background checks will be performed in an identical fashion with the source removed. During QC checks, instruments will be inspected for physical damage, current calibration and erroneous responses. The individual performing these tasks shall document the results in accordance with the associated instrument procedure and/or protocols. Instrumentation that does not meet the specified requirements of calibration, inspection, or response check will be removed from service. If an instrument is removed from service, any data obtained after the last successful QC check will be considered suspect due to faulty instrumentation.

Quality control source checks for the Eberline FCM4M, Ludlum 43-37, Ludlum 43-89, and Ludlum 43-93 will consist of a one-minute integrated count with the designated Thorium–230 (^{230}Th) and Technetium-99 (^{99}Tc) sources. QC source checks for the Bicron® MicroRem meter will consist of observing needle deflection and estimating an average dose rate once the instrument readings have stabilized (approximately 15 seconds) using a ^{137}Cs source. The acceptance criterion for these instrument response checks is within +/- 20% of the average response generated using ten initial source checks and ten measurements of ambient background performed at the beginning of the project. A response check outside these criteria will be cause for evaluation of conditions (e.g., instrument operation, source/detector geometry), and the response check will be repeated once prior to field use of that instrument. Instruments that fail the second successive response check will be removed from service and corrective actions will be taken. Only Field Supervisors can return a failed instrument back to service after proper corrective actions are taken and documented.

Quality control source response checks for the Ludlum 2929 will be checked daily by evaluating response to designated ^{230}Th (Alpha) and ^{99}Tc (Beta) sources and ambient background. Response checks will consist of one-minute counts of a ^{230}Th, ^{99}Tc source, and a 20 minute count of ambient background. The acceptance criteria for instrument response will be set to two and three-sigma of the average response generated using ten initial source checks and ten measurements of ambient background. A daily response check outside the two-sigma, but within the three-sigma criteria will be cause for a recount prior to use. A response check outside two sigma on the second count will be cause for further evaluation and or re-performance of QC control values prior to continued use. Response checks falling outside acceptance criteria will be cause for notification of the Field Supervisor and evaluation of conditions (e.g., instrument operation, source/detector geometry) prior to further counts and/or removal of the instrument from service. Instruments must pass a response check prior to field use. Only Field Supervisors can return a failed instrument back to service after proper corrective actions are taken and documented.

Quality control for volumetric sample analysis will be performed in accordance with applicable Paragon standard operating procedures.

8.2 Direct Alpha, Smear, and Exposure Rate Measurements

Instrumentation will be operated in accordance with standard operating procedures and/or protocols.

8.2.1 Duplicate Measurements

Duplicate measurements will be required for 10% of the static measurement locations for each survey unit. Duplicate measurements will be compared to the initial analytical results by determining a Normalized Absolute Difference (NAD) value and comparing it against the performance criteria specified as follows:

Analyses of field and laboratory duplicates will be compared to the initial analytical results by determining a NAD value for each data set by the following equation (PROB, 1993):

$$NAD = \frac{|\text{Sample - Duplicate}|}{\sqrt{\sigma^2_{\text{Sample}} + \sigma^2_{\text{Duplicate}}}}$$

Where:
Sample = first sample value (original),
Duplicate = second sample value (duplicate),
$\sigma_{\text{Sample}} = 2\sigma$ counting uncertainty of the sample, and,
$\sigma_{\text{Duplicate}} = 2\sigma$ counting uncertainty of the duplicate

The calculated NAD results will be compared to a performance criteria of less than or equal to 1.96. Calculated NAD values less than 1.96 will be considered acceptable and values greater than 1.96 will be investigated for possible discrepancies in analytical precision, or for sources of disagreement with the following assumptions of the test:

- the sample measurement and duplicate or replicate measurement are of the same normally distributed population.
- the standard deviations, σ_{Sample} and $\sigma_{\text{Duplicate}}$, represent the true standard deviation of the measured population.

9.0 REFERENCES

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Appendix A:
Uranium 238 Decay Series

Uranium 238 Decay Series
(Excerpted from Radioactive Decay Data Tables, David Kocher, 1981)

Radionuclide	Half-Life	Emissions	Energy (MeV)	Percent Yield
U-238	4.5 x 109 y	α	4.2	75
		α	4.15	25
Th-234	24.1 d	β	0.193	79
		β	0.1	21
		γ	0.093	4
		γ	0.063	3.5
Pa-234m	1.17 min	β	2.29	98
Pa-234	6.75 h	β	0.53	<1
		β	1.13	<1
U-234	2.47 x105 y	α	4.72	28
		α	4.77	72
Th-230	8.0 x 104 y	α	4.62	24
		α	4.68	76
Ra-226	1602 y	α	4.60	6
		α	4.78	95
		γ	0.186	4
Rn-222	3.82 d	α	5.49	100
Po-218	3.05 min	α	6.0	100
Pb-214	26.8 min	β	0.65	50
		β	0.71	40
		γ	0.3	19
		γ	0.35	36
Bi-214	19.7 min	β	1.0	23
		β	1.51	40
		β	3.26	19
		γ	0.609	47

Appendix B:
Army Regulation 11-9
Army Radiation Safety Program

Appendix C:
Survey Unit Maps and Sample Locations

Appendix D: Final Status Survey Plan, Bomb Throwing Device (BTD) Site, Aberdeen Proving Ground, Aberdeen, MD

DEPARTMENT OF THE ARMY
U. S. ARMY ABERDEEN TEST CENTER
400 COLLERAN ROAD
ABERDEEN PROVING GROUND, MARYLAND 21005-5059

J-8

REPLY TO
ATTENTION OF

September 18, 2003

Office of the Commander

SUB-834
04007354

Mr. James Schmidt
Nuclear Regulatory Commission, Region I
Division of Nuclear Materials Safety
475 Allendale Road
King of Prussia, Pennsylvania 19406

Dear Mr. Schmidt:

The final Status Survey Plan for the Aberdeen Test Center Bomb Throwing Device Site is provided for your review and approval (Enclosure).

A copy of this letter with the enclosure has been furnished to the Directorate for Installation Management (CSTE-DTC-MS-S/Mr. Robert Aaserude), U.S. Army Developmental Test Command, 314 Longs Corner Road, Aberdeen Proving Ground, Maryland 21005-5055.

My point of contact at the U.S. Army Aberdeen Test Center is Mr. John C. Beckman at 410-278-9618.

Mary K. Brown
Colonel, U.S. Army
Commanding

Enclosure

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REC'D IN LAT NOV 17 2003

FINAL

Final Status Survey Plan
Bomb Throwing Device (BTD) Site

Aberdeen Proving Ground, Aberdeen, MD

Contract Number
DAA09-00G-0002/0039

Prepared for:

U.S. ARMY

U.S. Army Joint Munitions Command
AMSIO-ACE-D Bldg., 350 5th Floor
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809 Main Street
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Cabrera Project No
01-3030.39

August 2003

Enclosure

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Appendix C: Ludlum NaI 3"x3" MDC_{SCAN} and Instrument Sensitivity Results Calculated Using Microshield®

Appendix D: Survey Unit Maps and Sample Locations

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
APG	Aberdeen Proving Ground
ATC	Aberdeen Test Center
BTD	Bomb Throwing Device
CABRERA	Cabrera Services, Inc.
cpm	Counts Per Minute
DCGL or DCGLw	Derived Concentration Guideline Level
DGPS	Differential Global Positioning System
dpm	Disintegrations Per Minute
DU	Depleted Uranium
FSS	Final Status Survey
GWS	Gamma Walkover Survey
HEPA	High Efficiency Particulate Air
LBGR	Lower Bound of the Grey Region
MARSSIM	Multi-Agency Radiation Survey And Site Investigation Manual
MDC	Minimum Detectable Concentration
MDC_{scan}	Minimum Detectable Concentration for gamma Scanning
µRem	Microrem
mrem	Millirem
NAD	Normalized Absolute Difference
NIST	National Institute of Standards and Technology
NRC	U. S. Nuclear Regulatory Commission
PARAGON	Paragon Analytics, Inc.
QA	Quality Assurance
QC	Quality Control
ROPC	Radionuclides of Potential Concern
SU	Survey Unit
WESTON	Roy F. Weston

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the United States Army Joint Munitions Command (JMC) to provide support to the Aberdeen Test Center (ATC) at the Aberdeen Proving Ground (APG) in Aberdeen, MD. CABRERA will perform radiological surveys of the Bomb Throwing Device (BTD) site to support consideration for unrestricted release. The BTD site consists of approximately 46,000 square meters of land on the APG. There are several support facilities and access roads located on the BTD site that were used for the testing of Depleted Uranium (DU) munitions. This document presents the plan for the BTD site Final Status Survey (FSS) activities, which are designed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000) guidance. This final status survey specifically addresses the survey of approximately 46,000 square meters of BTD site soil, two concrete pads, and three steel test structures located within the boundary of the BTD site. Buildings and other enclosed structures located on the BTD site will be addressed under a separate effort.

1.1 Site History

Aberdeen Proving Ground, located in Aberdeen, MD, is an active U.S. Army testing and research facility. The Aberdeen Proving Ground (APG) lies along the western shore of the Chesapeake Bay in Harford and Baltimore Counties, MD, approximately 15 miles northeast of Baltimore. The APG covers a total of 72,516 acres (land and water) and consists of two distinct areas: the northern portion of APG, referred to as the Aberdeen Area; and the southern portion of APG, referred to as the Edgewood Area. The Aberdeen Area became a formal military post, designated as the APG, in 1917.

The BTD site was used between 1982 and 1993 for the testing of DU munitions. The site consists of the Building Armor Reclamation Facility (BARF), Building 701 (DU Test Enclosure Building which has been recently removed), Plate Storage Area (PSA), access roads and several support buildings situated on approximately 46,000 square meters of land. During use, munitions were fired at steel plate and other targets placed inside the DU Test Enclosure Building. The ATC tested DU munitions utilizing an enclosure with high efficiency particulate air (HEPA) equipment, used to collect potentially contaminated air exiting the building.

Prior to remediation of the site, approximately 40 tons of DU-contaminated armor plate was located within the building and surrounding grounds. Heavy equipment was used to transport the armor plates between the PSA and the DU Test Enclosure Building. The DU Test Enclosure Building, which was recently demolished, had dimensions of approximately 25 by 50 feet with a height of 20 feet, will be disposed of at an appropriate facility. Associated HEPA equipment including filters and ductwork are also scheduled for removal and appropriate disposition. A HEPA motor may remain on the site.

1.2 General Approach to the BTD Site FSS

The FSS investigations are designed using the approach outlined in MARSSIM (NRC, 2000).

- Development of Derived Concentrations Guideline Levels
- Selection of instrumentation and measurement techniques
- Identification of survey units and classify areas by contamination potential

- Estimation of the number of measurement locations
- Collection of Data
- Evaluation of Data

2.0 SITE ASSESSEMENT

2.1 Area of Investigation

The focus of this FSS is the radiological assessment of the top six inches of surface soil over the entire 46,000 square meters BTD site and the surface activity on unenclosed structures located within the BTD site boundaries. The land area associated with the BTD site consists of open grassy areas with one area of standing trees. Originating near the center of the BTD site is a wetland ravine. The ravine is approximately 140 meters in length and often has water covered surfaces averaging up to several meters in width. Water depths in the ravine range from several centimeters to approximately 15 centimeters.

Roy F. Weston (Weston) provided a radiological characterization for the BTD site in 2001 (Weston, 2001). The Weston characterization encompassed the BTD site and divided the site into Class 1, 2, and 3 areas. Soil samples were taken from each area and compared to the NRC soil screening value of 14 pCi/g for uranium-238. Both surface (0-0.25 ft) and subsurface samples (1-1.5 ft) were taken. All values exceeding the soil action level as described in this report were found to exist in the surface soil (0-0.25 ft). An exception was the presence of several subsurface samples taken in the vicinity of the DU Test Enclosure Building that showed levels of soil contamination in excess of the soil action level. The removal of the DU Test Enclosure building by the CABRERA remediation and subsequent soil remediation activities will ensure that these areas of soil contamination have been addressed. In addition, the Weston characterization classified the majority of the BTD site as Class 3. The CABRERA remediation and FSS conservatively assumes the entire site is a Class 1.

The BTD site structures of interest are two concrete pads and three unenclosed steel structures. A motor associated with the HEPA filtration system is expected to remain onsite at its current location. The northern concrete pad is approximately 230 square meters size while the southern concrete pad is approximately 130 square meters in size. The unenclosed structures consist of a steel gun mount, a "Sabot Stripper", and a "Back Stop Plate". The bases of these structures are approximately 25 square meters each with an additional 20-25 square meters of vertical surface area. The HEPA motor is several square meters in overall area.

The land areas surrounding the facilities and structures where testing and transport of materials was performed are expected to have a greater potential for surface soil contamination than other areas. DU contamination below the top six inches are not expected in soil due to the trajectory and containment of the targets used during ordnance testing. Prior BTD site characterization study (Weston, 2001), confirms the presence of DU contamination in the upper six inches of the soil. DU contamination below the concrete pads and steel test structures are not expected as these structures were in place prior to testing protocols.

2.2 Radionuclides of Potential Concern

Site Radionuclides of Potential Concern (ROPC) are limited to DU and short-lived uranium progeny (Appendix A). For brevity, Appendix A does not show the radionuclides from the actinium decay series as parent uranium-235 contributes a vanishingly small fraction of the radioactivity and mass. The uranium ratios are based on isotopic uranium weight ratios used for

shipments of routine DU waste from APG (BARG, 1995). The activity fractions are calculated from the isotopic weight ratios and the specific activity of each uranium isotope. The result is a Uranium-234 (^{234}U): Uranium-235 (^{235}U): Uranium-238 (^{238}U) ratio of 0.084:0.012:0.904. This composition is similar to the 0.190:0.021:0.790 average ratio from three DU soil samples described in the APG report (ANL 1999) entitled "Derived Uranium Guideline for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland", Argonne National Laboratory Environmental Assessment Department, April 1999.

2.3 Residual Radioactivity Limit (DCGL)

As described by MARSSIM, a DCGL is a derived radionuclide activity concentration within a survey unit that corresponds to a dose-based release criterion. For this FSS, separate $DCGL_W$'s were developed for soil and structure surfaces. The release criteria for miscellaneous equipment (e.g. Back Stop Plate, HEPA Motor, etc) are discussed in Section 5.0.

Soil $DCGL_W$

A soil DCGL of 230 pCi/g total DU (resident-farmer scenario) developed for the Transonic Range is considered applicable for the BTD site based on a report prepared by CABRERA and included as Appendix B (CABRERA, 2003). The report evaluates site-specific RESRAD parameters/pathways, the similarity of both locations, and the equivalence of the radiological isotopic DU mixes at both locations. Use of the approved BTD soil DCGL will ensure that the potential dose to a hypothetical individual will not exceed 25 mrem in any one year over a 1,000 period consistent with 10 CFR Part 20 Subpart E requirements. For this FSS, a soil $DCGL_W$ of 105 pCi/g total DU in soil will be used based on the ALARA principle of as-low-as-reasonably-achievable to provide assurance that hypothetical doses are limited to a fraction of the 25 mrem/year requirement.

Structure Based $DCGL_W$

A release criterion of 25 mrem/yr per year will be used for the unenclosed structures per the requirement of 10CFR20 Subpart E. Doses from residual radioactivity will be kept as low as reasonably achievable (ALARA) whenever possible. Using MARSSIM Section 4.3.4, and the equation below, and knowing that there is one alpha decay per decay of each uranium isotope, a single total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 was derived for DU. This $DCGL_W$ was calculated using the values provided by the NRC screening guidelines of 90.6 dpm/100cm^2, 97.6 dpm/100cm^2, 101 dpm/100cm^2 and for U^{234}, U^{235}, and U^{238}, respectively, as presented in Table 5.19 of NUREG/CR-5512, Volume 3, October 1999 and the DU activity fractions as presented in Section 2.2 of this FSS. As noted in the NUREG/CR-5512 document, screening level guidelines are based on the assumption that the fraction of removable surface contamination is ten percent.

$$DCGL_W = \frac{1}{\left(\frac{f_1}{DCGL_1}\right) + \left(\frac{f_2}{DCGL_2}\right) + \left(\frac{f_3}{DCGL_3}\right)}$$

Where: $DCGL_w$= Combined gross activity DCGL (i.e., release limit).

f = Activity fraction of radionuclide

DCGL = DCGL of radionuclide

2.4 Action Levels

For soil, the soil ALARA $DCGL_W$ of 105 pCi/g will be used as the action level for scanning measurements. If any scan measurement results in readings above the soil $DCGL_W$ (Section 3.1), the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, the immediate area will be rescanned to verify the initial result. If the verified result is greater than the $DCGL_W$, the location will be marked and remediated to ensure that the soil $DCGL_W$ of 105 pCi/g is not exceeded. Additional scans of the area will be performed to verify that the additional remediation has removed soil above the action level of 105 pCi/g.

For unenclosed non-equipment structures (e.g., concrete pads), the structural $DCGL_W$ of 100 dpm alpha/100 cm^2 for total uranium will be used as the action level for both scanning and integrated measurements (Section 3.2 & 3.4). If any survey measurement results in readings above this $DCGL_W$, the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, a follow-up measurement shall be performed at the measurement location to verify the initial result. If the result of the verification measurement is in excess of the $DCGL_W$, a biased smear sample (Section 3.6) will be performed at that location. Follow-up remediation and survey scan and integrated measurements will be provided at the subject location as necessary.

For equipment, the $DCGL_W$ will be based on equipment release criteria of 1,000 dpm alpha/100 cm^2 removable contamination and 5,000 dpm alpha/100 cm^2 total contamination in accordance with Army Regulation 11-9 (AR11-9, 1999) Table 5-2 (Section 5.0). If any survey measurement results in readings above this $DCGL_W$, the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, a follow-up measurement shall be performed at the measurement location to verify the initial result. If the result of the verification measurement is in excess of the $DCGL_W$, a biased smear sample (Section 3.6) will be performed at that location. In certain cases, the equipment may be removed from the site and the small area beneath the equipment will be resurveyed in accordance with the soil $DCGL_W$.

3.0 SURVEY INSTRUMENTATION AND TECHNIQUES

The purpose of this section is to describe radiological survey instruments and techniques that will be used for surveys implemented during site radiological investigations. Specific measurement/sampling frequencies and approaches for the FSS are discussed in later sections.

For the soil FSS, ambient gamma scanning, discrete soil sampling, offsite laboratory analyses of the soil, and dose rate measurements will be performed to measure radioactivity concentrations of total uranium in surface soil. Implements used to collect soil samples will be cleaned and surveyed after each sample is collected to minimize cross-contamination of samples.

For unenclosed structures, scanning and integrated direct measurements will be performed to measure surface radioactivity concentrations of total uranium. These measurements will be based solely on alpha emissions. Beta measurements will be collected in tandem with alpha measurements and presented for qualitative review in an appendix of the FSS report. Prior to the initiation of alpha survey activities on unenclosed structures, surfaces of interest will be cleaned to remove dirt and grime that could shield alpha emissions from detection. The cleaning implements used to clean surfaces will be collected and stored on site and disposed in accordance with the contaminants found.

3.1 Gamma Walkover Surveys (GWS)

A GWS will be performed over soil to identify surface soil DU contamination. These surveys will provide position-correlated gross gamma count rate data proportional to the gross gamma fluence rate at the ground surface. The results of these surveys will be used to detect areas of elevated activity and select locations for biased soil sampling.

The GWS will be performed using a Ludlum Model 44-20 3" x 3" NaI gamma scintillation detector (or equivalent) coupled to a Ludlum Model 2221 rate meter (or equivalent). These instruments will be linked with differential global positioning system (DGPS) receiver/dataloggers. The gamma detection systems will be setup to measure gamma interactions in the NaI crystal that are discernable from electronic noise. Specifically, the detection systems will be calibrated with no lower level discriminator and no upper level discriminator (i.e., open window). This system will log the gross gamma reading and position every second in State Plane Coordinates.

Using NUREG-1507 as guidance, a minimum detectable scanning concentration (MDC_{SCAN}) and scanning sensitivity was calculated using Microshield®. The results of these calculations are presented in Table 3.1-1. The action level of 6,800 cpm above ambient gamma background was calculated by multiplying the instrument scanning sensitivity by the $DCGL_W$ of 105 pCi/g.

The calculations performed and the assumptions made in the sensitivity estimates are presented in Appendix C. The assumptions include an ambient gamma background of 10uR/hr and a 56 cm diameter soil source term uniformly contaminated to a depth of 15 cm as described by NUREG-1507. The Ludlum Model 44-20 instrument sensitivity and scanning evaluation incorporates 18 energy response groups covering the energy range associated with DU. The sensitivity evaluation also assumes that scanning will be performed in accordance with

MARSSIM protocol by walking straight parallel lines over an area while moving the detector in a serpentine motion, approximately 10 cm above the ground surface. Survey passes will be approximately 1 meter apart and the scan rate will be approximately 0.5 meters per second. The CABRERA General Countrate Meter QC template will be used to assure proper instrument operability prior to daily scanning.

The action level of 6,800 cpm above background, the instrument scanning sensitivity, and the MDC_{scan} values are shown in Table 3.1-1.

Table 3.1-1: NaI Scanning Sensitivities for Soil

Detector	Description	MDC_{SCAN} (pCi/g)	Scanning Sensitivity (cpm/pCi/g)	Action Level (cpm above background)
Ludlum 44-20	NaI 3"x3"	38	65	6,800

3.2 Direct Alpha Radioactivity Scan Surveys

Direct alpha scanning will be performed to identify surface locations on structures where contaminant concentrations may exceed the criterion for unrestricted release. Scanning surveys for alpha activity will also be performed to determine if radiological surface contamination is present on soil sampling equipment. Scanning will be performed using a Ludlum Model 43-93 (100 cm^2) active area scintillation detectors, or equivalent. Scanning will be performed with the active area of the detector at a height of 0.5 cm above the surface of interest using the detector specific assumptions listed in Table 3.2-1. Scanning measurements will be performed in accordance with CABRERA procedures OP-020 *"Operation of Contamination Survey Meters," Rev 0* and use CABRERA General Countrate Meter QC template.

Using MARSSIM equation J-5 and the instrument specific assumptions listed in Table 3.1-2, the MDC_{SCAN} is determined to be equal to the structural $DCGL_W$. The chance of detecting a concentration equal to the $DCGL_W$ would be 90% and signified by the incidence of one alpha count occurring within the pause time of that stationary instrument.

$$P(n \geq 1) = 1 - P(n = 0) = 1 - e^{-A} \qquad \text{(MARSSIM J-5)}$$

$$\text{for } A = \frac{GEd}{60v}$$

where,

$P(n \geq 1)$ = probability of getting 1 or more counts during the time interval t
$P(n = 0)$ = probability of not getting any counts during the time interval t
G = source activity (dpm)
E = detector efficiency (4π)
d = width of the detector in the direction of scan (cm)
v = scan speed (cm/s)
A = detector area (cm^2)

Whenever an alpha count is detected during the scan, the detector will be held in place over the location where the count was detected for the duration of the pause time (approximately 7 seconds). If a second alpha count is detected over this location during the pause time, a two minute integrated count will be performed. If the result of the integrated measurement is in excess of the structural $DCGL_W$ (Section 2.3), the area will be marked and further investigated by the Field Supervisor.

The net count rate will be determined as the difference between the measurement count rate and the daily background count rate measured prior to use.

Table 3.2-1: Alpha Scan Assumptions

Model #	Probe Area (cm^2)	Probe Width (cm)	α Efficiency (cpm /dpm)	α Bkgrd (cpm)	Scan Speed (cm/sec)	Pause Time (sec)	P(n>=1)	Dwell Time (sec)	P(n>=2)
43-93	100	9	0.20	3	1	6.9	0.95	NA	NA

3.3 Soil Sampling

Soil samples will be collected to measure surface soil contaminant concentrations at discrete locations. The soil samples will be analyzed for total uranium and the results will be used to facilitate statistical testing. Discrete sampling locations will be identified using the Trimble DGPS system to get the appropriate Easting and Northing coordinates (North American Datum System). Samples will be sent to Paragon Analytics, Inc. (Paragon) for analysis for isotopic uranium and analyzed in accordance with Paragon's standard operating procedure. Volumetric samples will be collected in accordance with CABRERA procedure *OP-005 Volumetric and Material Sampling, rev 0.*

Soil samples will be collected using surface scraping tools such as trowels or spoons. In general, surface soil samples will be collected from the top six inches of soil. The sample will be transferred into a stainless steel bowl, where it will be thoroughly mixed to homogenize the sampled media. Visually identifiable non-soil components such as stones, twigs, and foreign objects will be manually separated in the field and excluded from the laboratory samples to avoid biasing results. Samples will not be preserved in the field, as there are no preservation requirements for the radiological analyses. All sampling equipment, mixing utensils, and homogenizing bowls will be decontaminated using distilled water after each sample to avoid cross contaminating the subsequent sample. A Ludlum 43-93 detector and smear sample will be used to ascertain that no cross-contamination occurs between samples. The presence of less than 1,000 dpm/100 cm^2 of DU alpha activity on a smear is sufficient to show non-contamination of volumetric samples from the sampling equipment thus limiting cross-contamination between soil samples.

Soil will be collected in 500 ml sample containers. These containers will hold sufficient sample material as to allow detection of radioactive materials at the MDC values specified (approximately 4 pCi/gram DU). The analysis lab has indicated this amount to be equivalent to

approximately 500 grams of soil. Each filled 500 ml container will hold more than 500 grams of soil.

Samples will be marked to show the sample identification number. Sample identification number, northing and easting coordinates, and other pertinent data will be recorded on appropriate field data recording sheets. Samples will be collected in accordance with the Paragon Laboratories applicable chain of custody procedures.

3.4 Integrated Direct Surface Alpha Radioactivity Measurements

Integrated direct measurements (i.e., static measurements) of surface alpha radioactivity will be performed during the FSS to compare contaminant concentrations at discrete sampling locations on construction materials (i.e., concrete pad) to the release criterion and facilitate statistical testing. Model 43-93 hand held (active area 100 cm^2) alpha scintillation detector or equivalent. The estimated detector sensitivity and the assumptions used for this detector are presented in Table 3.4-1.

Static measurements will be performed in accordance with CABRERA procedures OP-020 *"Operation of Contamination Survey Meters," Rev 0,* and OP-021 *"Alpha-Beta Counting Instrumentation," Rev 0, and* CABRERA standard radiation instrumentation templates *"Alpha Beta Counting and Smear Worksheet", Rev 2.* Prior to field mobilization, FSS instrumentation will be checked for expected response using a Chi-Square distribution utilizing the CABRERA template *"Equipment Chi-Square Distribution Worksheet", Rev 0.*

The net count rate will be determined as the difference between the measurement count rate and the daily background count rate measured prior to use.

Table 3.4-1: Detector Sensitivities and Assumptions

Model #	Count/Bkg Time (min)	Probe Area (cm^2)	α[1] Efficiency (cpm /dpm)	α Background (cpm)	α Static MDC (dpm / 100 cm^2)
43-93	2	100	0.20	3	36
2929	4	smear	0.37	0.5	6

[1] Instrument efficiencies are estimated from vendor literature-based ^{230}Th and ^{239}Pu efficiencies.

3.5 Gamma Dose Rate Measurements

Gamma dose rate measurements may be qualitatively performed during the FSSs to ensure worker health and safety and to identify unusual dose rate conditions. Measurements will be performed using a Bicron MicroRem tissue-equivalent scintillation detector, or equivalent, and will be performed in accordance with CABRERA Procedure OP-023, *Operation of micro-R Meters, Rev 0.* Measurements will be performed using the "slow" response time constant setting. The detector will be positioned over the area of interest and allowed to stabilize prior to recording the measurement. The technician will use their judgment to determine when the

instrument has stabilized, it is estimated that this will take at least 15 seconds. Such measurements will typically be performed at 30 cm from and/or on contact with the surface being evaluated.

3.6 Smear Sample Collection and Analysis

For non-equipment structural smear samples (e.g., concrete pads), gross transferable alpha contamination will be collected and analyzed to determine if transferable activity is less than or equal to 10% of total activity as assumed in the NUREG/CR-5512 document for screening level guidelines.

For equipment smear samples, gross transferable alpha contamination will be collected and analyzed to ensure compliance with equipment release criterion of Army Regulation 11-9 of 1,000 dpm/100 cm^2.

Smear samples will be collected over approximately 100 cm^2 areas at systematic and biased locations identified during scanning activities. Smear samples will be analyzed for alpha and beta radioactivity using a Ludlum 2929 alpha/beta scintillation counter or equivalent in accordance with CABRERA procedure OP-021 *"Alpha-Beta Counting Instrumentation," Rev 0.* Based on the assumptions listed in Table 3.4-1, an alpha MDC of 6 dpm/100cm^2 will be achieved.

4.0 FINAL STATUS SURVEY DESIGN

The FSS to be performed at the BTD site is designed in accordance with Final Status Survey guidance from MARSSIM (NRC, 2000). FSS activities will consist of scanning surveys over 100% of the reasonable accessible surface soil and structure surfaces. Discrete soil sampling and integrated direct surface measurements will be performed at frequencies based on MARSSIM guidance. Survey activities will also include biased smear sample collection. The FSS is designed conservatively in that the radiological background present in the soil will be neglected and the measure of total activity will be used for statistical comparisons to the respective $DCGL_W$.

4.1 Area Classification Based on Contamination Potential

Using MARSSIM as guidance, the BTD site will be divided into 29 Class 1 survey units (SU). The initial SU classifications are based on sample matrix, area, and contamination potential. Table 4.1-1 lists each SU by matrix type, area, number of samples to be collected in that SU, and the distance between each sample using a triangular grid pattern.

For soil areas, MARSSIM suggests that outdoor Class 1 SUs be not more than 2,000 square meters in size. For unenclosed structures (concrete pads), SU size was limited to approximately 100 square meters that MARSSIM suggests for interior SUs. This more restrictive size was selected for unenclosed structures based on the possibility that enclosures may be built upon existing concrete pads and around test equipment in the future. To accommodate the interior SU size, concrete pads remaining in place were divided into two separate SUs of equal size.

Three pieces of steel test equipment and a HEPA motor are considered equipment and will be released based on Army Regulation 11-9 as described in sections 4.2 and 5.1.

MARSSIM identifies Class 1 areas as having, or had prior to remediation, a potential for radioactive contamination or known contamination. Initially, all survey units will be considered Class 1 survey units based on the process involved (i.e., the testing and firing of DU munitions), the amount of DU present on the BTD site (i.e., approximately 40 tons of contaminated plate armor), the on-site transport of contaminated materials, the length of time the BTD site was used to test munitions. This is a conservative assumption.

Table 4.1-1: Survey Units

SU #	Matrix	Area (m^2)	L (m)	No. of Samples	SU #	Matrix	Area (m^2)	L (m)	No. of Samples
1	Soil	1235	10.1	16	16	Soil	1970	12.8	15
2	Soil	1600	11.5	15	17	Soil	1590	11.5	15
3	Soil	1560	11.3	17	18	Soil	2000	12.8	15
4	Soil	1840	12.3	15	19	Soil	2000	12.8	15
5	Soil	1945	12.7	14	20	Soil	1935	12.6	14
6	Soil	1995	12.8	14	21	Soil	1950	12.7	15
7	Soil	2000	12.8	15	22	Soil	1970	12.8	17
8	Soil	2000	12.8	15	23	Soil	1300	10.4	17
9	Soil	1335	10.5	15	24	Soil	2000	12.8	14
10	Soil	1650	11.7	17	25	Soil	2000	12.8	15
11	Soil	1900	12.5	14	26	Concrete	65	1.94	20
12	Soil	2000	12.8	15	27	Concrete	65	1.94	20
13	Soil	1980	12.8	15	28	Concrete	115	2.58	20
14	Soil	2000	12.8	14	29	Concrete	115	2.58	20
15	Soil	2000	12.8	15					

4.2 Number of Static Measurements/Soil Samples

MARSSIM provides a method to determine the number of measurement locations required in a given survey unit. A minimum number of measurement locations are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The following subsections describe the bases for and derivation of the minimum required measurement locations per survey unit.

Estimation of Relative Shift

The minimum number of measurement locations required is dependent on the distribution of site residual radionuclide concentrations relative to the $DCGL_w$ and acceptable decision error limits (α and β).

The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated using the guidance found in Section 5.5.2.3 of MARSSIM. The relative shift is calculated as follows:

$$\Delta/\sigma = \frac{DCGL_w - LBGR}{\sigma}$$

Where: $DCGL_w$ = Derived Concentration Guideline Level

LBGR = concentration at the lower bound of the gray region. The Lower Bound of the Grey Region (LBGR) is the concentration at which the survey unit has an acceptable probability of passing the statistical tests.

σ = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system).

The $DCGL_w$ for surface soil radioactivity is 105 pCi/g. The LBGR is estimated at 52.5 pCi/g which is half of the $DCGL_w$ as suggested by MARSSIM. Using an estimated coefficient of variation of 30 percent and the LBGR as an estimate of the sample mean, a sigma value of 15.8 pCi/g is calculated. Using the parameters discussed above, the relative shift is calculated as 3.3.

The unenclosed concrete pad $DCGL_w$ for surface alpha radioactivity is 100 dpm/100cm^2. The LBGR was conservatively estimated at 70 dpm alpha/100 cm^2 based on previous studies with similar instruments on concrete. Without prior survey, it is reasonable to assume a coefficient of variation on the order of 30 percent (MARSSIM Section 5.5.2.2). Using a coefficient of variation of 30 percent and the LBGR as an estimate of the sample mean, a sigma value of 21 dpm/100cm^2 is estimated. Using the parameters discussed above, the relative shift is calculated as 1.4.

The unenclosed steel structures and HEPA motor are considered equipment and will be released based on Army Regulation 11-9, submitted as part of the APG ATC NRC License document SUB-834. Table 5-2 of Army Regulation 11-9 provides for surface radioactivity values of up to 1,000 dpm/100 cm^2 removable and 5,000 dpm/100 cm^2 total activity for ^{235}U and ^{238}U and associated decay products. These values are the same as provided by Regulatory Guide 1.86.

Determination of N (Number of Required Measurement Locations)

For soil SUs, the final number of suggested measurement locations per survey unit is 14 as per MARSSIM (Table 5.5) given a relative shift of 3.7 and an error rate for both Type I and Type II errors of five percent (i.e., $\alpha = \beta = 0.05$). The actual number of measurements to be performed in each survey unit ranges from 14 to 17 samples based on the size and geometry of the SU and are presented in Table 4.1-1.

For unenclosed concrete structures, the final number of direct surface required measurement locations per survey unit is 20 as per MARSSIM (Table 5.5) given a relative shift of 1.4 and an error rate for both Type I and Type II errors of five percent (i.e., $\alpha = \beta = 0.05$). The actual number of measurements to be performed in each concrete survey unit is 20 samples based on the size and geometry of the survey area.

4.3 Elevated Measurement Criterion ($DCGL_{EMC}$)

MARSSIM states that, for Class 1 survey units, a dose area factor should be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion. For the purpose of ALARA, the $DCGL_w$ will be used as the $DCGL_{EMC}$ for both soil and structures. This corresponds to an area factor of one. Since soil and structure MDC_{SCAN} values are sensitive enough to identify a concentration that is less than half of their respective $DCGL_w$, it is unlikely that small areas of elevated activity exceeding the release criterion would be missed during scanning.

4.4 Static Measurement Locations

Measurement locations in Class 1 survey units will be established using a random start point in a systematic triangular grid. The grid spacing for Class 1 survey units will be determined, based on the measured area of the survey unit, using the following equation (Equation 5-7 from MARSSIM).

$$L = \sqrt{\frac{A}{0.866\,N}}$$

Where: L = rectangular grid spacing for survey unit
A = area of survey unit
N = number measurement locations

Measurement spacing results (L) using the equation above are presented in Table 4.1-1. Maps presenting the BTD site SU delineations and the reference coordinate system are presented in Appendix D.

4.5 Gamma Walkover Surveys

GWS will be performed as described in Section 3.1 over 100% of reasonably accessible soil SU areas. If a scan measurement exceeds the soil action level, the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, the immediate area will be rescanned to verify the initial result. If the verified result is greater than the action level, the location will be marked for further remediation followed by additional surveying of the location.

As described previously in section 2.1, the ravine area site feature has water covered surfaces that range from several centimeters to approximately 15 centimeters in depth. Scan surveys over soil areas covered by more than 13 cm of water may result in a MDC_{SCAN} sensitivity less than the soil $DCGL_W$ of 105 pCi/g. To compensate for potential reduced instrument sensitivity in these areas, streambed sediment samples will be taken. The GWS for the area will be provided up to the areas of standing water. Sediment samples will be taken in the center of the streambed ravine where GWS measurements stop. Section 4.7 provides additional details associated with the sediment sampling.

4.6 Surface Alpha Radioactivity Scan Surveys

Alpha scan surveys will be performed as described in Section 3.2 and will cover 100% of reasonably accessible structure surfaces. Areas of elevated radioactivity identified during scanning will be physically marked and biased integrated measurements will be performed to quantify surface alpha activity concentrations for direct comparison to the $DCGL_W$. Survey areas in excess of the $DCGL_W$ will be investigated by the Field Supervisor and flagged for additional biased sampling (e.g., smear sampling). Beta scans will be performed in tandem with alpha measurements and recorded for qualitative purposes only.

4.7 Soil Sampling

Sampling of surface soil will be performed in soil SUs at locations selected for MARSSIM statistical testing and at biased locations identified during the GWS. Such measurements will be performed as described in Section 3.3. Collected samples will be sent to an offsite laboratory for isotopic uranium analysis.

Sediment samples will be taken in the streambed of the ravine to provide additional assurance that the soil action levels are not exceeded for this area. The sediment samples collected may take the place of systematic soil samples that may be co-located in streambed areas covered by water. Sediment samples will be taken in the approximate center of the ravine streambed at a rate of 1 sediment sample for every 7 linear meters of the ravine. This will result in a statistically significant number of samples (20 samples) based on the estimated total length of the ravine of 140 meters. The locations for these samples will be determined in the field due to the transient nature of the water in the ravine area.

4.8 Integrated Direct Surface Alpha Radioactivity Measurements

Measurements of surface alpha radioactivity will be performed on structures at locations selected for MARSSIM statistical testing and at biased locations identified prior to and during scanning activities. Such measurements will be performed as described in Section 3.4. Beta measurements will be performed in tandem with alpha measurements and recorded for qualitative purposes.

If any alpha survey measurement results in readings above the structure $DCGL_W$, the Field Supervisor shall be notified and the detector and survey location shall be evaluated. Following evaluation, a follow-up measurement shall be performed at the measurement location to verify the initial result. If the result of the verification measurement is in excess of the $DCGL_W$, remediation of the surface followed by biased sampling will be performed at that location.

4.9 Gamma Dose Rate Measurements

Gamma dose rate measurements will be performed at locations selected for MARSSIM statistical testing and at biased locations identified during scanning. At soil locations, dose rate measurements will be prior to soil samples being drawn. Gamma dose rate measurements may be performed to ensure worker safety and to identify unusual dose rate conditions. Gamma dose rate measurements will be performed as described in Section 3.5.

4.10 Smear Sample Collection and Analysis

Smear samples will be collected at biased survey locations and at least 10% of systematic survey locations. Smear samples will be collected as described in Section 3.6. Beta measurements will be performed in tandem with alpha measurements and recorded for qualitative purposes. Smear samples will also be collected on soil sampling equipment between sampling.

5.0 EQUIPMENT RELEASE

5.1 Survey of Equipment for Release Without Restriction

Certain equipment present within the BTD site boundaries may need to be surveyed for consideration of release without restriction. CABRERA will follow the surface release limits of 1,000 dpm/100 cm^2 removable DU alpha activity and 5,000 dpm/100 cm^2 total DU alpha activity per Army Regulation 11-9, "*The Army Radiation Safety Program*". It is expected that all final release surveys of equipment will be performed by the licensee and these surveys will follow APG procedures. If CABRERA performs these release surveys for APG, then CABRERA will follow the APG procedures.

6.0 DATA PROCESSING

This section describes how project events and data will be retained for this FSS.

6.1 Project Log Book

All significant events which occur during this FSS be documented and retained for future reference. While many types of project events have specific forms on which they are documented, many events occur on a routine basis during survey field activities that must be documented as they occur. Additionally, project data transactions must also be recorded as they occur. To provide a practical means of capturing this information, a project logbook will be initiated upon project commencement.

Significant project events, including data transactions involving project electronic data, shall be recorded in the Project Logbook. Data transactions are defined as any transfer, download, export, copy, differential correction, sort, or other manipulation performed on project electronic data. Project Logbook records shall be sufficient to allow data transactions to be reconstructed after the project is completed. The Field Supervisor shall be responsible for maintaining the Project Data Logbook and will review the Project Data Logbook at least daily to report significant issues.

The Project Logbook is considered a legal record and will be permanently bound and the pages will be pre-numbered. Pages may not be removed from the logbook under any circumstances. Entries shall be legible, factual, detailed, and complete and shall be signed and dated by the individual(s) making the entries. If a mistake is made, the individual making the entry shall place a single line through the erroneous entry and shall initial and date the deletion. Under no circumstances shall any previously entered information be completely obliterated. Use of whiteout in the Project Logbook is not permitted for any reason. Only one Project Logbook will be maintained. If a Project Logbook is completely filled, another volume shall be initiated. In this case, each volume shall be sequentially numbered.

6.2 Project Electronic Data

Much of this FSS will rely on data collected and stored electronically. Electronic data is subject to damage and/or loss if not properly protected. As such, all project electronic data shall be downloaded from its collection device (e.g., laptop computers, data loggers, etc.) on at least a daily basis. At the conclusion of each day's survey activities, the Field Supervisor shall back up all electronic data collected that day to appropriate removable media (e.g., CD, zip disk, or equivalent) and shall ensure the backup is removed from site. Under no circumstances shall the backup be stored in the same building in which the original project electronic data is stored.

Data files shall be named according to a naming protocol designated by the Field Supervisor. No variations from this protocol shall occur without the prior concurrence of the field supervisor. During data download and transfer transactions, the applicable data file name(s) shall be included in project data logbook entries.

7.0 INTERPRETATION OF SURVEY RESULTS

The results of individual soil and sediment samples and direct integrated alpha measurements performed for this FSS will be evaluated statistically and compared to the release criteria. This comparison will determine if the BTD site can be considered for release without radiological restriction. If all of the SUs of the BTD site meet the criteria for unrestricted release, the entire BTD site as defined in this FSS will be considered a viable candidate for unrestricted release.

Background in the sampled matrix is not considered during interpretation of individual soil samples, concrete smear samples, or the integrated alpha count measurements associated with soil, sediment, and concrete at the BTD site. This is a conservative approach and is appropriate since the background for these media are small compared to the $DCGL_w$ levels.

In accordance with MARSSIM guidance, a preliminary data review will be performed to identify patterns, relationships, and potential anomalies present in the survey data. In this review, basic statistics including the mean, standard deviation, maximum, and minimum values will be calculated for each SU. A graphical review of the data will be performed consisting of posting plots and histograms. Posting plots will be used to review the spatial independence of measurements within survey units, while histograms will be employed to review the overall symmetry of the data.

Once the data have been reviewed, soil sample or direct integrated alpha measurement results for each SU will be compared to the respective $DCGL_W$. If all of the results for a SU are below the $DCGL_W$, the survey unit meets the release criteria. If the average residual radioactivity in an individual SU is greater than the $DCGL_W$, the SU does not meet the release criteria. If any results in a SU are greater than the $DCGL_W$ and the average residual radioactivity in that survey unit is below the $DCGL_W$, the Sign test will be performed as described in MARSSIM to compare the median concentration of residual radioactivity in individual survey units to the $DCGL_W$. If the results of that survey unit pass the Sign test, that SU meets the release criteria. Finally, a retrospective power curve will be computed to measure the power of the Sign test based on the results of the measurements performed. The results of all of these statistical processes will be provided in the FSS Report.

8.0 SURVEY QUALITY ASSURANCE/QUALITY CONTROL

Activities associated with this work plan shall be performed in accordance with written procedures and/or protocols to ensure consistent, repeatable results. Topics covered in project procedures and protocols may include proper use of instrumentation, Quality Control (QC) requirements, equipment limitation, etc. Implementations of Quality Assurance (QA) measures for this work plan are described herein.

8.1 Instrumentation Requirements

The Field Supervisor is responsible for selecting the instrumentation required to complete the requirements of this work plan. Only instrumentation approved by the Field Supervisor will be used to collect radiological data. The Field Supervisor is responsible for ensuring individuals are appropriately trained to use project instrumentation and other equipment, and that instrumentation meets the required detection sensitivities. Instrumentation shall be operated in accordance with either a written procedure or manufacturers' manual, as determined by the Field Supervisor. The procedure and/or manual will provide guidance to field personnel on the proper use and limitations of the instrument.

Calibration Requirements

Instruments used during the FSS shall have current calibration/maintenance records kept on site for review and inspection. The records will include, at a minimum, the following:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

Instrumentation shall be maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments are maintained. Instruments will be calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using National Institute of Standards and Technology (NIST) traceable sources.

8.2 Instrument QC Source and Background Checks

The following subsections describe the techniques that will be used to evaluate accuracy and precision of measurements obtained with project instrumentation. Daily instrument response check data and calibration certificates for each instrument will be included in an appendix of the FSS.

Sodium Iodide (NaI) Gross Gamma Systems

NaI detectors coupled to count rate meters and DGPS systems will be used to perform gamma walk-over surveys and integrated fixed location measurements. Instruments will be calibrated at

least annually at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using NIST-traceable standards.

Instruments will be response checked daily for quality control by comparing the instrument response to a designated ^{137}Cs source. Response checks will consist of a one-minute integrated count of the ^{137}Cs source positioned in a reproducible geometry (i.e., a jig). The acceptance criterion for these instrument response checks is within +/- 20% of the mean response generated using ten initial source checks and ten measurements of ambient background. A response check outside these criteria will be cause for evaluation of conditions (e.g., instrument operation, source/detector geometry). The response check will be repeated once prior to field use of that instrument. Instruments that fail the second response check will be removed from service. During daily response checks, instruments will be inspected for physical damage, battery voltage levels, current calibration and erroneous readings.

Background checks will be performed daily for each instrument. These checks will be performed to monitor fluctuations in ambient gamma background that could impact the interpretation of the gross gamma measurements, not to monitor the performance of the instruments. The results of the background measurements will be recorded and presented on a control chart.

MicroRem Meter

A MicroRem meter will be to provide gamma dose rate information during performance of area radiation surveys. The instrument was calibrated at least annually by a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using NIST-traceable standards.

Instruments will be checked daily for quality control by comparing response to a designated ^{137}Cs source. Response checks will consist of exposing the instrument to a designated ^{137}Cs source positioned in a reproducible geometry and location. The acceptance criterion for these instruments is response within a +/- 20% of the mean response generated using ten initial source checks and ten measurements of ambient background. A response check outside these criteria is cause for evaluation of conditions (e.g., instrument operation, source/detector geometry). The response check is repeated once prior to field use of that instrument. Instruments that fail the second response check will be removed from service pending evaluation. During daily response checks, the instrument used to obtain radiological data was also inspected for physical damage, battery voltage levels, current calibration and erroneous readings in accordance with CABRERA procedures.

Alpha/Beta Detector

Quality control source checks for the Ludlum 43-93 will consist of a one-minute integrated count with the designated Thorium–230 (^{230}Th) and Technetium-99 (^{99}Tc) sources. The acceptance criterion for this instrument response is within +/- 20% of the average response generated using ten initial source checks and ten measurements of background performed at the beginning of the project. A response check outside these criteria will be cause for evaluation of conditions (e.g., instrument operation, source/detector geometry), and the response check will be repeated once

prior to field use of that instrument. Instruments that fail the second successive response check will be removed from service and corrective actions will be taken. Only Field Supervisors can return a failed instrument back to service after proper corrective actions are taken and documented.

Smear Counter

A Ludlum Model 2929 smear counter will be used for on site analysis of radiological contamination smears in conjunction with project soil sampling. The instrument will be calibrated at least annually at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using NIST-traceable standards.

Instruments will be checked daily for quality control by comparing response to designated ^{230}Th (Alpha) and ^{99}Tc (Beta) NIST-traceable sources and to ambient background. Response checks will consist of a one-minute count of the ^{230}Th and ^{99}Tc sources positioned in a reproducible geometry and location within the detector system. Background measurements will be performed in an identical fashion for a twenty-minute count, with the source removed. The acceptance criteria for instrument response will be set to two and three-sigma of the mean response generated using ten initial source checks and ten measurements of ambient background. A response check outside the two-sigma, but within the three-sigma criteria will be cause for a recount prior to further evaluation. A response check outside two sigma on the second count or three-sigma on the initial count will be cause for further evaluation prior to continued use. A response check outside these criteria is cause for notification of the Field Supervisor and evaluation of conditions (e.g., instrument operation, source/detector geometry) prior to further counts and/or removal of the instrument from service. Instruments must pass a response check prior to field use. During daily response checks, instruments used to obtain radiological data will also be inspected for physical damage, battery voltage levels, current calibration and erroneous readings in accordance with CABRERA procedures.

Digital Global Positioning System

DGPS point features will be collected at the beginning and end of the day at a fixed location established at the beginning of the FSS. Results of these feature counts will be compared to the mean of a series of sequential initial positions. This data will be entered into a spreadsheet and examined to ensure no more than one-meter variability occurs. A feature count outside these criteria is cause for notification of the Site Supervisor and evaluation of conditions prior to further counts and/or removal of the GPS from service. GPS units must pass a feature count prior to field use. During daily feature counts, GPS systems will also be inspected for physical damage, battery voltage levels and erroneous readings in accordance with SOPs.

8.3 Duplicate Measurements

Instrumentation will be operated and sampling performed in accordance with standard operating procedures and/or protocols.

Duplicate Measurements

Duplicate measurements will be required for 10% of the total soil samples collected from all survey units. Duplicate measurements will be compared to the initial analytical results by determining a Normalized Absolute Difference (NAD) value and comparing it against the performance criteria specified as follows:

Analyses of field and laboratory duplicates will be compared to the initial analytical results by determining a NAD value for each data set by the following equation:

$$NAD = \frac{|Sample - Duplicate|}{\sqrt{\sigma^2_{Sample} + \sigma^2_{Duplicate}}}$$

Where: Sample = first sample value (original),
Duplicate = second sample value (duplicate),
σ_{Sample} = 2σ counting uncertainty of the sample, and,
$\sigma_{Duplicate}$ = 2σ counting uncertainty of the duplicate

The calculated NAD results will be compared to a performance criteria of less than or equal to 1.96. Calculated NAD values less than 1.96 will be considered acceptable and values greater than 1.96 will be investigated for possible discrepancies in analytical precision, or for sources of disagreement with the following assumptions of the test:

- the sample measurement and duplicate or replicate measurement are of the same normally distributed population.
- the standard deviations, σ_{Sample} and $\sigma_{Duplicate}$, represent the true standard deviation of the measured population.

9.0 REFERENCES

(ANL, 1999) ANL Environmental Assessment Department Health Risk Report, "*Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland*", M. Picel and S. Kamboj, Argonne National Laboratory, April 1999

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

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Appendix A:
Uranium 238 Decay Series

Uranium 238 Decay Series

(Excerpted from Radioactive Decay Data Tables, David Kocher, 1981)

Radionuclide	Half-Life	Emissions	Energy (MeV)	Percent Yield
U-238	4.5 x 109 y	α	4.2	75
		α	4.15	25
Th-234	24.1 d	β	0.193	79
		β	0.1	21
		γ	0.093	4
		γ	0.063	3.5
Pa-234m	1.17 min	β	2.29	98
Pa-234	6.75 h	β	0.53	<1
		β	1.13	<1
U-234	2.47 x105 y	α	4.72	28
		α	4.77	72
Th-230	8.0 x 104 y	α	4.62	24
		α	4.68	76
Ra-226	1602 y	α	4.60	6
		α	4.78	95
		γ	0.186	4
Rn-222	3.82 d	α	5.49	100
Po-218	3.05 min	α	6.0	100
Pb-214	26.8 min	β	0.65	50
		β	0.71	40
		γ	0.3	19
		γ	0.35	36
Bi-214	19.7 min	β	1.0	23
		β	1.51	40
		β	3.26	19
		γ	0.609	47

Appendix B:

Derived Concentration Guideline Level (DCGL) Determination For U. S. Army Garrison, Aberdeen Proving Grounds (APG) Bomb Throwing Device Site

U. S. ARMY GARRISON, ABERDEEN PROVING GROUND DERIVED URANIUM GUIDELINES FOR DEPLETED URANIUM AT THE BTD SOIL SAMPLE AREA

Contract Number
DAAA09-00-G-0002 / 039

Prepared for:

U.S. Army Operations Support Command
Rock Island, Illinois

Performed By:

CABRERA Services Inc.
809 Main Street
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Project No. 01-3030.39

EXECUTIVE SUMMARY

The depleted uranium (DU) derived concentration guideline level (DCGL) developed for the Transonic Range is considered applicable to and adequately protective for the BTD Site on the basis of comparable site-specific RESRAD parameters/pathways, the similarity of both locations, and the equivalence of the radiological isotopic DU mixes at both locations. Use of the approved Transonic DCGL at the BTD Site will ensure that the potential dose to a hypothetical individual will not exceed 25 mrem in any one year over a 1,000 period consistent with 10 CFR Part 20 Subpart E requirements.

On these bases, the proposed DCGL for the BTD Site in soil is 230 pCi/g total DU (resident-farmer scenario). This evaluation utilizes the more conservative resident-farmer scenario. Additionally, the ALARA principle of as-low-as-reasonably-achievable is applied to provide assurance that hypothetical doses are limited. The ALARA action level has been set at 105 pCi/g.

DERIVED CONCENTRATION GUIDELINE LEVEL (DCGL) DETERMINATION FOR U. S. ARMY GARRISON, ABERDEEN PROVING GROUNDS (APG) BOMB THROWING DEVICE SITE

1.0 BACKGROUND

The Aberdeen Test Center (ATC) Bomb Throwing Device (BTD) site was used between 1982 and 1993 for the testing of Depleted Uranium (DU) munitions. The site consists of the BTD Butt Enclosure, access roads, Plate Storage Area (PSA), and several support buildings situated on approximately 4-5 acres of land. The BTD Butt Enclosure has dimensions of approximately 25 by 50 feet with a height of 20 feet. WESTON previously performed a MARSSIM type characterization at the BTD Site. Data from that characterization has been utilized in this evaluation. The total BTD site land area is approximately 10 acres.

During testing at the site, munitions were fired at either steel plate targets or vehicles placed inside the BTD Butt Enclosure. A HEPA ventilation system associated with the BTD Butt Enclosure was designed to filter potentially contaminated air exiting the building. Heavy equipment was used to transport the armor plates between the PSA and the BTD Butt Enclosure. Currently, approximately 40 tons of DU-contaminated armor plate is located within the BTD Site.

A characterization study was initiated to identify DU and other environmental contaminants currently present in the soil as well as gamma radiation levels at the site. This is in preparation for removal of the BTD Butt Enclosure and decommissioning of the BTD Site currently covered by **NRC LICENSE #.** The WESTON characterization study provided quantitative activity concentration levels of ^{235}U and ^{238}U in soil and identified MARSSIM class 1, 2, and 3 areas based on comparison of results to NRC screening derived concentration guideline levels (DCGLs).

Results from the WESTON BTD Site characterization are compared in this evaluation to characterization data from the Transonic Range. The Transonic Range Decommissioning Plan (DP) developed by ATG utilized the characterization data and DCGL dose analysis as provided by Argonne National Laboratory. NRC has approved this DP.

2.0 SCOPE/PURPOSE

The purpose of this evaluation is to contrast and compare the parameters used to develop the DU-contaminated soil (DCGL) applied at the Transonic Range to the BTD Site. This evaluation will be used to demonstrate that the DCGL used at the Transonic Range may be equally applied at the BTD Site.

3.0 DCGL EVALUATION

The DCGL for the DU Study Area of the Transonic Range is based on a site-specific uranium guideline derived on the basis of a 50-year Total Effective Dose Equivalent (TEDE) to a

hypothetical individual not exceeding 25 mrem in any one year and evaluated over a 1,000 year time interval.

3.1 DCGL Derivation from Transonic DP

The results of a previous DU DCGL developed for the Transonic Range were submitted to NRC as part of a DP for the Transonic Range and was approved. The computer code, RESRAD, Version 5.82 (ANL 1999) used to develop DCGLs for the Transonic Range. The RESRAD code parameters/pathways used in the Transonic Range evaluation was set up to consider nine exposure pathways:

1) Direct exposure from contaminated soil,

2) Internal dose from inhalation of contaminated dust,

3) Internal radiation from the inhalation of emanating radon-222,

4) Internal radiation from the ingestion of plant foodstuffs grown in contaminated soil and irrigated with groundwater drawn from a well located within the decontaminated area,

5) Internal radiation from the ingestion of meat from livestock fed fodder grown in the decontaminated area and irrigated with groundwater from the decontaminated area,

6) Ingestion of milk from milk animals raised with fodder and irrigation groundwater drawn from the decontaminated area,

7) Internal radiation from ingestion of fish from a pond drawing water from the decontaminated area,

8) Internal dose from the ingestion of on-site soil, and

9) Internal radiation from drinking water drawn from an on-site well.

Two potential exposure scenarios were considered using combinations of the above pathways. These are the industrial-worker scenario and the resident-farmer scenario. The industrial-worker scenario assumes the continued industrial use of the site. The scenario assumes 2,000 hours per year at the site with 6 hours per day spent indoors and 2 hours per day spent outdoors. No plant foodstuffs, meat, milk, fish, or water is consumed from the site. The dose is assumed to arise only from the contaminated soil. This scenario reflects the current use and is a likely future use scenario.

The resident-farmer scenario has a subsistence farmer who lives on the site and consumes foodstuffs grown on the site. This includes on-site groundwater for drinking and irrigation, vegetables, fruits, livestock meat, milk, and 50% of the farmer's fish consumption. At the present time, no agricultural activity occurs on the site. This scenario is plausible but considered an unlikely future use. Table 1 provides a summary of the exposure pathways by scenario.

TABLE 1 - Applicable Pathways for Industrial-Worker and Resident-Farmer Scenarios		
	Applicable Pathways	
Pathway	Industrial-worker	Resident-Farmer
External gamma exposure	Yes	Yes
Inhalation of soil	Yes	Yes
Inhalation of radon	Yes	Yes
Ingestion of soil	Yes	Yes
Ingestion of plant foodstuffs	No	Yes
Ingestion of meat	No	Yes
Ingestion of milk	No	Yes
Ingestion of fish	No	Yes
Ingestion of water	No	Yes

3.2 Evaluation of Applicability of Transonic Range DCGL to BTD Site

Since the BTD Site and the Transonic Range are within a few miles of each other at APG, the climate, meteorology, irrigation rates, the type, growth rate, and root depths of vegetation, type of meat and milk producing animals, fish and aquatic organisms, and the geology and soil characteristics are considered to be similar in nature for purposes of this evaluation. Additionally, the types of work activities causing the contamination of the soil are similar and result in like soil surface and vertical distributions. Table 2 provides a summary comparison of the parameters.

The DU contaminated soil at the Transonic Range was characterized from the analysis of 100 total soil samples collected from 1-3 inch and 3-6 inch depths. The samples were analyzed for ^{234}U, ^{235}U, and ^{238}U isotopes by alpha spectroscopy.

TABLE 2 - RESRAD Parameters for Transonic Range and BTD Site												
Region	Area	Soil Cover	Vegetation	Water	Meat	Milk	Fish Pond	Radon	Direct Soil Irrad.	Soil Inhal	Meteor-ology	Geology/ Soil Char.
Transonic Range	12 acre	none	Site parameters are those indigenous to the eastern shore area of Maryland at APG									
BTD Site	10.5 acre	none	Due to geographic proximity of both sites and type of work activities causing soil activity, BTD Site parameters are considered the same									

A soil characterization (WESTON) was completed at the BTD Site in 2001. As with the Transonic Range soil samples, soil was collected from the surface and near surface. At the BTD Site soil was collected from the surface to a depth of 3 inches. Samples were collected in areas designated as class 1, class 2, and class 3 areas following MARSSIM definition and an assumed NRC screening DCGL. A total of 44 samples from the class 1 area had detectable ^{235}U; 36 samples from the class 2 area had detectable ^{235}U; and 20 samples from the class 3 area had detectable ^{235}U activity concentrations. In addition, 13 samples from a background area had detectable ^{235}U activity concentrations.

For the purpose of contaminant magnitude and isotopic mixture evaluation, the BTD Site class 1 and class 2 area characterization results were lumped together as one category because of the significant levels of uranium identified in these areas. The listed class 3 area results were similar in magnitude to that observed in the background area and had ^{235}U/^{238}U ratios that are indicative of natural uranium concentrations as opposed to typical DU ratios. These areas are not considered further in this evaluation.

The BTD Site class 1 and class 2 area data was analyzed in the same fashion as the Transonic Range soil samples, namely case 1 included all samples, case 2 included samples greater than 1 pCi/g, and case 3 excluded samples greater than 1,000 pCi/g ^{238}U. Since the BTD Site analysis was based on gamma spectroscopy, only the ^{235}U and ^{238}U isotopes are identified. A comparison of the soil concentration activity ranges and ^{235}U/^{238}U activity ratios at the Transonic Range and the BTD Site for the 3 cases is shown in Table 3.

The comparison indicates that the ^{235}U/^{238}U activity concentration ratio at the BTD Site is similar to that detected at the Transonic Range. This is expected because the DU utilized at both locations has the same ^{235}U depletion. At both the Transonic Range and the BTD Site the activity ratio of ^{235}U/^{238}U indicates that the uranium is in fact DU since the activity ratio ranges from 0.013 to 0.028 while natural uranium has a ^{235}U/^{238}U activity ratio of 0.045.

TABLE 3 – Transonic Range and BTD Site Soil Data Activity Ratio Comparison									
		Transonic Range				BTD Site			
Case No.	Item	^{234}U	^{235}U	^{238}U	$^{235}U/^{238}U$	^{234}U	^{235}U	^{238}U	$^{235}U/^{238}U$
1[a]	Activity Range, pCi/g	0.19 - 49,000	0.001 - 8,300	0.19 - 370,000	-	No results provided	0.055- 31.7	0.974- 1,470	-
1[a]	Average Activity Fraction	0.211	0.0205	0.768	0.027	-	-	-	0.027
2[b]	Activity Range, pCi/g	6.7 - 49,000	1.2 - 8,300	45 – 370,000	-	No results provided	1.05 – 31.7	70.6 – 1470	-
2[b]	Average Activity Fraction	0.138	0.0234	0.839	0.028	-	-	-	0.013
3[c]	Activity Range, pCi/g	0.19 - 46	0.001 – 6.3	0.19 - 290	-	No results provided	0.055- 5.99	0.974- 528	-
3[c]	Average Activity Fraction	0.222	0.0193	0.759	0.025	-	-	-	0.027
Nat. U	Activity Fraction	0.489	0.022	0.489	0.045	0.489	0.022	0.489	0.045

[a] For case 1, all samples were grouped together
[b] For case 2, only samples with ^{235}U activity greater than 1 pCi/g were grouped together
[c] For case 3, hot samples were removed, and the remaining samples were grouped together

The ^{234}U soil activity concentrations were not determined for the BTD Site since analysis was performed using gamma spectroscopy. However, the dose fraction assigned to a hypothetical individual from the ^{234}U isotope is a small fraction of the total dose. Tables 4 and 5 summarize the maximum dose-to-source concentration ratio (dose conversion factor or DCF) as a function of pathway and scenario at Transonic range as derived from ANL 1999. Since the maximum dose occurs immediately after remediation, the dose from the inhalation of radon, water ingestion, and fish ingestion pathways are zero (ANL 1999). Since the BTD Site depth to ground water is deeper than at the Transonic Range, it is logical that the breakthrough time for the BTD area would be longer than at Transonic. The breakthrough time (i.e., time it takes the uranium to reach the water table) does not occur within 1,000 years (ANL 1999).

The ^{234}U dose contribution DCF for the industrial-worker and the resident-farmer scenarios immediately following remedial action is small, being on the order of 3.4% and 6.5% of the total uranium DCF respectively. Tables 4 and 5 list the fractional DCF for ^{234}U compared to total uranium DCF for the Transonic Range. Based on the information in these two tables, the ^{234}U DCF components are expected to be generally smaller or comparable to the ^{235}U and ^{238}U DCFs. Therefore the ^{234}U DCF may be estimated for the BTD Site as being the same as the Transonic Range without incurring any significant calculation differences.

TABLE 4 – Maximum Dose/Source Concentration Ratios for the Industrial-Worker Scenario at the Depleted Uranium Study Area of the Transonic Range

	Maximum Dose/Source Concentration Ratios[a] (mrem/yr)/(pCi/g)			
Pathway	^{234}U	^{235}U	^{238}U	^{234}U/Total U
External gamma exposure	8.3E-5	1.5E-1	2.6E-2	4.7E-4
Inhalation of dust	4.3E-3	4.0E-3	3.8E-3	3.6E-1
Inhalation of radon	0	0	0	-
Ingestion of soil	2.4E-3	2.2E-3	2.3E-3	3.5E-1
Total	6.7E-3	1.6E-1	3.2E-2	3.4E-2

[a] All values are reported to two significant figures. Maximum dose/source concentration ratios would occur immediately following remedial action for all uranium isotopes. This value is the dose conversion factor, DCF.

TABLE 5 – Maximum Dose/Source Concentration Ratios for the Resident-Farmer Scenario at the Depleted Uranium Study Area of the Transonic Range

	Maximum Dose/Source Concentration Ratios[a] (mrem/yr)/(pCi/g)			
Pathway	^{234}U	^{235}U	^{238}U	^{234}U/Total U
External gamma exposure	2.4E-4	4.3E-1	7.2E-2	4.8E-4
Inhalation of dust	9.9E-3	9.2E-3	8.9E-3	3.5E-1
Inhalation of radon	0	0	0	-
Ingestion of plant foods	1.0E-2	9.7E-3	9.8E-3	3.4E-1
Ingestion of meat	3.2E-3	3.0E-3	3.0E-3	3.5E-1
Ingestion of water	0	0	0	-
Ingestion of milk	8.2E-3	7.7E-3	7.8E-3	3.5E-1
Ingestion of fish	0	0	0	-
Ingestion of soil	7.7E-3	7.3E-3	7.4E-3	3.4E-1
Total	4.0E-2	4.7E-1	1.1E-1	6.5E-2

[a] All values are reported to two significant figures. Maximum dose/source concentration ratios would occur immediately following remedial action for all uranium isotopes. This value is the dose conversion factor, DCF.

The residual radioactive material guideline is the concentration of contaminated material that may remain in a decontaminated area and still allow for unrestricted use of the area. The residual radioactive material guideline, or derived concentration guideline level (DCGL) for a given dose limit, DL, to a hypothetical individual derived from the soil data at the Transonic Range may be calculated as

$$DCGL = DL/DCF$$

Where,

DCGL = Derived Concentration Guideline Level, pCi/g in soil

DL = NRC Dose Limit for unrestricted use, 25 mrem/year for both industrial-worker and resident-farmer

DCF = Dose conversion factor to transform volumetric concentration to dose rate, (mrem/year)/(pCi/g)

The DCF ratios listed in Table 6 were used in turn to determine the allowable residual radioactivity for uranium in soil at the Transonic Range using the *above relationship*. The resulting DCGL for each radionuclide is shown in Table 7. The ^{238}U isotope may be used as an indicator radionuclide by multiplying the Table 7 individual depleted uranium DCGL guideline by the appropriate ^{238}U activity concentration fraction. This allows for use of the readily identified field indicator, ^{238}U, to be used as the indicator radionuclide DCGL.

TABLE 6 – Total Dose/Source Concentration Ratios for Uranium at the Depleted Uranium Study Area of the Transonic Range

	Maximum Dose/Source Concentration Ratios[a] (mrem/yr)/(pCi/g)	
Radionuclide	Industrial-Worker[b]	Resident-Farmer[c]
^{234}U	6.7E-3	4.0E-2
^{235}U	1.6E-1	4.7E-1
^{238}U	3.2E-2	1.1E-1
Natural Uranium	2.2E-2	8.3E-2
Depleted Uranium[d]	2.9E-2	1.0E-1
Depleted Uranium[e]	3.1E-2	1.1E-1
Depleted Uranium[f]	2.9E-2	1.0E-1

[a] All values are reported to two significant figures. Maximum dose/source concentration ratios would occur immediately following remedial action for all uranium isotopes
[b] Industrial-Worker: no consumption of water or food obtained on the site (current use scenario)
[c] Resident-Farmer : Water used for drinking, household purposes, livestock, watering, and irrigation assumed to be from an on-site well (an unlikely but plausible future use scenario)
[d] The uranium isotopes (^{238}U, ^{234}U, and ^{235}U) are present in the activity ratio of 0.768:0.211:0.0205
[e] The uranium isotopes (^{238}U, ^{234}U, and ^{235}U) are present in the activity ratio of 0.839:0.138:0.0234
[f] The uranium isotopes (^{238}U, ^{234}U, and ^{235}U) are present in the activity ratio of 0.759:0.222:0.0193

TABLE 7 – Residual Radioactive material DCGL for Depleted Uranium Study Area of the Transonic Range (25 mrem)		
	DCGL Guideline, pCi/g[a]	
Radionuclide	Industrial-Worker[b]	Resident-Farmer[c]
^{234}U	3,700	630
^{235}U	160	54
^{238}U	790	230
Natural Uranium	1,100	300
Depleted Uranium[d]	860; (660)[g]	250; (190)[g]
Depleted Uranium[e]	800; (670)[g]	230; (190)[g]
Depleted Uranium[f]	880; (670)[g]	250; (190)[g]

[a] All values are reported to two significant figures.
[b] Industrial-Worker: no consumption of water or food obtained on the site (current use scenario, dose constraint 25 mrem/yr)
[c] Resident-Farmer : Water used for drinking, household purposes, livestock, watering, and irrigation assumed to be from an on-site well (an unlikely but plausible future use scenario, dose constraint 25 mrem/yr)
[d] The uranium isotopes (^{238}U, ^{234}U, and ^{235}U) are present in the activity ratio of 0.768:0.211:0.0205
[e] The uranium isotopes (^{238}U, ^{234}U, and ^{235}U) are present in the activity ratio of 0.839:0.138:0.0234
[f] The uranium isotopes (^{238}U, ^{234}U, and ^{235}U) are present in the activity ratio of 0.759:0.222:0.0193
[g] First number is the total DU DCGL; number in parenthesis is the indicator radionuclide ^{238}U value

4.0 SUMMARY

Since the BTD Site and the Transonic Range are within close proximity of each other, the climate, meteorology, irrigation rates, the type, growth rate, and root depths of vegetation, type of meat and milk producing animals, fish and aquatic organisms, and the geology and soil characteristics are considered to be similar in nature. Additionally, since the type of work activities and the DU isotopic activity fractions at both locations are similar they result in surface and vertical distributions of DU that are comparable at both the Transonic Range and the BTD Site.

The DCGL developed at the Transonic Range is considered applicable to and adequately protective for the BTD Site on the basis of comparable site-specific RESRAD parameter/pathways, the similarity of both locations, and the equivalence of the radiological isotopic DU mixes. Use of the approved Transonic DCGL at the BTD Site will ensure that the potential dose to a hypothetical individual will not exceed 25 mrem in any one year over a 1,000-year period. The DCGL for the BTD Site soil is 230 pCi/g total DU (resident-farmer scenario). Additionally, the ALARA principle of as-low-as-reasonably-achievable is applied to provide

assurance that hypothetical doses are limited. The ALARA action level DCGL has been set at 105 pCi/g total DU.

5.0 REFERENCES

1. ANL 1999 — *Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland,* ANL Rad Health Risk Study, M. Picel and S. Kamboj, April 16, 1999

2. WESTON — *Radiological Characterization for the Bomb Throwing Device Interim Report Aberdeen Test Center Aberdeen Proving Ground, MD,* Addendum to the BEST Contract General Safety and Health Program, Rev. 2 September 1999, Contract No. DAAD05-97-D-7004, Delivery Order No. 191, dated September 2001

Appendix C:

Ludlum NaI 3"x3" MDC_{SCAN} and Instrument Sensitivity Results Calculated Using Microshield®

Bomb Throwing Device Area 3x3 NaI Calibration Factor (DU)

MDC_{SCAN}: 38 pCi/g
Sensitivity: 65 cpm per pCi/g
Assumed bkg: 10 uR/hr
Source Distribution per: NUREG-1507 (56 cm dia soil uniformly contaminated to a depth of 15 cm)
DU Activity fractions: 84.7% U238; 14.2% U234; 1.1% U235

BTDA 3x3 NaI Scan for DU @ 1pCi/g total Uranium w/ no soil cover at 15 cm thick x 28 cm RADIUS

Fluence rate to exposure rate (FRER, no units) = ~ (1 uR/h)/(Eγ)(u_{en}/ρ)air

TABLE 1		
Energy$_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g	FRER
15	1.29	0.0517
20	0.516	0.0969
30	0.147	0.2268
40	0.064	0.3906
50	0.0384	0.5208
60	0.0292	0.5708
80	0.0236	0.5297
100	0.0231	0.4329
150	0.0251	0.2656
200	0.0268	0.1866
300	0.0288	0.1157
400	0.0296	0.0845
500	0.0297	0.0673
600	0.0296	0.0563
800	0.0289	0.0433
1,000	0.0280	0.0357
1,500	0.0255	0.0261
2,000	0.0234	0.0214

Probability of interaction (P) through end of detector for given energy is

Probability = $1-e^{-(\mu/\rho)NaI\ (x)\ (\rho NaI)}$

TABLE 2		
Energy$_\gamma$, keV	$(\mu/\rho)_{NaI}$, cm^2/g	P
15	47.4	1.00
20	22.3	1.00
30	7.45	1.00
40	19.3	1.00
50	10.7	1.00
60	6.62	1.00
80	3.12	1.00
100	1.72	1.00
150	0.625	1.00
200	0.334	1.00
300	0.167	0.99
400	0.117	0.96
500	0.0955	0.93
600	0.0826	0.90
800	0.0676	0.85
1,000	0.0586	0.80
1,500	0.0469	0.73
2,000	0.0413	0.68

for Ludlum 3x3 Model 44-20 7.6 cm dia x 7.6 cm thick NaI crystal

aluminum window per Ludlum ~0.05 inch thick

x = 7.6 cm

ρ = 3.67 g/cm^3

Relative Detector Response (RDR) = relative fluence-to-exposure rate (FRER) times probability (P) of interaction

TABLE 3

Energy$_\gamma$, keV	FRER	P	RDR
15	0.0517	1.00	0.0517
20	0.0969	1.00	0.0969
30	0.2268	1.00	0.2268
40	0.3906	1.00	0.3906
50	0.5208	1.00	0.5208
60	0.5708	1.00	0.5708
80	0.5297	1.00	0.5297
100	0.4329	1.00	0.4329
150	0.2656	1.00	0.2656
200	0.1866	1.00	0.1866
300	0.1157	0.99	0.1146
400	0.0845	0.96	0.0812
500	0.0673	0.93	0.0626
600	0.0563	0.90	0.0507
800	0.0433	0.85	0.0367
1,000	0.0357	0.80	0.0287
1,500	0.0261	0.73	0.0191
2,000	0.0214	0.68	0.0146

Estimated Ludlum 44-20 7.6 cm dia x 7.6 cm thick NaI response for Cs-137 is 2700 cpm/uR/hr

Use same methodology and interpolating for Cs-137 response have:

Energy$_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g		
662	0.0294	FRER ~	0.0514

Energy$_\gamma$, keV	$(\mu/\rho)_{NaI}$, cm^2/g		
662	0.0780	Probability =	0.89
		RDR =	0.0455

For this detector the response to another energy is based on the ratio of the relative detector response, RDR, to the Cs-137 energy cpm/μR/h, $E_i = (cpm_{cs\text{-}137})*(RDR_{Ei})/(RDR_{Cs\text{-}137})$

TABLE 4

Energy$_\gamma$, keV	RDR_{Ei}	Ludlum 44-20 3x3 NaI Detector, E_i, cpm per μR/hr
15	0.0517	3064
20	0.0969	5745
30	0.2268	13445
40	0.3906	23161
50	0.5208	30881
60	0.5708	33842
80	0.5297	31404
100	0.4329	25667
150	0.2656	15748
200	0.1866	11061
300	0.1146	6797
400	0.0812	4816
500	0.0626	3714
600	0.0507	3005
662	0.0455	2700
800	0.0367	2175
1,000	0.0287	1704
1,500	0.0191	1131
2,000	0.0146	867

MDC for Cs-137 energy

Assume 10 μR/hr bkg then have 27,000 cpm

b_i =	450	counts
MDCR =	1756	cpm
$MDCR_{surveyor}$ =	2484	cpm

minimum detectable exposure rate = 0.92 μR/hr

Table 5				
keV	MicroShield Exposure Rate, μR/hr (with buildup)	cpm/μR/hr	cpm/μR/hr (weighted)	Percent of NaI detector response
15	8.274E-09	3064	0	0.0%
20	6.657E-11	5745	0	0.0%
30	4.852E-06	13445	9	0.1%
40	7.972E-09	23161	0	0.0%
50	1.133E-06	30881	5	0.1%
60	3.234E-04	33842	1483	16.8%
80	4.275E-05	31404	182	2.1%
100	1.398E-03	25667	4863	55.0%
150	1.108E-04	15748	236	2.7%
200	5.489E-04	11061	823	9.3%
300	1.301E-05	6797	12	0.1%
400	1.473E-05	4816	10	0.1%
500	2.694E-05	3714	14	0.2%
600	1.309E-04	3005	53	0.6%
800	9.470E-04	2175	279	3.2%
1000	3.690E-03	1704	852	9.6%
1500	1.083E-04	1131	17	0.2%
2000	1.755E-05	867	2	0.0%
Total	7.378E-03		8840	100%

Minimum Detectable Exposure Rate =

MDCR surveyor/(cpm/μr/hr)
0.281 μr/hr

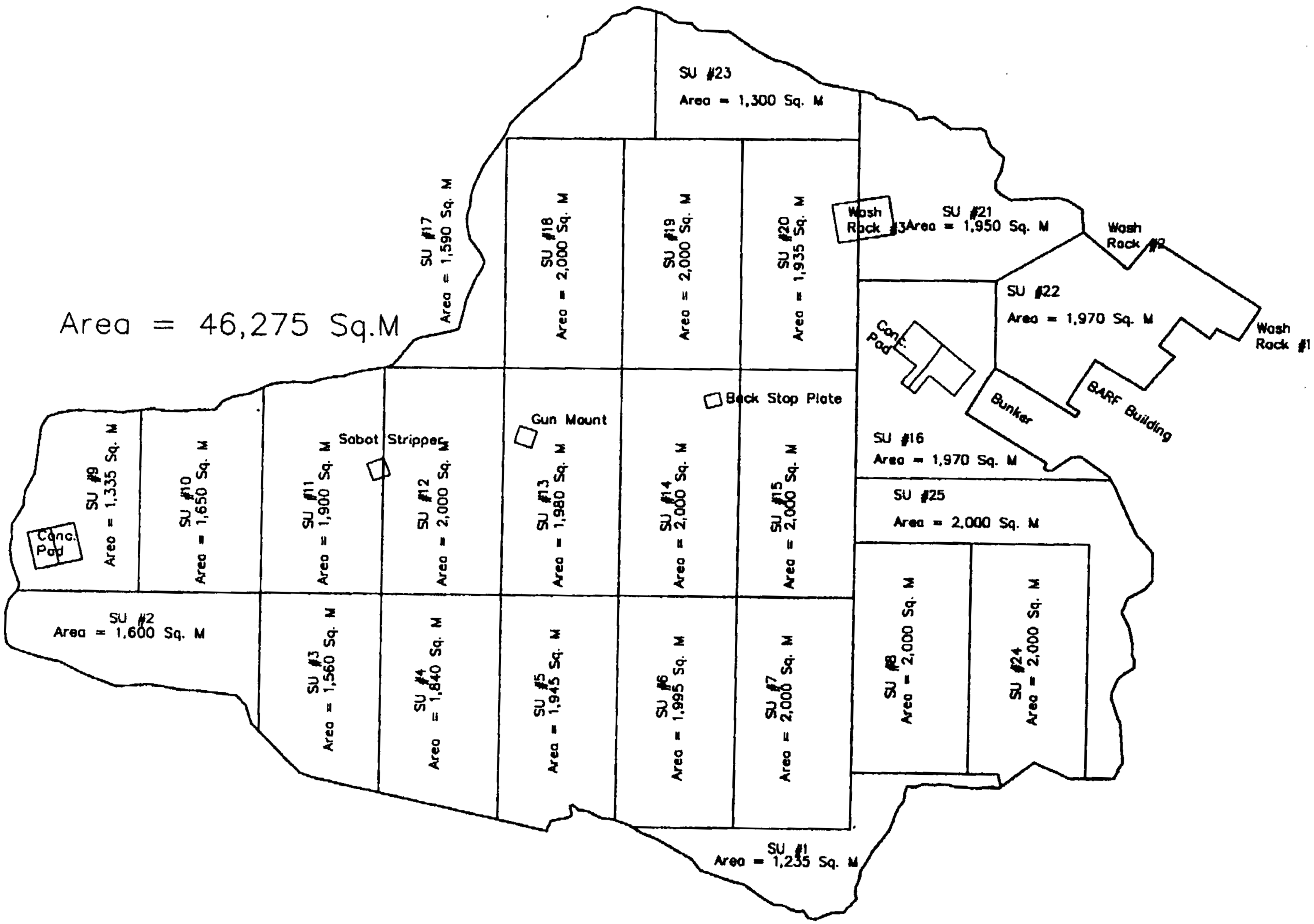
and MDC for DU and 50-year equilibrium progeny based on a normalized 1 pCi/g total uranium

Scan MDC = (Assumed MDC U_{TOTAL}Conc) x (Exposure Rate $MDCR_{Surveyor}$)/(Exposure $Rate_{assumed\ U\ Conc}$)

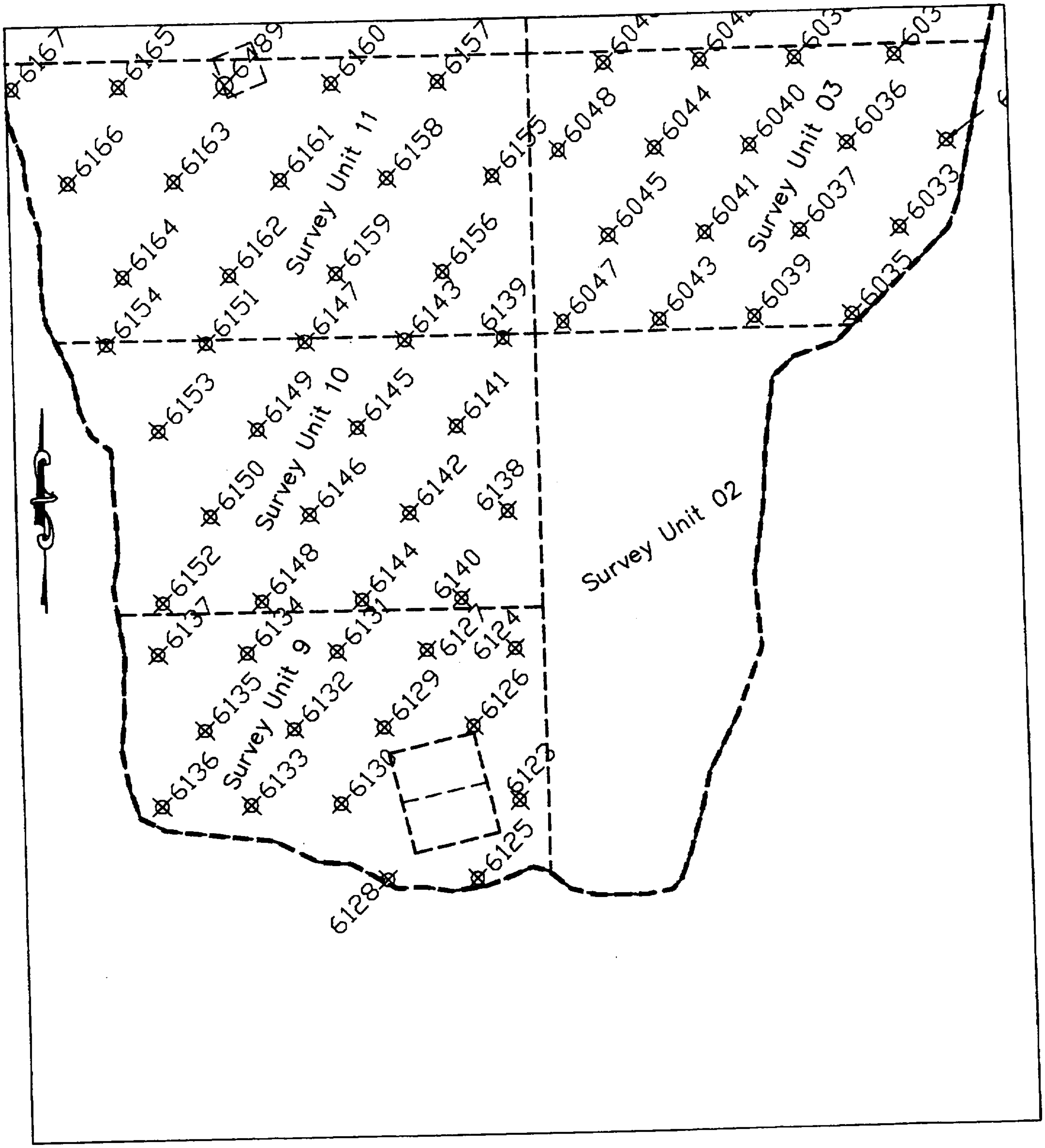
Scan MDC = 38.08 pCi/g

Appendix D:

Survey Unit Maps and Sample Locations



Area = 46,275 Sq.M
SU #23
Area = 1,300 Sq. M
SU #17
Area = 1,590 Sq. M
SU #18
Area = 2,000 Sq. M
SU #19
Area = 2,000 Sq. M
SU #20
Area = 1,935 Sq. M
Wash Rock #3
SU #21
Area = 1,950 Sq. M
Wash Rock #2
SU #22
Area = 1,970 Sq. M
Wash Rock #1
Conc. Pad
Bunker
BARF Building
Back Stop Plate
Gun Mount
Sabot Stripper
SU #16
Area = 1,970 Sq. M
SU #25
Area = 2,000 Sq. M
SU #9
Area = 1,335 Sq. M
Conc. Pad
SU #10
Area = 1,650 Sq. M
SU #11
Area = 1,900 Sq. M
SU #12
Area = 2,000 Sq. M
SU #13
Area = 1,980 Sq. M
SU #14
Area = 2,000 Sq. M
SU #15
Area = 2,000 Sq. M
SU #2
Area = 1,600 Sq. M
SU #3
Area = 1,560 Sq. M
SU #4
Area = 1,840 Sq. M
SU #5
Area = 1,945 Sq. M
SU #6
Area = 1,995 Sq. M
SU #7
Area = 2,000 Sq. M
SU #8
Area = 2,000 Sq. M
SU #24
Area = 2,000 Sq. M
SU #1
Area = 1,235 Sq. M


Survey Unit 11
Survey Unit 10
Survey Unit 9
Survey Unit 03
Survey Unit 02
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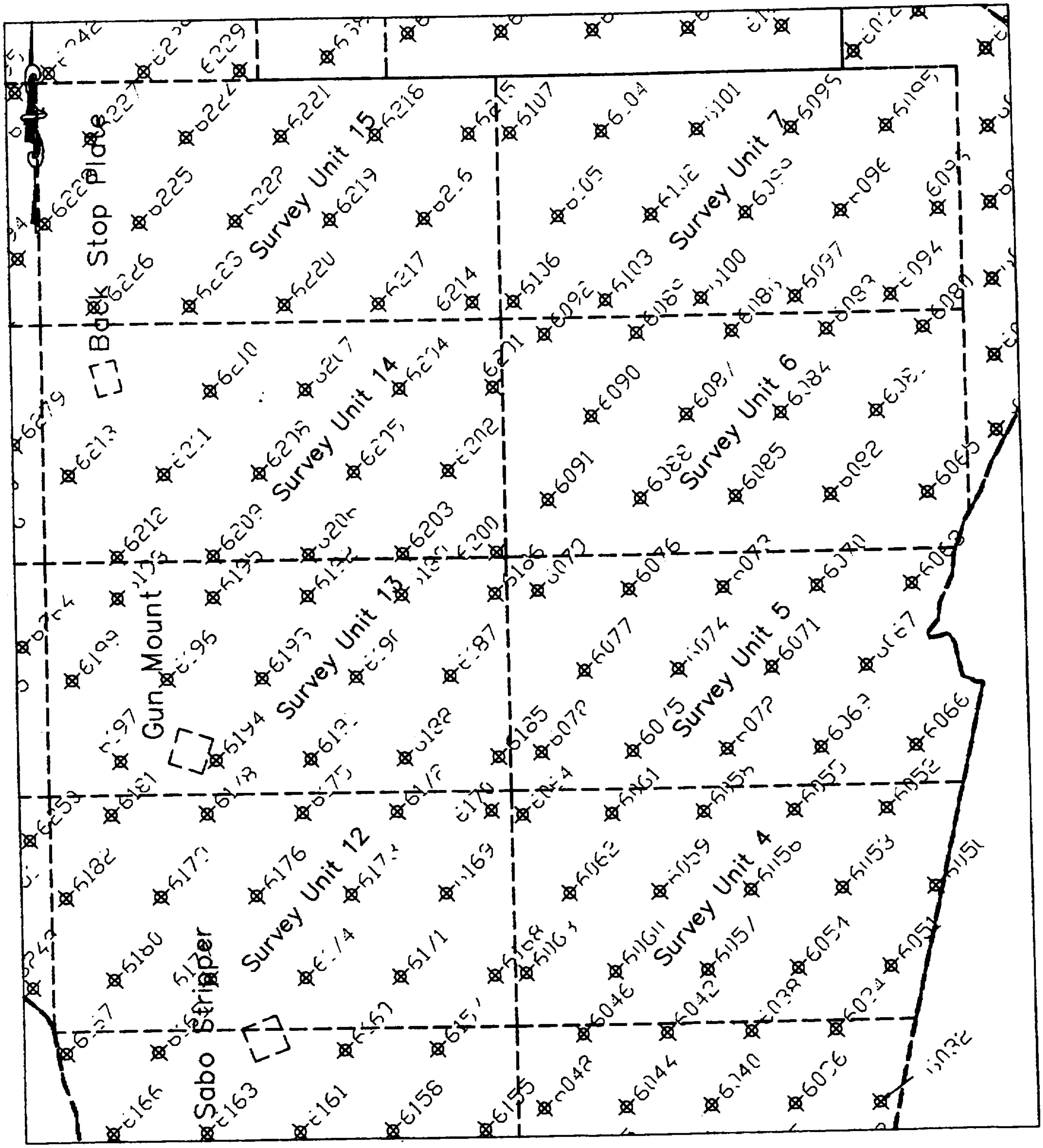
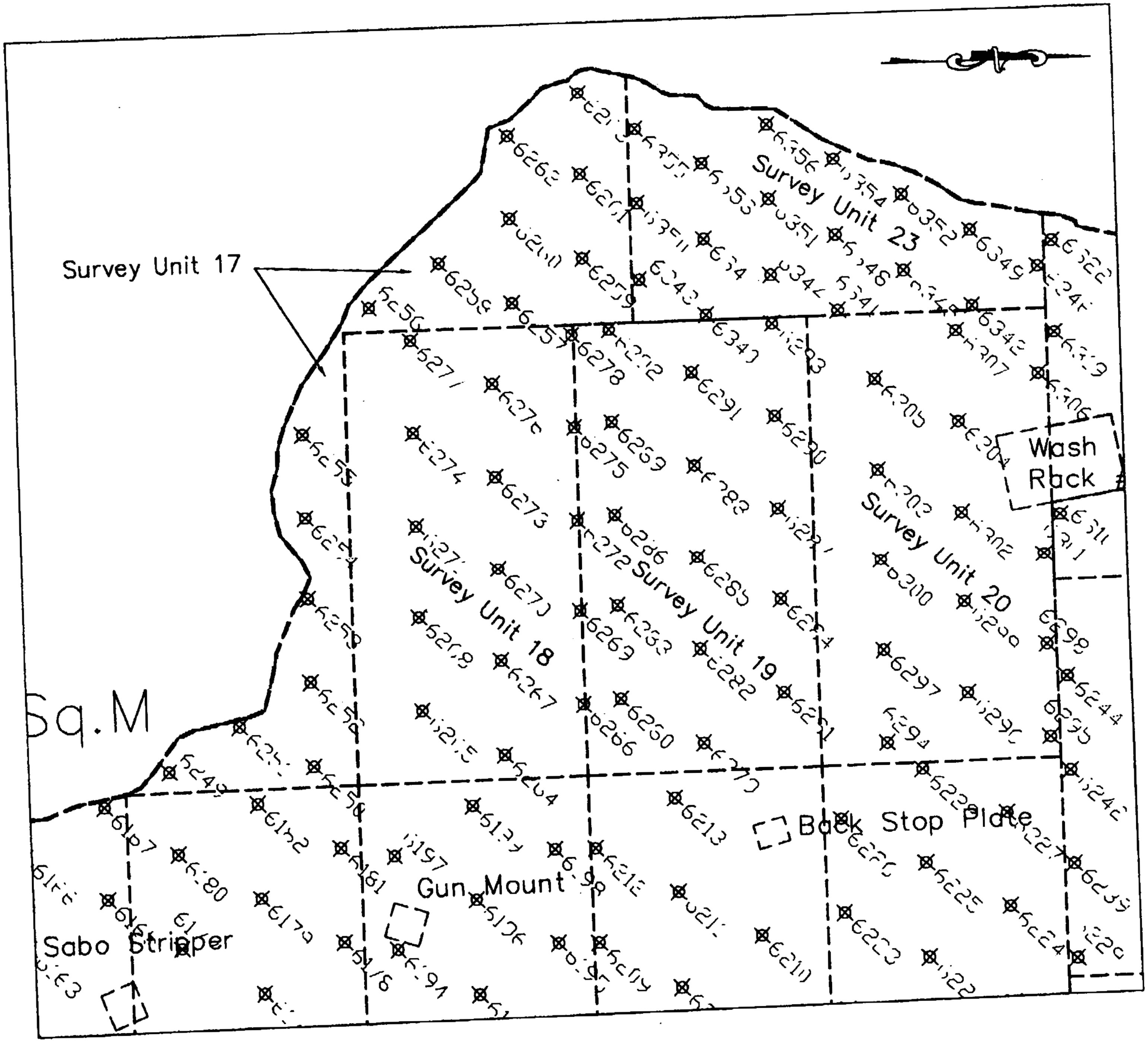


Survey Unit 15
Survey Unit 7
Survey Unit 14
Survey Unit 6
Survey Unit 13
Survey Unit 5
Survey Unit 12
Survey Unit 4
Back Stop Plate
Gun Mount
Sabo Stripper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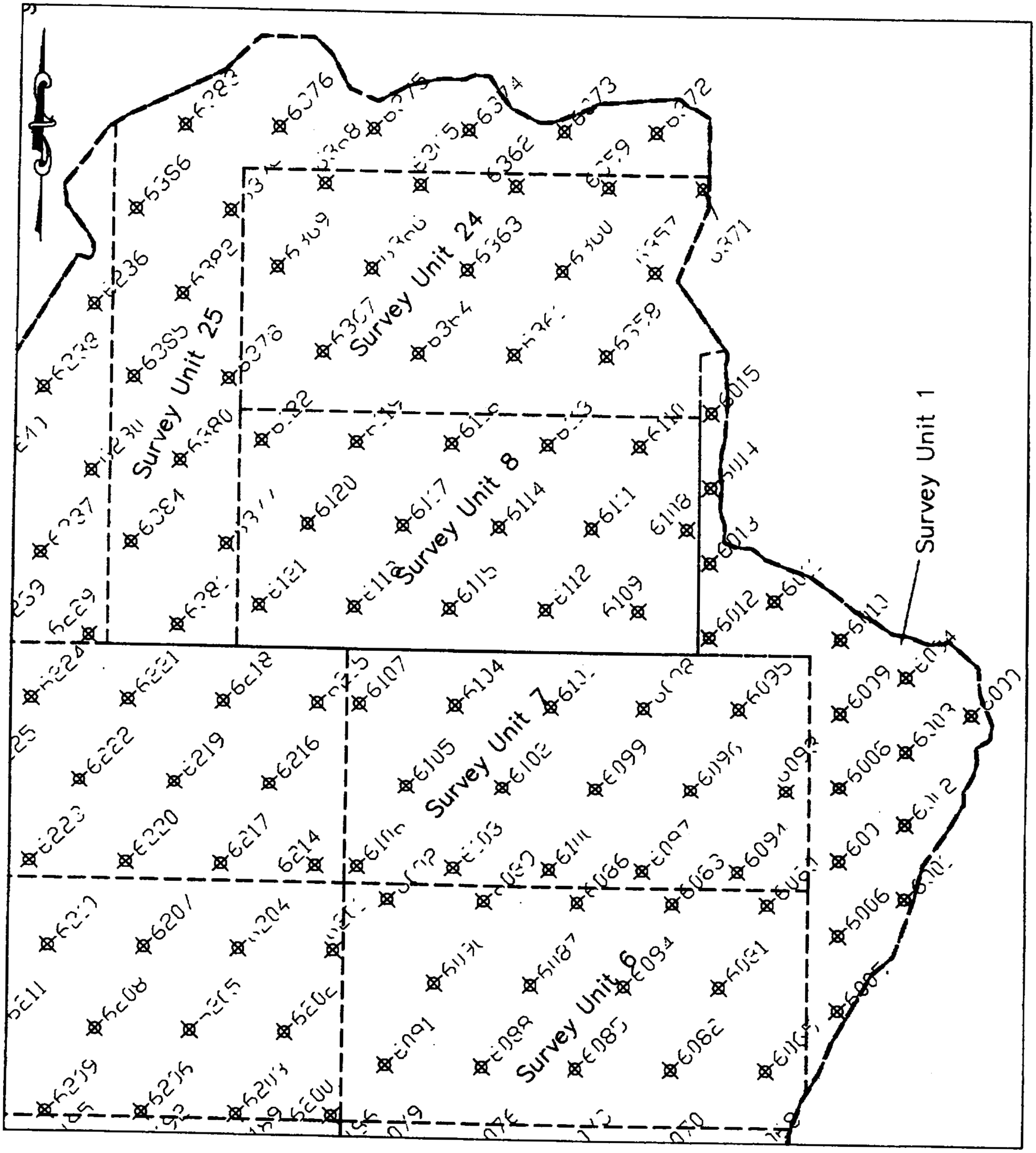
Survey Unit 23
Survey Unit 20
Survey Unit 19
Survey Unit 18
Wash Rack
Back Stop Plate
Gun Mount
Sabo Stripper
Sq.M



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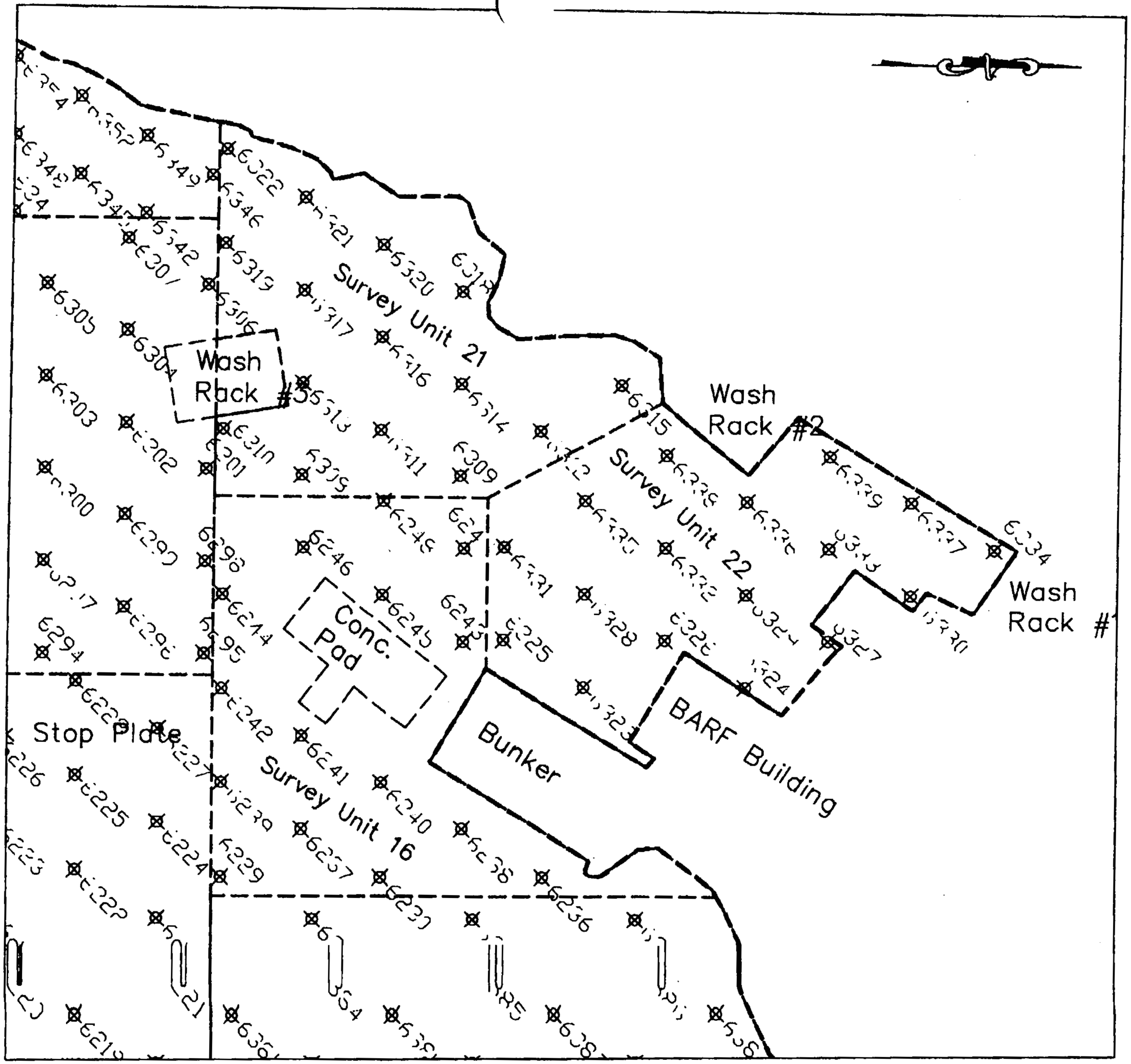
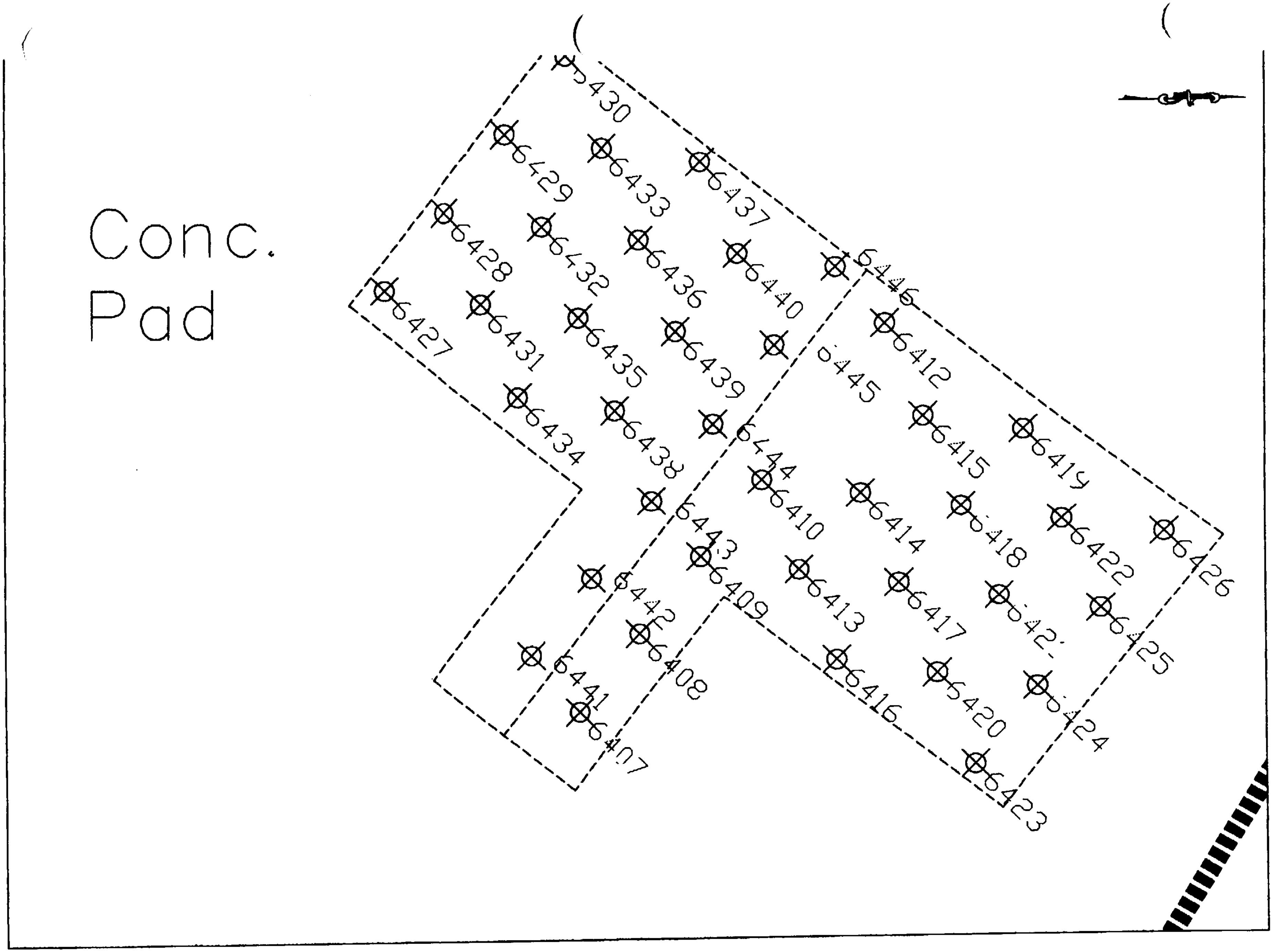
Survey Unit 24
Survey Unit 8
Survey Unit 7
Survey Unit 6
Survey Unit 1


Survey Unit 21
Survey Unit 22
Survey Unit 16
Wash Rack #3
Wash Rack #2
Wash Rack #1
Conc. Pad
Stop Plate
Bunker
BARF Building


Conc.
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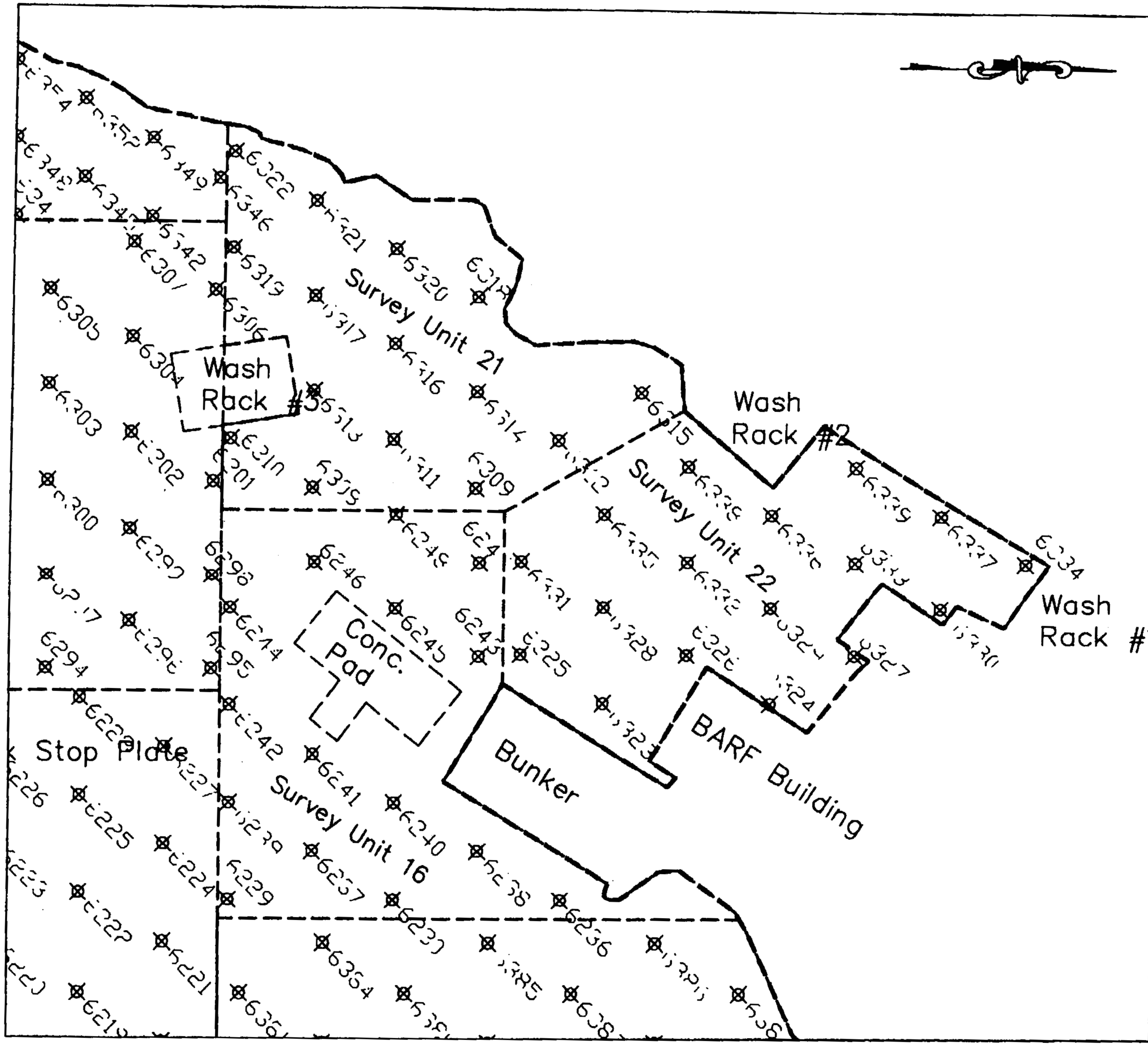


Survey Unit 21
Survey Unit 22
Survey Unit 16
Wash Rack #3
Wash Rack #2
Wash Rack #1
Conc. Pad
Stop Plate
Bunker
BARF Building

(FOR LFMS USE)
INFORMATION FROM LTS

BETWEEN:

License Fee Management Branch, ARM
and
Regional Licensing Sections

Program Code: 11221
Status Code: 0
Fee Category: EX 2B 2C
Exp. Date: 20080930
Fee Comments: SHIELDING AND OTHER
Decom Fin Assur Reqd: Y

LICENSE FEE TRANSMITTAL

A. REGION I

1. APPLICATION ATTACHED
   Applicant/Licensee: ARMY, DEPARTMENT OF THE
   Received Date: 20031117
   Docket No: 4007354
   Control No.: 133995
   License No.: SUB-834
   Action Type: Notifications

2. FEE ATTACHED
   Amount: ______
   Check No.: ______

3. COMMENTS

Signed M. A. Perkins
Date 11/17/2003

B. LICENSE FEE MANAGEMENT BRANCH (Check when milestone 03 is entered /__/)

1. Fee Category and Amount: ______________________

2. Correct Fee Paid. Application may be processed for:
   Amendment ______
   Renewal ______
   License ______

3. OTHER ______________________

Signed ______________________
Date ______________________

ATTACHMENT
CABRERA OPERATIONAL PROCEDURES

CABRERA SERVICES
RADIOLOGICAL • ENVIRONMENTAL • REMEDIATION

Radiation Safety Procedure

For

Volumetric and Material Sampling

OP-005

Revision 0

Reviewed By: ______________________ Date: 1/24/00
David Watters, Radiological Safety Engineer

Approved By: ______________________ Date: 1/24/00
Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: ______________________ Date: 1/24/00
Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure establishes the requirements Cabrera Services, Inc. (CABRERA) implements for the collection of volumetric and material samples for analysis.

2.0 APPLICABILITY

The applicability of this procedure is limited to collecting volumetric and material samples on CABRERA field projects. It also applies to volumetric samples taken for the purpose of analysis for radioactivity. This procedure is applicable to all volumetric and material samples taken by CABRERA to fulfill a requirement for sampling.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Special situations such as evaluating trends or airborne deposition, determining contamination profiles, and measuring non-radiological contaminants, necessitates special sampling procedures. These special situations are evaluated and incorporated into site specific survey plans as the need arises.

The shipping container (e.g., box, cooler, or equivalent) should be lined with plastic and approved absorbent material prior to placing samples inside the shipping container if the samples are to be shipped for analysis. A load rating stamped o the bottom of the shipping container should be noted. This rating shall not be exceeded to prevent degradation of the box during shipment. The PM or designee shall approve packaging material and method.

3.2 Limitations

3.2.1 Do not exceed load rating for containers when shipping samples to prevent degradation of the container during shipping.

3.3 Requirements

3.3.1 Direct surface radiation measurements are to be performed at each location before initiating sampling. This may identify the presence of gross contamination, which may require that samples and equipment be treated as radioactive and handled in accordance with appropriate procedures.

3.3.2 Material sampling requires documentation as follows:

- Record forms
- Sample Chain of Custody forms
- Field Sample Logbook

4.0 REFERENCES

- RSP — Radiation Safety Program
- SHSP — Site Health and Safety Plan
- SWP — Site Work Plan
- NUREG/CR-5512 — Residual Radioactive Contamination from Decommissioning
- 40 CFR 192 — Code of Federal Regulations
- AP-001 — Record Retention
- OP-008 — Chain of Custody
- MARSSIM — Multi-Agency Radiation Survey and Site Investigation Manual

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Sediment – Sediment is solid material that has settled to the bottom of a liquid, usually water (MARSSIM).

5.2 Surface Soil – The top layer of soil that is available for direct exposure, growing plants, re-suspension of particles for inhalation, and mixing from human disturbances (MARSSIM). Surface soil may also be defined as the thickness of soil that can be measured using direct measuring techniques (MARSSIM). Typically, this layer is represented as the top 15 cm (6 inches) of soil (40 CFR 192).

5.3 Subsurface Soil – Subsurface soil is any soil not considered surface soil, typically anything greater than 15 cm (6 inches) below the ground surface (MARSSIM).

5.4 Volumetric Sample – A sample of material, taken for the purpose of determining the radioactivity content in units of activity per unit volume or mass. This does not apply to loose surface material sampled using a cloth smear/swipe, or to activity present only on the surface of solid materials.

6.0 EQUIPMENT

6.1 Volumetric Sampling

The following is a list of the minimum equipment required to perform field volumetric sampling under this procedure.

- A Lietz level log book 8152-50 or the equivalent;
- Survey map(s);
- Chain of Custody and Record Forms;
- Decontamination detergent (e.g., Alconox);
- Sample Containers;
- Indelible marker;
- Distilled Water;
- Clean towels (paper);
- Brushes for decontamination;
- Sample location markers; and
- Digging implement: garden trowel, shovel, spoons, post-hole digger, etc.
- Special sampling apparatus (cup cutter, shelby tube, etc.) as required
- Plastic bags, approximately 10 cm diameter x 30 cm long
- Cardboard "ice cream" containers (1 quart size) or geology sample bags
- Twist-ties
- Masking or duct tape
- Record forms
- Labels and security seals
- Applicable sample collection equipment.

For collecting water samples, the following may also be required:

- pH meter; and
- Nitric acid preservative.

For sample packing and shipping, at a minimum, the following may be required:

- Box, Coolers, or the equivalent;
- Clear packing tape;
- Zipper locking plastic bags;
- Packaging material (vermiculite or use preformed poly-foam liner or equivalent)
- Self adhesive labels;
- "Fragile" and "This Side Up" stickers;
- Chain of Custody and Record Forms as required;
- Ice and;
- Mailing labels.

Equipment is chosen based on the type of material to be sampled. The following list represents some possibilities:

- Paint sampling: heat gun, paint stripper solution, hammer and chisel
- Drains or pipes: plumber's snake, swabs
- Residues: trowels, scoops
- Concrete or asphalt: core boxes, hammer, and chisel
- Metals: emery cloth or scraping tool
- Dusts: scraping tool and plastic bags

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – The PM is responsible for ensuring that personnel assigned the task of collecting volumetric and material samples are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in obtaining material samples described in this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT collecting volumetric and/or material samples is responsible for knowing and complying with this procedure.

7.5 Sample Collectors - Sample Collectors are responsible to follow the instructions of the RFS and Health Physics technicians and to ensure compliance with this procedure.

8.0 INSTRUCTIONS

8.1 General - Collection of Samples

This section is applicable to surface subsurface, sediment, surface water, ground water, and other sample collections.

8.1.1 Survey maps shall be used to document soil sample location, and any survey results related to the particular sample (i.e. loose surface activity of sample container or sampling equipment).

8.1.2 Sample locations should be clearly identified with a stake or other appropriate marker, and labeled with a corresponding sample number when available.

8.1.3 Ensure that the sample container is of adequate type and size prior to collecting a sample. The sample size may depend on the type of analysis being performed, and the desired detection sensitivity. Consult with the laboratory performing the analysis for proper sample container type and size.

8.1.4 If multiple samples are taken, bring appropriate cleaning materials along for cleaning the sampling equipment. Refer to the applicable section of this procedure for instructions regarding sampling equipment decontamination.

8.1.5 A field-sampling logbook shall be used to document pertinent information about the sampling event. Note any significant observations during the sampling event in the field-sampling logbook.

8.1.6 Seal the container with a tamper proof seal. The sampling technician shall initial and date the seal.

8.1.7 Initiate the sample chain of custody record for the sample.

8.1.8 Identify the sample location with a stake or other appropriate marker. Document the sample location on a survey in such a manner that the location can be easily and accurately re-identified.

8.1.9 Clean the sampling equipment prior to collecting another sample in accordance with requirements of this procedure.

8.1.10 Survey sampling equipment to ensure no removable contamination exists, which could result in cross-contamination of samples.

8.1.10.1 Samples that require gamma, beta, or alpha spectroscopy or isotopic discrimination of any type shall be sent to an approved laboratory for analysis.

8.1.10.2 Samples that can fit into a 1/8" x 2" planchette that require gross alpha and/or beta/gamma results may be counted in a Ludlum 2929 or equivalent.Ensure that minimum counting system sensitivity requirements are met by calculating MDA values for alpha and beta, as applicable.

8.1.10.2.1 Place the sample into a planchette with the surface to be measured facing upward.

8.1.10.2.2 Count sample for an appropriate length of time.

8.1.10.2.3 Record count and counting time data, and calculate activity estimates. Record information and data on appropriate Survey Form.

8.1.11 If the collected sample is suspected to contain radioactivity above background levels, survey the sampling equipment for loose surface activity prior to using the equipment to collect another sample. Document the results on a survey map.

8.2 Collection of Surface Samples

8.2.1 Surface Soil Samples shall be collected using appropriate equipment (stainless-steel hand auger, post-hole digger, shovel, etc.)

8.2.2 Ensure that the sampling equipment which makes contact with the soil (i.e. split-spoon sampler, shovels, post-hole digger, sieves, sample containers, etc.) is free from radioactive material contamination. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.2.3 Fill the sample container to the top with surface soil.

8.2.4 Remove large rocks, vegetation, and foreign objects (these items may also be collected as separate samples, if directed). It may be necessary to use a sieve or screen to remove large objects.

8.2.5 Assign a unique sample identification number to the sample. For surface samples, the identifier shall begin with "SS" followed by a series of numbers, where "SS" indicates surface soil as the sample matrix. Additional numerical/alphanumerical designators will be added to indicate the sampling location and number. Label the sample container with the sample number using a permanent marker.

8.2.6 Ensure that the sample is properly labeled and secure the sample container.

8.3 Collection of Subsurface Samples

8.3.1 Subsurface Soil Samples shall be collected using appropriate equipment (stainless-steel hand auger, post-hole digger, shovel, etc.)

8.3.2 Ensure that the sampling equipment which makes contact with the soil (i.e. split-spoon sampler, shovels, post-hole digger, sieves, sample containers, etc.) is free from radioactive material contamination. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.3.3 Fill the sample container to the top with surface soil.

8.3.4 Remove large rocks, vegetation, and foreign objects (these items may also be collected as separate samples, if directed). It may be necessary to use a sieve or screen to remove large objects.

8.3.5 Assign a unique sample identification number to the sample. For surface samples, the identifier shall begin with "SS" followed by a series of numbers, where "SS" indicates surface soil as the sample matrix. Additional numerical/alphanumerical designators will be added to indicate the sampling location and number. Label the sample container with the sample number using a permanent marker.

8.4 Collection of Sediment Samples

8.4.1 Sediment samples shall be collected using the appropriate equipment (i.e. stainless steel Ponar dredge, sample containers, etc.).

8.4.2 Ensure that the sampling equipment which makes contact with the sediment (i.e. stainless steel Ponar dredge, sample containers, etc.) is free from radioactive material contamination. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.4.3 It is important to minimize disturbance of the sediment caused by sampling activities. Move slowly when approaching the sample location. Approach the sampling location from downstream (for moving water) and downwind (for stationary water).

8.4.4 Remove the sediment slowly and gently from the water using the appropriate sampling equipment. Fill the sample container.

8.4.5 Remove large rocks, vegetation, and foreign objects (these items may also be collected as separate samples, if directed). It may be necessary to use a sieve or screen to remove large objects.

8.4.6 Assign a unique sample identification number to the sample. For surface samples, the identifier shall begin with "SS" followed by a series of numbers, where "SS" indicates surface soil as the sample matrix. Additional numerical/alphanumerical designators will be added to indicate the sampling location and number. Label the sample container with the sample number using a permanent marker.

8.5 Collection of Surface Water Samples

8.5.1 Surface water samples shall be collected using the appropriate equipment (i.e. ladle, scoop, pond sampler, funnel, etc.) or by submerging the sample container.

8.5.2 Ensure that the sampling equipment which makes contact with the surface water (i.e. ladle, scoop, pond sampler, funnel, etc.) is free from radioactive material contamination. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.5.3 It is important to minimize disturbance of the sediment caused by sampling activities. Move slowly when approaching the sample location. Approach the sampling location from downstream (for moving water) and downwind (for stationary water).

8.5.4 Rinse the sampling equipment and sampling container with distilled water, or in the same water to be sampled if possible. Remove the water slowly and gently using the appropriate sampling equipment, and fill the sample container. If the water is deep enough, surface water samples can be collected by dipping the polyethylene sample container directly into the water body.

8.5.5 Test the pH of the water sample. If the pH is greater than 2.0, add nitric acid to reduce the pH to 2.0 or less.

8.5.6 Assign a unique sample identification number to the sample. For surface samples, the identifier shall begin with "SS" followed by a series of numbers, where "SS" indicates surface soil as the sample matrix. Additional numerical/alphanumerical designators will be added to indicate the sampling location and number. Label the sample container with the sample number using a permanent marker.

8.6 Collection of Ground Water Samples

8.6.1 Ground water samples shall be collected using the appropriate equipment (i.e. peristaltic pump, bailer, etc.).

8.6.2 Ensure that the sampling equipment which makes contact with the surface water (i.e. tubing, sample containers, pH probe, etc.) is free from radioactive material contamination. It may be helpful to dedicate sampling equipment, such as Teflon tubing, to each monitoring well. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.6.3 It is important to minimize disturbance of the sediment caused by sampling activities. Use a low flow peristaltic pump, or slowly sample with a bailer, to avoid increased sample turbidity.

8.6.4 Rinse the sampling equipment and sampling container with distilled water.

8.6.5 Purge standing water in the well until flow from the surrounding aquifer is established. Draw water into an intermediate container and test periodically for pH, conductivity, and temperature during the purging.

8.6.6 Repeat step 8.6.5 until the pH, conductivity, and temperature readings are within ± 10% of the previous reading for three consecutive measurements.

8.6.7 When the criteria in Step 8.6.6 are met, the sample container can be filled.

8.6.8 Test the pH of the water sample. If the pH is greater than 2.0, add nitric acid to reduce the pH to 2.0 or less.

8.6.9 Assign a unique sample identification number to the sample. For surface samples, the identifier shall begin with "SS" followed by a series of numbers, where "SS" indicates surface soil as the sample matrix. Additional numerical/alphanumerical designators will be added to indicate the sampling location and number. Label the sample container with the sample number using a permanent marker.

8.7 Collection of Other Samples

8.7.1 For the purposes of this procedure, "other" refers to any type of sample not previously defined in this document.

8.7.2 Other samples shall be collected using the appropriate equipment (i.e. peristaltic pump, bailer, etc.).

8.7.3 Consult with the analytical laboratory, and the responsible radiological engineer, prior to collecting the sample, for specific instructions on taking any other sample types.

8.7.4 Ensure that the sampling equipment which makes contact with the media is free from radioactive material contamination. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.7.5 Obtain the sample using appropriate techniques. Transfer the sample to the appropriate sample container.

8.7.6 Foreign objects, which are not representative of the desired sample matrix, or which may effect the laboratory analysis, shall be removed from the sample.

8.7.7 Assign a unique number to the sample. The unique sample number shall identify the media sampled, the location, and the number as appropriate. Label the sample container with the sample numbers using a permanent marker.

8.8 Material Sampling

Methods for collecting miscellaneous samples should be determined based upon the characteristics of the sample media. Care should be taken to limit the potential for spreading contamination during sample collection. Sample quantities should be determined based upon the following:

8.8.1 Type of analyses required

8.8.2 Number of analyses requested

8.8.3 Detection sensitivity required of analytical result

8.8.4 Estimated activity level of material

8.8.5 Consult with the analytical laboratory, and the responsible radiological engineer, prior to collecting the sample, for specific instructions on taking any other sample types.

8.8.6 Ensure that the sampling equipment which makes contact with the media is free from radioactive material contamination. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.8.7 Remove material to be sampled by using the tools required and contamination control techniques to prevent loss of material from the sampled area.

8.8.8 Assign a unique number to the sample. The unique sample number shall identify the media sampled, the location, and the number as appropriate. Label the sample container with the sample numbers using a permanent marker.

8.8.9 Clean all sampling tools before proceeding to the next sampling location.

8.9 Sample Equipment Decontamination

8.9.1 Sample equipment must be clean before use. Used sample equipment must be decontaminated before a sample is taken to prevent cross contamination between samples. Perform the following steps, in order, to properly decontaminate sampling equipment.

8.9.1.1 Remove loose debris from the subject sampling equipment.

8.9.1.2 Wash the sample equipment with an inert detergent solution such as Alconox or the equivalent.

8.9.1.3 Rinse the sample equipment several times with distilled water.

8.9.1.4 Allow the sample equipment to dry prior to use. Perform a loose surface activity survey of the sampling equipment if necessary. Document the results on the survey map corresponding to the sample.

8.9.1.5 Collect the rinsate in a drum or authorized container. Label the drum or container "Rinsate-Awaiting Sampling Results" and "Possible Internal Contamination".

8.10 Sample Packing and Shipping

8.10.1 Sample Labeling Instructions

8.10.1.1.1 Place self-adhesive labels on appropriate sample containers.

8.10.1.2 Record sample identification, date, and time of sample collection on label.

8.10.1.3 If sample containers contain water (e.g., preserved with ice) place clear plastic tape around the label.

8.10.1.4 Collect sample as per appropriate section of this procedure.

8.10.1.5 If necessary, wipe the outside of the sample container to decontaminate prior to packing.

8.11 Packaging and Shipping

8.11.1 Prepare coolers for shipment as follows:

8.11.1.1 Tape container openings such as box seams and cooler drains (when used) shut.

8.11.1.2 Affix "This Side Up" labels on all four sides, and "Fragile" labels on at least two (2) sides of each shipping container.

8.11.1.3 Place mailing label with laboratory address on the top of container(s).

8.11.1.4 Fill bottom of container(s) with about three inches of absorbent material (e.g.,Vermiculite) or use preformed poly-foam liner or an equivalent and authorized packing material.

8.11.2 Arrange decontaminated sample containers in groups by sample number.

8.11.3 Arrange samples in shipping containers so that they do not touch and the potential for motion is minimized.

8.11.4 If ice is required to preserve the samples, cubes should be repackaged in double zipper locking bags and placed on and around the sample containers.

8.11.5 Fill remaining spaces with absorbent material.

8.11.6 Sign chain-of-custody form (or obtain signature) and indicate air bill number if applicable.

8.11.7 Separate copies of forms. Seal proper copies in large zipper lock plastic bags and tape to the inside of the appropriate container top or lid as necessary.

8.11.8 If a cooler serves as the shipping container, close the lid and secure latch.

8.11.9 Tape the container shut on both ends, making several complete revolutions with strapping tape.

8.11.10 Relinquish samples to the shipper.

8.11.11 Sample collection and shipment documentation is kept for the project file.

8.12 Shipment of Samples

Shipments of samples containing potentially hazardous or radioactive materials may require specific packaging and shipping precautions not specified above. Consult the RSO or duly authorized representative, the analytical laboratory, or other pertinent resources for instruction when shipping these samples.

NOTE: Do not exceed load rating for containers when shipping samples to prevent degradation of the container during shipping.

CAUTION: Samples should be contained within an outer protective cover to prevent cross-contamination of samples.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 Instruments used for measurements required by this procedure shall be checked with standards and verified to have current calibration.

9.1.2 Surveillance of this procedure (in use) shall be performed at least annually to verify that operations are within the guidelines of this procedure. Any time this procedure is in effect, the PM should ensure by personal observation that samples are collected and controlled appropriately.

9.2 Records

9.2.1 Documented information shall be legible written in ink.

9.2.2 Data shall not be obliterated by erasing or using white-out. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed and dated.

9.2.3 The HPT shall ensure that the attachments are of the most current.

9.2.4 The HPT shall review completed attachment forms for accuracy and completeness.

9.2.5 Entries on forms must be dated and initialed by the HPT to be valid.

9.2.6 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

OP-005-01 Sample Status Log

OP-005-01

Sample Status Log

Project/Location: ______________________________

Sample ID #	Sampling Location	Date and Time Sample Was Obtained	Requested Analysis	Technician Initials	Sample Status

Reviewed By: ______________________________

Name Title Date

CABRERA SERVICES
RADIOLOGICAL • ENVIRONMENTAL • REMEDIATION

Radiation Safety Procedure

For

Operation of Contamination Survey Meters

OP-020

Revision 0

Reviewed By: ______________________ Date: 1/24/00
David Watters, Radiological Safety Engineer

Approved By: ______________________ Date: 1/24/00
Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: ______________________ Date: 1/24/00
Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure provides the methods for operating alpha/beta survey meters when performing contamination surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

2.0 APPLICABILTY

This procedure will be used by Cabrera Services, Inc. (CABRERA) personnel to measure fixed and removable alpha and/or beta emitting radioactive material on facility surfaces, equipment, waste packages, personnel, personnel protective clothing, etc.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 Ensure that the thin Mylar or mica window on the probe face is protected from punctures during survey operations.

3.1.2 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the Radiation Safety Officer (RSO) or duly authorized representative.

3.2 Limitations

None

3.3 Requirements

3.3.1 Calibration sources shall be traceable to the National Institutes of Science and Technology (NIST).

3.3.2 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily following work activities as a final verification.

3.3.3 Survey instrument calibrations shall be performed by an NRC or Agreement State licensed calibration facility.

4.0 REFERENCES

- RSP Radiation Safety Program
- AP-001 Record Retention
- OP-001 Radiological Surveys
- OP-009 Use and Control of Radioactive Check Sources

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Restricted Area - An area containing radioactive material(s) to which access is controlled to protect individuals from exposure to ionizing radiation.

5.2 Alpha/Beta Contamination Survey - A survey technique to determine fixed and removable alpha/beta contamination.

5.3 Acceptance Range - A range of values that describe an acceptable daily instrument source check result.

6.0 EQUIPMENT

6.1 For Alpha Surveys Ludlum Model 43-5 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

6.2 For Beta Surveys Ludlum Model 44-9 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating contamination survey meters are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in the use of contamination survey meters described in this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT operating contamination survey meters are responsible for knowing and complying with this procedure.

8.0 OPERATION

8.1 Instrument Inspection

8.1.1 Select the contamination survey meter and probe to be used in the survey.

8.1.2 Before each use, perform the following checks:

8.1.2.1 Verify the instrument has a current calibration label.

8.1.2.2 Visually inspect the instrument for physical damage or defects.

8.1.2.3 Position the meter switch to "BAT". Check to see that the needle falls within the "Bat Test" checkband.

- If the needle falls below the "Bat Test" checkband, install new battery(s).
- If the needle still falls outside the "Bat Test" checkband after the installation of new battery(s), tag the instrument "Out of Service" and notify the RSO or duly authorized representative.

8.1.2.4 Check alpha detectors for light leaks by pointing the mylar window of the detector toward a light source and observing no change in the meter indication.

8.1.3 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.2.1 through 8.1.2.44 and notify the RSO or duly *authorized representative.*

NOTE: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO or duly authorized representative be notified.

8.2 Pre-operation of instrument

8.2.1 Position the meter fast/slow ("F/S") switch to "S".

8.2.2 *Position the meter switch to the appropriate range scale.*

8.2.3 Obtain an OP-020-01 Form.

8.2.4 If a Quality Control (Q.C.) acceptance range has not already been calculated on the OP-020-01 Form, then follow the instructions below, other wise proceed to step 8.2.5.

8.2.4.1 Ensure the source and detector are in documented reproducible positions, which will be used each time this check is performed. Document this position on Form OP-020-01.

8.2.5 Place the QC check source and detector in the documented position on Form OP-020-01.

8.2.6 Allow the instrument reading to stabilize (approximately 30 seconds). Compare the reading to the response check criteria on Form OP-020-01. If the response reading falls outside of the acceptance range, tag the instrument "Out of Service" and notify the RSO or duly authorized representative.

8.3 Contamination Survey Techniques

Caution: The window area of alpha detectors are covered with a very thin (1 mg/cm^2) aluminized Mylar window and beta detector windows are 1.7 mg/cm^2 mica. Either window can be easily when surveying areas, which have protruding fragments that might puncture the detector face. Remove these fragments before performing surveys.

Note: To maintain the calibrated detection efficiency, the detector must be held at the appropriate height, determined during calibration, when surveying. For example, if a beta probe's efficiency was calculated at 1/2 inch from the calibration source, the detector must be held at 1/2 inch from the surface being surveyed to maintain calibrated detection efficiency.

Note: Avoid contacting the detector probe to the area being surveyed. This potentially could contaminate the probe.

8.3.1 Verify the instrument selector switch is in the X 0.1 position.

8.3.2 For a stationary reading, place the detector over the area to be measured and allow meter to stabilize. Record the average meter indication in either CPM α/PA (probe area) or CPM β/PA on applicable forms.

8.3.3 For a scan survey move the detector slowly over the surface (less than one detector width per second). Observe meter indication. If increased readings are observed return to the area and obtain a stationary reading. Record maximum area meter indication in either CPM α/PA or CPM β/PA, on applicable forms.

8.4 Final Verification

Upon completion of work activities, repeat steps 8.1.2.1 through 8.2.2.4 and

8.2.5 through 8.2.6, as a final verification that the instrument is working properly

8.5 Interpretation of Results

The meter reading on the alpha and beta survey meters must be corrected for detector efficiency and detector surface area before comparing results with the contamination units in Section 3.6 of the Radiation Safety Program. The conversion from CPM α/PA or CPM β/PA to DPM $\alpha/100\ cm^2$ or $\beta/100\ cm^2$ is performed using the following equation.

$$(DPM\ /100\,cm^2) = \frac{(AxB)}{C}$$

Where:

A = Alpha or Beta survey meter indication in net CPM α/PA or β/PA (i.e. Gross Alpha or Beta Survey Counts minus background counts = Net CPM/PA)

B = 100 cm^2 divided by the effective detector surface area in cm^2. With an *effective surface area of 50 cm^2 for* the Ludlum 43-5 alpha detector, the value of B is approximately 2 or for the 15 cm^2 for the Ludlum 44-9 beta detector, the value of B is approximately 6.7.

C = Detector efficiency (expressed as decimal).

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 The health physics technician performing the survey shall ensure that this procedure is the most current and approved revision.

9.2 Records

9.2.1 Documented information shall be legibly written in ink.

9.2.2 Data shall not be obliterated by erasing, using white-out, or by any other means. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed, and dated.

9.2.3 The HPT performing the survey shall review Form OP-020-01 and any other applicable forms for accuracy and completeness.

9.2.4 Entries on Form OP-020-01 and any other pertinent forms must be dated and initialed by the HPT performing the survey to be valid.

9.2.5 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

OP-020-01 Survey Meter Source Check

Survey Meter Source Check Form

Instrument: ____________________ Serial No.: ________

Source: ____________ Acceptable Range: ______ to ______

Date	Cal Due	Reading	H.P. Technician	H.P. Technician Initial

Review By: ____________________ Date: __________

CABRERA SERVICES
RADIOLOGICAL • ENVIRONMENTAL • REMEDIATION

Radiation Safety Procedure

For

Alpha – Beta Counting Instrumentation

OP-021

Revision 0

Reviewed By: ______________________ Date: 1/24/00
David Watters, Radiological Safety Engineer

Approved By: ______________________ Date: 1/24/00
Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: ______________________ Date: 1/24/00
Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure provides instruction on the operation and setup of an alpha/beta sample counter. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

2.0 APPLICABILITY

This procedure will be used by Cabrera Services, Inc., (CABRERA) personnel operating an alpha/beta sample counter during surveys. Types of surveys that may use an alpha/beta sample counter are:

- Smear surveys performed to determine the removal of alpha and beta contamination on facility surfaces, equipment, waste, and source packages, etc.
- Air sample surveys performed in a workers breathing zone to determine alpha and beta air concentrations.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 If any instrument inconsistencies are observed (e.g., unusually high or low background counts, source checks outside the tolerance range, etc.), remove the instrument from use and report the condition to the RSO or duly authorized representative.

3.1.2 Individuals performing work with an alpha/beta counter shall be familiar with the requirements set forth in the current and approved version of this procedure.

3.2 Limitations

3.2.1 This instrument should be set up for use in low background area as determined by the RSO or duly authorized representative.

3.3 Requirements

3.3.1 Calibration sources shall be traceable to the National Institutes of Science and Technology (NIST).

3.3.2 Survey instrument calibrations shall be performed by an NRC or Agreement State licensed calibration facility.

3.3.3 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily following work activities as a final verification.

4.0 REFERENCES

- RSP — Radiation Safety Program
- AP-005 — ALARA Program
- AP-001 — Record Retention
- AP-013 — Packaging Radioactive Material
- OP-001 — Radiological Surveys
- NUREG-1556 — Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

5.2 Smear sample survey – a technique using a two-inch diameter filter papers to determine removable contamination of alpha and/or beta emitting radioactive material.

5.3 Air sample survey – a technique in which particulates are collected from a known volume of air drawn through a filter paper and concentrations of airborne alpha and beta activity associated with the particulates is determined by sample counting.

5.4 Plateau – portion of a voltage curve where changes in operating voltage introduce minimum changes in the counting rate.

5.5 Chi-square test – A statistical test to evaluate the operation of a sample counter by determining how data fit a series of counts to a Poisson distribution.

5.6 Daily calibration – A determination of alpha and beta sample counting efficiency by counting National Institute of Standard Technologies (NIST) radioactive standards.

6.0 EQUIPMENT

Ludlum model 2929 or equivalent

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating alpha/beta sample counters are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation Safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in the use of alpha/beta sample counters described in this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT using alpha/beta sample counters are responsible for knowing and complying with this procedure.

8.0 OPERATION

8.1 Instrument Inspection

8.1.1 Before each use, perform the following checks:

8.1.1.1 Verify the instrument has a current calibration label.

8.1.1.2 Visually inspect the instrument for physical damage or defects.

8.1.2 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.1.1 through 8.1.1.2 and notify the RSO or his duly authorized representative.

NOTE: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO or his duly authorized representative be notified.

8.2 Initial Startup.

8.2.1 Turn high voltage potentiometer to its lowest position (fully counterclockwise).

8.2.2 Turn instrument on.

8.2.3 The operator can select one of four operational procedures depending on the function to be performed. Before performing any of the following complete steps 8.1.1 to 8.1.2.

a) Plateau Curve – The Plateau Curve is used to find the proper operating voltage of the instrument and will be performed at the discretion of the RSO or duly authorized representative. This test shall be documented on the attached Form OP-021-01 or equivalent.

b) Chi–square Test – The Chi-Square Test will be performed at the discretion of the RSO or duly authorized representative in order to test the operational adequacy of the instrument and will be recorded on Form OP-021-02. This test statistically evaluates the sample counter against a poisson distribution.

c) Daily Calibration Check – This portion of the procedure is performed before samples are counted on any day the instrument is in use.

8.3 Plateau Curve

NOTE: Before beginning, record the previous calibration high voltage values.

8.3.1 Set up the instrument in a low background area.

8.3.2 Rotate the high voltage potentiometer slowly clockwise until the meter indicates proper voltage. This proper voltage is approximately 500 volts.

8.3.3 Set time multiplier switch to "x1."

8.3.4 Set the instrument-preset timer to one (1) minute.

8.3.5 Insert an alpha calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a one minute count.

8.3.6 Upon completion of the count, record high voltage reading and digital counts appearing in the instrument alpha display in the indicated columns on Form OP-021-01(Plateau Data Sheet)

8.3.7 Continue increasing high voltage by 50-volt increments, as described above, obtaining counts and recording data until the end of the plateau is reached. If rapid increase in count rate is observed, proceed to step 8.3.8. If not, notify the RSO or duly authorized representative.

8.3.8 Remove the alpha source and replace with a beta source.

8.3.9 Reduce high voltage reading to the voltage level chosen during Step 8.3.2 by turning potentiometer counterclockwise.

8.3.10 Perform one-minute counts at 50-volt increments and record the data on Form OP-020-01, until the end of the plateau is reached. If a rapid increase in count rate is observed reduce the high voltage.

8.3.11 Using linear graph paper or equivalent plotting system, plot alpha and beta counts on the "Y" axis and the voltage for the indicated count on the "X" axis.

8.3.12 Select an operating voltage 1/3 the distance beyond the knee of the plateau curve by marking the voltage on the graph and on the plateau data sheet.

8.3.13 Sign and date Form OP-021-01 and forward the results along with any graphs produced to the RSO or duly authorized representative for review.

8.4 Chi-Square Test

8.4.1 Set up the Instrument in a low background area.

8.4.2 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust if necessary.

8.4.3 Set the time multiplier switch to "x1".

8.4.4 Set the instrument-preset timer to one (1) minute.

8.4.5 Insert the alpha calibration standard into center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a one minute count.

8.4.6 Upon completion of the count, record digital counts appearing in the alpha display in the "X_i" column on Form OP-021-02 (Chi -Square Data Sheet).

8.4.7 Repeat counting sequence without changing settings until a total of 20 counts have been taken and recorded in the "X_i" column on Form OP-021-02.

8.4.8 Add the 20 counts recorded in the "X_i" column and record in the "Sum" column. Then divide by 20 to obtain the mean number of counts (X_m) and record on the line "X_m".

8.4.9 Calculate the individual count "X_i" difference from the mean (X_m) value and record in the "(X_i-X_m)" column on Form OP-021-02 for all 20 values.

8.4.10 Calculate $(X_i-X_m)^2$, sum the "$(X_i-X_m)^2$ " column, and record on Form OP-020-02.

8.4.11 Calculate the value of Chi- Square using the following formula.

$$X^2 = \frac{\sum (X_i - X_m)^2}{X_m}$$

8.4.12 The value of Chi-square should be between 8.91 and 32.8 (represents a probability between 0.025 and 0.975). Record this value at "X^2". If the Chi-square value falls outside this range, contact the RSO or duly authorized representative for further instructions.

8.4.13 Sign and date Form OP-021-02 and forward the results to the RSO or duly authorized representative for review.

8.5 Daily Calibration Check

8.5.1 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust, slowly, if necessary.

8.5.2 Set time multiplier switch to "x1".

8.5.3 Set the instrument-preset timer to five (5) minutes.

8.5.4 Record the source type to be used and corresponding serial number on the proper line indicated on Form OP-021-03. Use separate rows of the form for each source efficiency to be calculated.

8.5.5 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a five minute background count.

8.5.6 Calculate and record the background total counts and count rate in the columns labeled "Total Counts" and "BKG CPM" respectively, under Background Information on Form OP-021-03. The background count rate in CPM (counts per minute) can be calculated as follows:

$$CPM = \frac{\text{Total Counts}}{\text{Total Time}}$$

8.5.7 Remove the blank sample and insert the alpha or beta calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a five minute count.

8.5.8 Upon completion of the measurement, calculate and record the total counts and count rate in the columns labeled "Total Counts" and "CPM" respectively, under Source Information on Form OP-021-03. The count rate (CPM) can be calculated as listed in Step 8.5.6.

8.5.9 Calculate Net Source CPM as below and record on Form OP-021-03 under "Net CPM".

Net Source CPM = CPM – BKG CPM

NOTE: Obtain activity (DPM) value from the source certification paperwork. Decay correct activity, if needed.

8.5.10 Use the source disintegration per minute (DPM) to calculate the efficiency as shown below and record as a decimal on Form OP-021-03.

$$\%\ Efficiency = \frac{Net\ Source\ CPM}{DPM} * 100$$

8.5.11 To calculate the efficiency for the next source, remove the current source standard, insert a new source standard and repeat steps 8.5.1 through 8.5.10, as necessary.

8.5.12 Remove calibration standards and place in source holders.

8.5.13 Generate a control chart tracking the daily efficiencies and notify the RSO or duly authorized representative if any point falls outside of 2σ variance.

NOTE: For the first day on control chart use five data points to begin trend line.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 The alpha/beta sample counter will be checked for proper calibration daily with a NIST traceable source when in use.

9.1.2 Chi-square and plateau tests are verified and noted as currently valid.

9.1.3 The HPT shall ensure that the attachments are of the most current.

9.2 Records

9.2.1 Documented information shall be legible written in ink.

9.2.2 Data shall not be obliterated by erasing or using white-out. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed and dated.

9.2.3 The HPT shall review completed attachment forms for accuracy and completeness.

9.2.4 Entries on forms must be dated and initialed by the HPT to be valid.

9.2.5 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

- OP-021-01 Plateau Data Sheet
- OP-021-02 Chi–Square Data Sheet
- OP-021-03 Daily Calibration Check

OP-021-01

Plateau Data Sheet

Date:______________ Recommended Operating Voltage:________________

Instrument:_________________________ Serial Number:________________

Alpha Source Serial No.____________________ Activity (dpm)______________

Beta Source Serial No.______________________ Activity (dpm)______________

Voltage Setting	Alpha Counts	Voltage Setting	Alpha Counts	Voltage Setting	Beta Counts	Voltage Setting	Beta Counts

Prepared By:____ Date:__________
Print/Sign

Reviewed By:____ Date:__________
Print/Sign

OP-021-02

Chi-Square Data Sheet

Date:________Instrument:__________________Serial Number:___________ X^2________

Alpha Source No./Activity:________________Beta Source No./Activity:__________________

Count Number	X_i	(X_i-X_m)	$(X_i-X_m)^2$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Sum		\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	
X_m		\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

Prepared By: ______________________________________ Date: ______________
Print/Sign

Reviewed By: ______________________________________ Date: ______________
Print/Sign

OP-021-03

Daily Calibration Check

Instrument________________________________ Serial No.________________

Alpha Source No./Activity______________ Beta Source No./Activity______________

Background Information				Source Information				
Date/Time	Total Time	Total Counts	BKG CPM	Total Time	Total Counts	CPM	Net CPM	% Eff.

Prepared By: __________________________________ Date: ______________
Print/Sign

Reviewed By: __________________________________ Date: ______________
Print/Sign

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Operation of Micro-R Meters

OP-023

Revision 0

Reviewed By: ______________________ Date: 1/24/00
David Watters, Radiological Safety Engineer

Approved By: ______________________ Date: 1/24/00
Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: ______________________ Date: 1/24/00
Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

The purpose of this procedure is to provide instruction for the operation of the micro-R meter for gamma radiation surveys. Adherence to this procedure will provide reasonable assurance that the radiological surveys performed have reproducible results.

2.0 APPLICABILITY

This procedure will be used by Cabrera Services, Inc. (CABRERA) personnel operating the micro-R meter during gamma radiation surveys. The micro-R meter is used to determine gamma radiation levels from facility surfaces, equipment, waste and source packages, etc., containing gamma emitting radioactive materials.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Individuals performing work with the micro-R meter shall be familiar with the requirements set forth in the current and approved version of this procedure.

3.1.2 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the Radiation Safety Officer (RSO) or duly authorized representative.

3.2 Limitations

None

3.3 Requirements

3.3.1 Calibration sources shall be traceable to the National Institutes of Science and Technology (NIST).

3.3.2 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily following work activities as a final verification.

3.3.3 Survey instrument calibrations shall be performed by an NRC or Agreement State licensed calibration facility.

4.0 REFERENCES

- RSP Radiation Safety Program
- ALARA ALARA Program
- AP-001 Record Retention
- OP-001 Radiological Surveys
- OP-009 Use and Control of Radioactive Check Sources
- OP-020 Operation of Contamination Survey Meters
- NUREG-1556 Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

5.2 Gamma Radiation Survey – A survey technique to determine gamma radiation levels from radioactive material(s) in facilities, materials, landmasses, etc.

5.3 Acceptance Range – A range of values that describe an acceptable daily instrument source check result.

6.0 EQUIPMENT

Ludlum Model 19 or equivalent

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating a micro-R meter is familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in the operation of a micro-R meter described in this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT operating the micro-R meter are responsible for knowing and complying with this procedure.

8.0 OPERATION

8.1 Instrument Inspection

8.1.1 Before each use, perform the following checks:

8.1.1.1 Verify the instrument has a current calibration label.

8.1.1.2 Visually inspect the instrument for physical damage or defects.

8.1.1.3 Position the meter switch to "BAT". Check to see that the needle falls within the "Bat Test" checkband.

- If the needle falls below the "Bat Test" checkband, install new battery(s).
- If the needle still falls outside the "Bat Test" checkband after the installation of new battery(s), tag the instrument "Out of Service" and notify the RSO or duly authorized representative.

8.1.2 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.1.1 through 8.1.1.3 and notify the RSO or duly authorized representative.

NOTE: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO or duly authorized representative be notified.

8.2 Pre-operation of instrument

8.2.1 Position the meter fast/slow ("F/S") switch to "S".

8.2.2 Position the meter switch to the appropriate range scale.

8.2.3 If a Quality Control (Q.C.) acceptance range has not already been calculated, then follow the instructions below, other wise proceed to step 8.2.5.

8.2.3.1 Ensure the source and detector are in documented reproducible positions, which will be used each time this check is performed. Document this position on appropriate form.

8.2.4 Place the QC check source and detector in the documented position on appropriate form.

8.2.5 Allow the instrument reading to stabilize (approximately 30 seconds). Compare the reading to the response check criteria. If the response reading falls outside of the acceptance range, tag the instrument "Out of Service," and notify the RSO or duly authorized representative.

8.3 Operation of the instrument

8.3.1 Grid Surveys

8.3.1.1 Turn the audio switch to the "On" position.

8.3.1.2 Verify the instrument selector switch is on the lowest scale (usually the μR position). Turn the instrument selector switch to the next higher scale only if meter indication is off scale.

8.3.1.3 For a stationary grid reading in a facility or land mass, position the instrument one meter above the surface to be surveyed and allow meter to stabilize. With the instrument toggle switch set in the "SLOW" position, the meter reaches 90% of its final reading in 22 seconds. Record the average meter indication in μR/hr on appropriate form(s).

Note: Two survey methods (step 8.3.1.4 or 8.3.1.5) can be used to obtain contact readings in the survey grids. The survey method used will be specified in the site specific work plan.

8.3.1.4 For a scan survey, make sure the meter response is set to fast and suspend the instrument from a strap which locates the detector at surface or ground level. Move the instrument slowly over the surface while walking in an "S" pattern unless otherwise instructed by the RSO or duly authorized representative. Areas, which could concentrate radioactive materials such as drainage ditches, floor cracks, and wall/floor joints, should be surveyed. Observe meter indication and listen for increases in audible clicks from the speaker. If elevated readings above background are observed, a stationary survey shall be performed (at one-meter height and at the surface) at the point of elevated activity. Record area meter indications above background in μR/hr on appropriate form.

8.3.1.5 As an alternate to the "S" pattern survey used in step 8.3.1.4, the survey grid can be divided into subgrids and readings taken as directed by the site work plan. Elevated measurements should be performed in the same manner as above (i.e., at one meter and at the surface). The readings from each measurement are recorded on appropriate form.

8.3.2 Waste Container Surveys

8.3.2.1 Set the instrument scale to accommodate the highest expected radiation level. If radiation levels may approach 5000 μR/hr (5 mR/hr) obtain an instrument with appropriate range before performing any radiation surveillance.

8.3.2.2 Slowly scan the total surface of the package and record the maximum contact reading obtained on appropriate forms.

8.3.2.3 Obtain instrument readings at one meter from all sides of the package and record the maximum reading obtained on appropriate form.

8.3.3 Final Verification

Upon completion of work activities, repeat steps 8.1.1.1 through 8.2.2 and 8.2.4 through 8.2.5, as a final verification that the instrument is working properly

8.3.4 Additional Information

8.3.4.1 In a uniform background radiation field (without interfering sources of radiation), methods such as selectively shielding the detector, soil sample analysis, etc., can be used to differentiate between extraneous radioactive sources (e.g., skyshine or radioactive waste shipment containers), naturally occurring radioactive material and/or radioactive contamination.

8.3.4.2 Note the location of installed devices, which contain radioactive material and could cause elevated background radiation levels in localized areas.

8.3.4.3 Land mass surveys might contain areas with naturally occurring radioactive materials, which will elevate background radiation levels.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 The health physics technician performing the survey shall ensure that this procedure is current.

9.2 Records

9.2.1 Documented information shall be legibly written in ink.

9.2.2 Data shall not be obliterated by erasing, using white-out, or by any other means. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed, and dated.

9.2.3 The health physics technician performing the survey shall review appropriate forms and any other applicable forms for accuracy and completeness.

9.2.4 Entries must be dated and initialed by the health physics technician performing the survey to be valid.

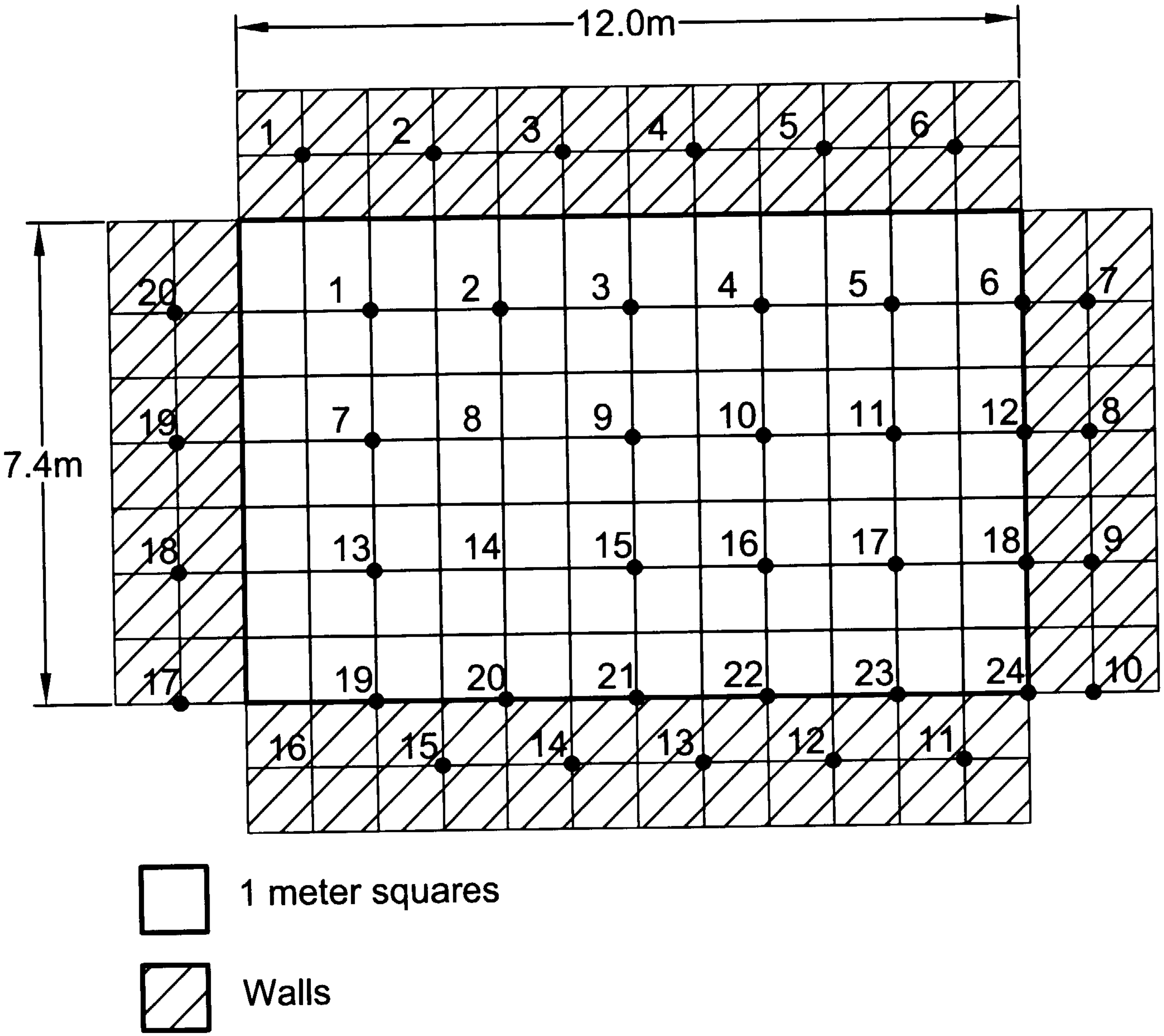
9.2.5 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

None

Appendix E: Survey Unit Maps and Sample Locations

BARF - North Room Floor and Lower Walls



Date: 11/2/2004
Created by: JTM

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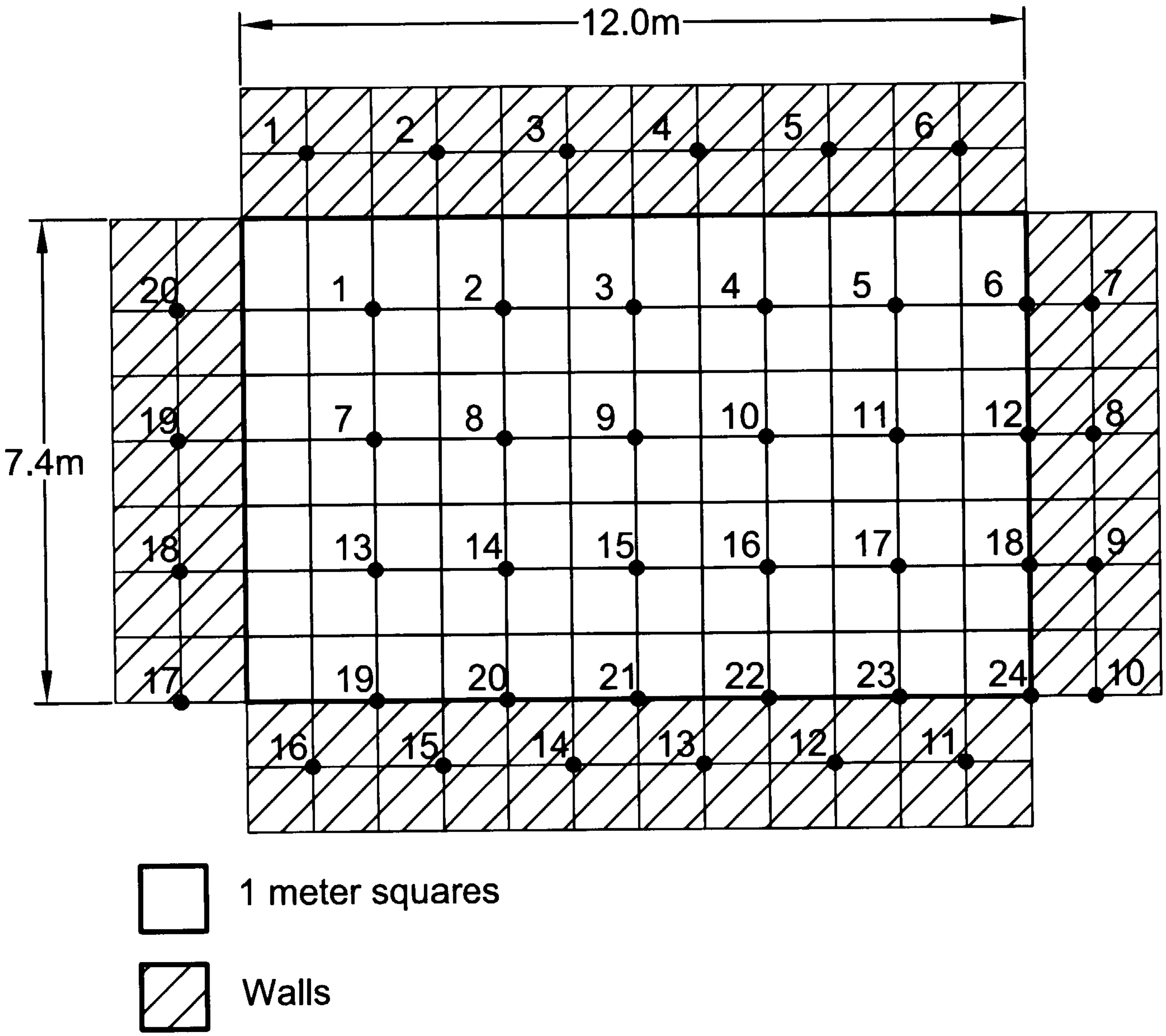
Figure: E-1

BARF - South Room Floor and Lower Walls



Date: 11/2/2004
Created by: JTM

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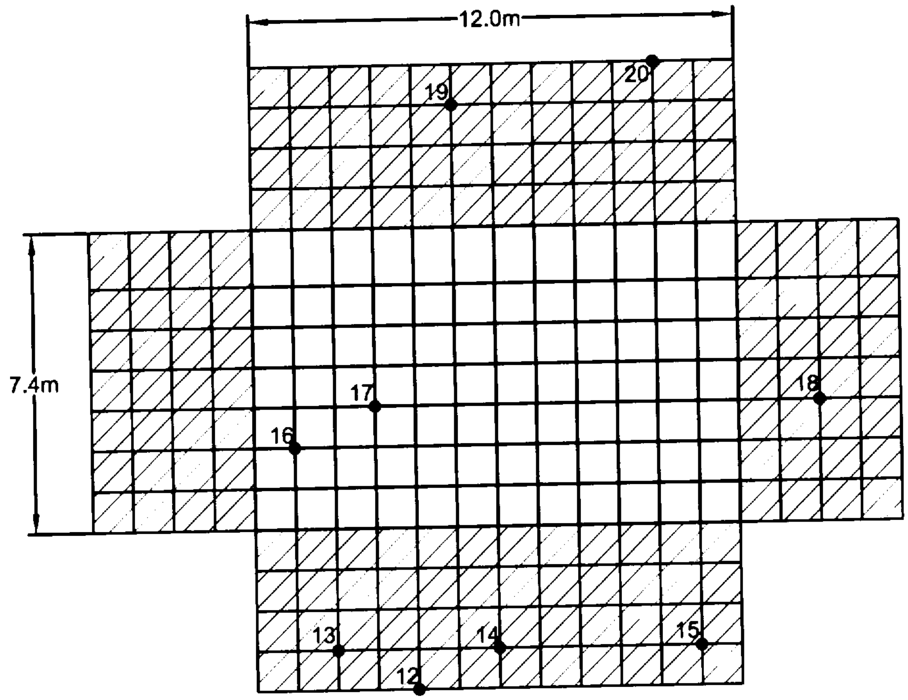
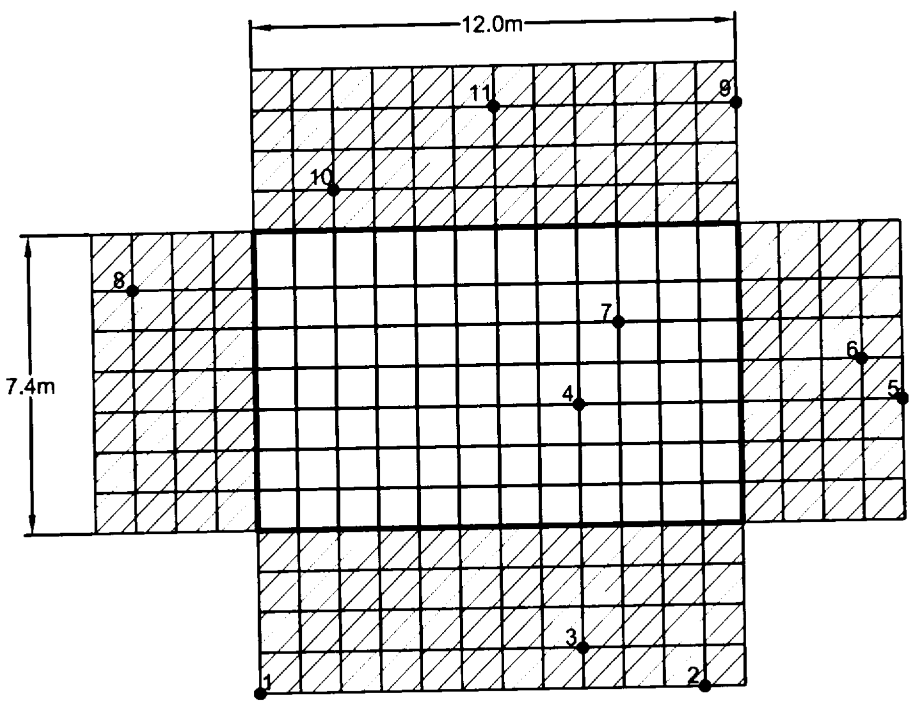
Figure: E-2

BARF - North Room Ceiling and Upper Walls



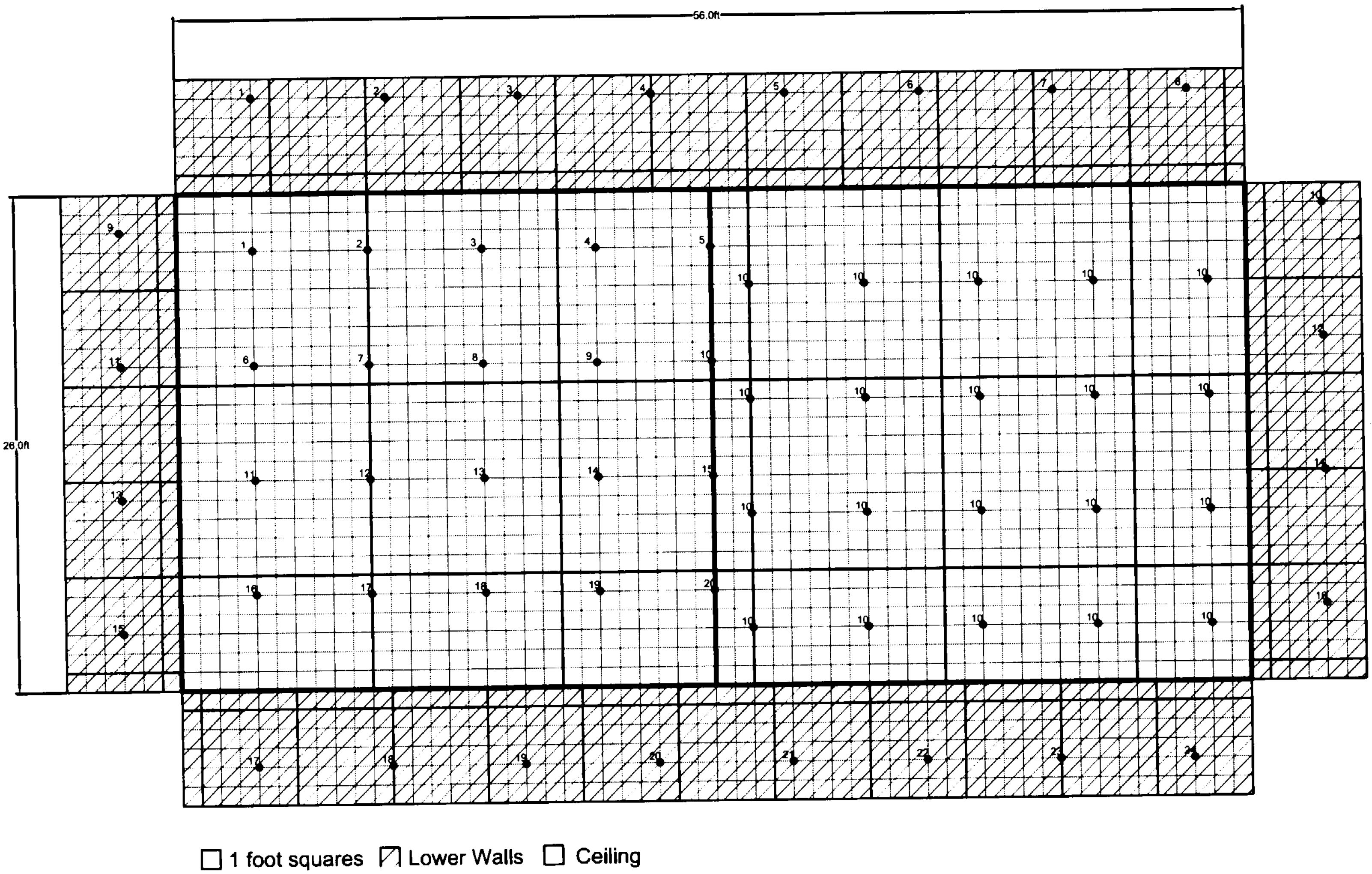
BARF - South Room Ceiling and Upper Walls



1 meter squares | Upper Walls | Ceiling

Figure: E-3	Remediation and FSS BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL • ENVIRONMENTAL • REMEDIATION WWW.CABRERASERVICES.COM	Date: 11/2/2004 Created by: JTM

Wash Rack 2 Floor and Lower Walls



Date: 11/2/2004

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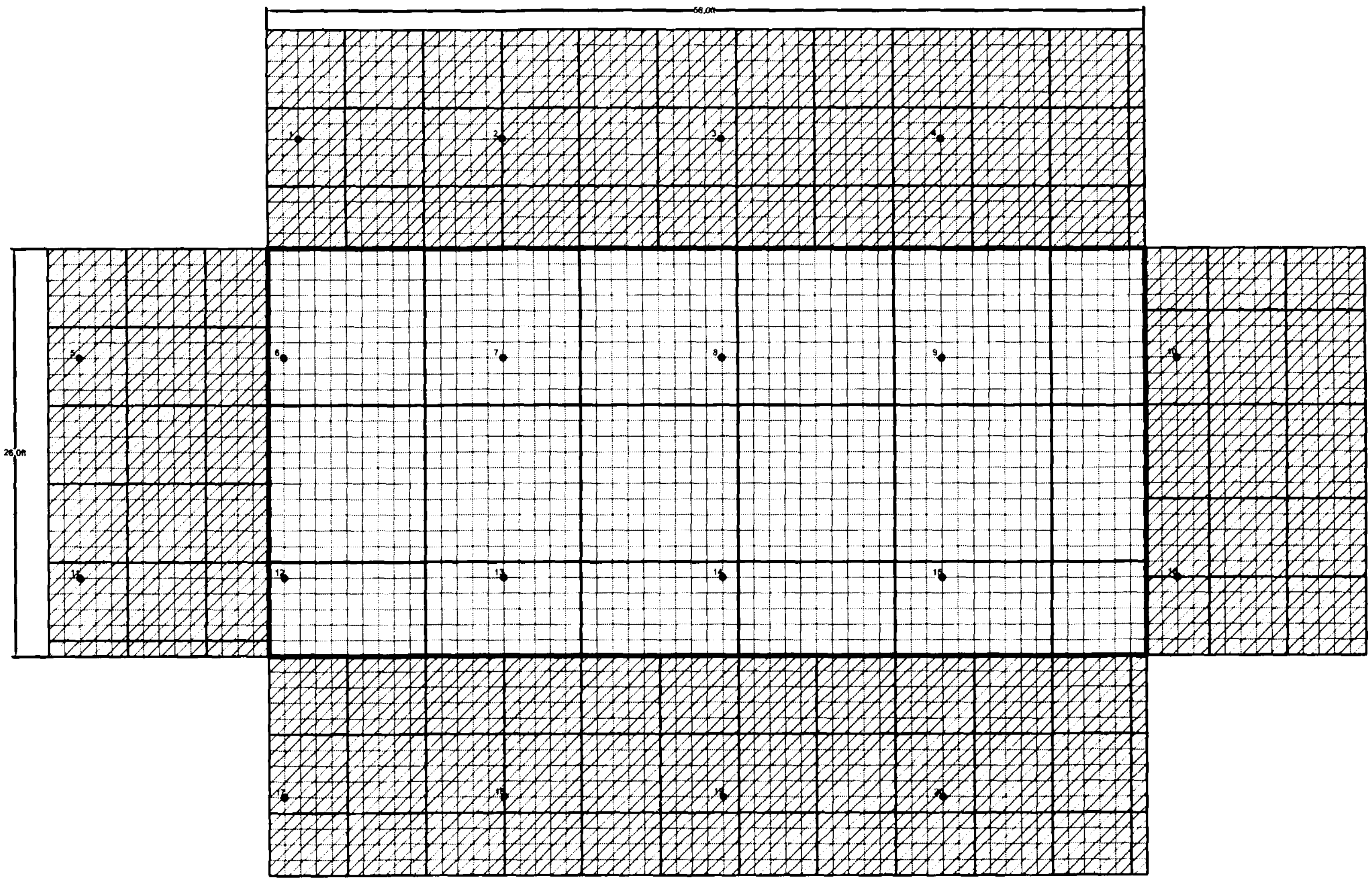
Figure: E-4

Wash Rack 2 Ceiling and Upper Walls



☐ 1 foot squares ☐ Upper Walls ☐ Ceiling

Date: 11/2/2004
Created by: JTM

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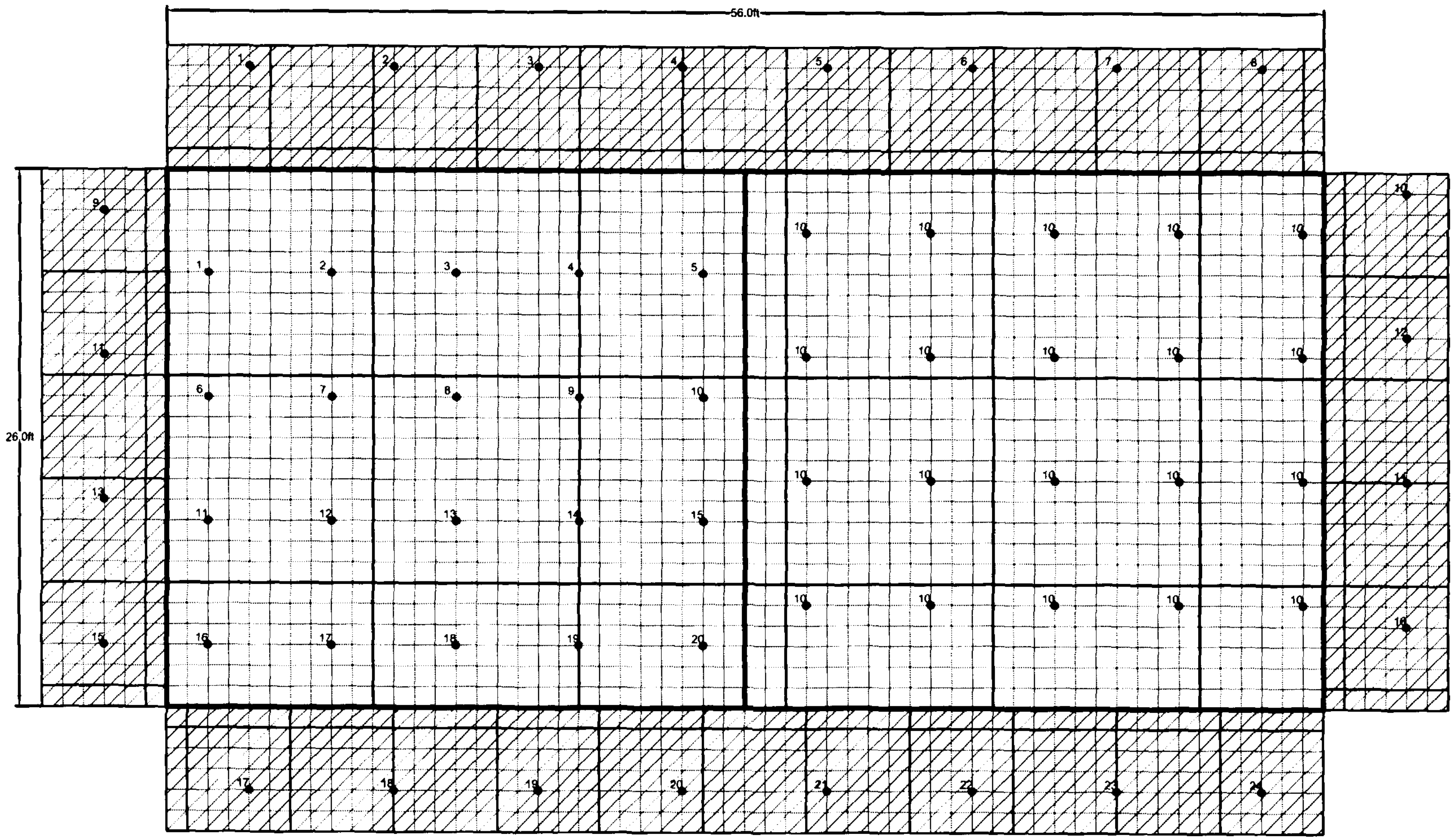
Figure: E-5

Wash Rack 3 Floor and Lower Walls



☐ 1 foot squares ☐ Lower Walls ☐ Ceiling

Date: 11/2/2004
Created by: JTM

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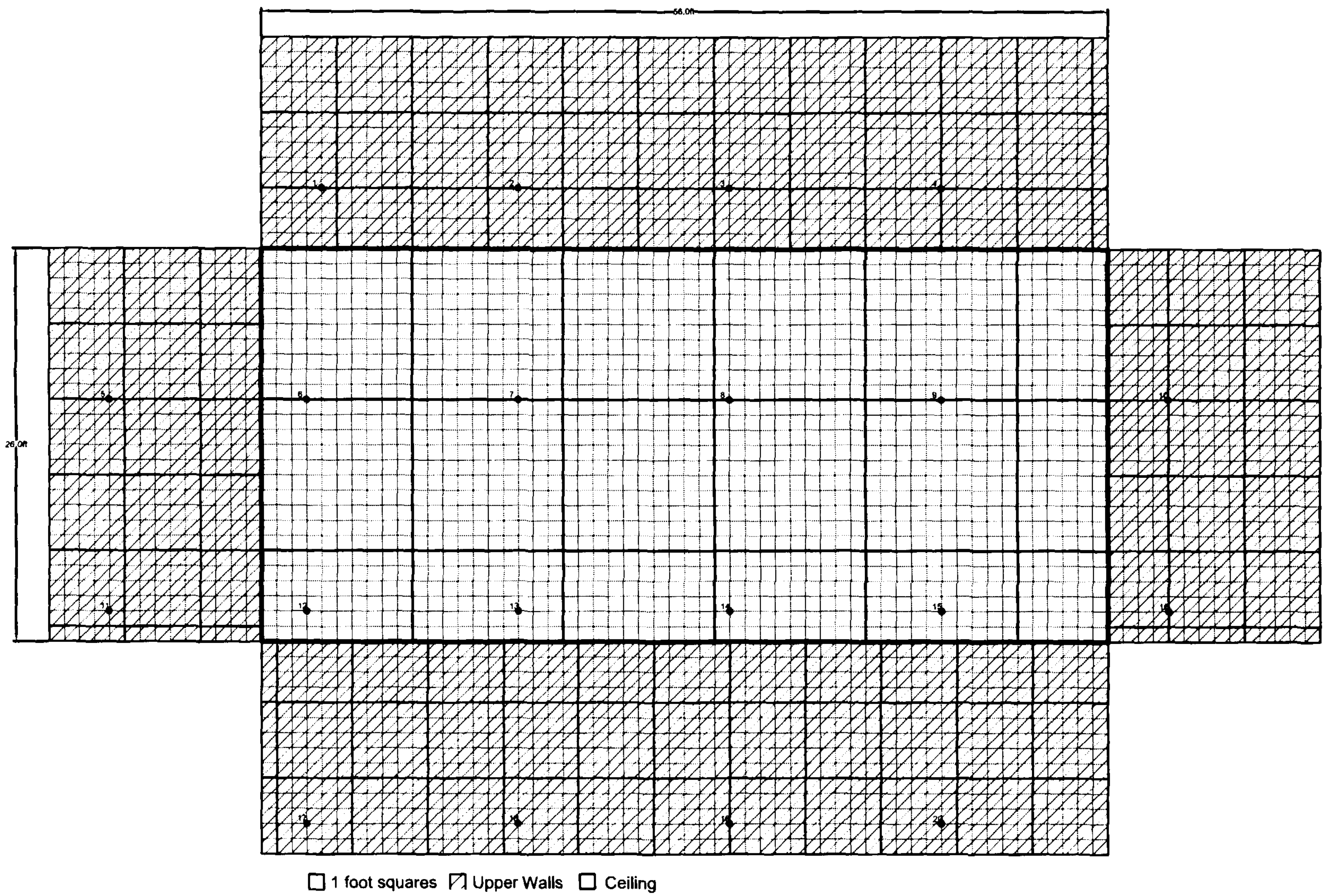
Figure: E-6

Wash Rack 3 Ceiling and Upper Walls



Date: 11/2/2004

Created by: JTM

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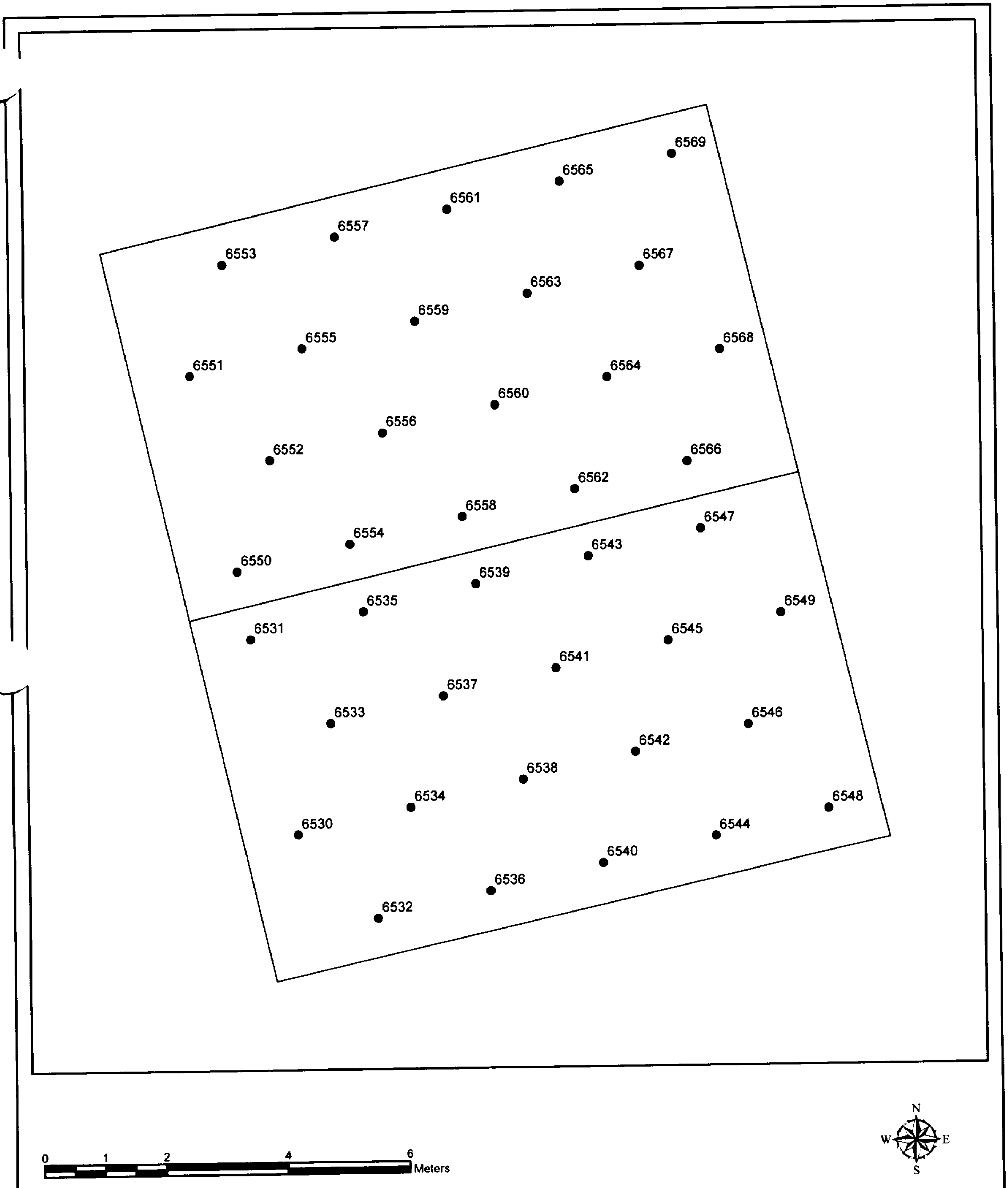
Figure: E-7



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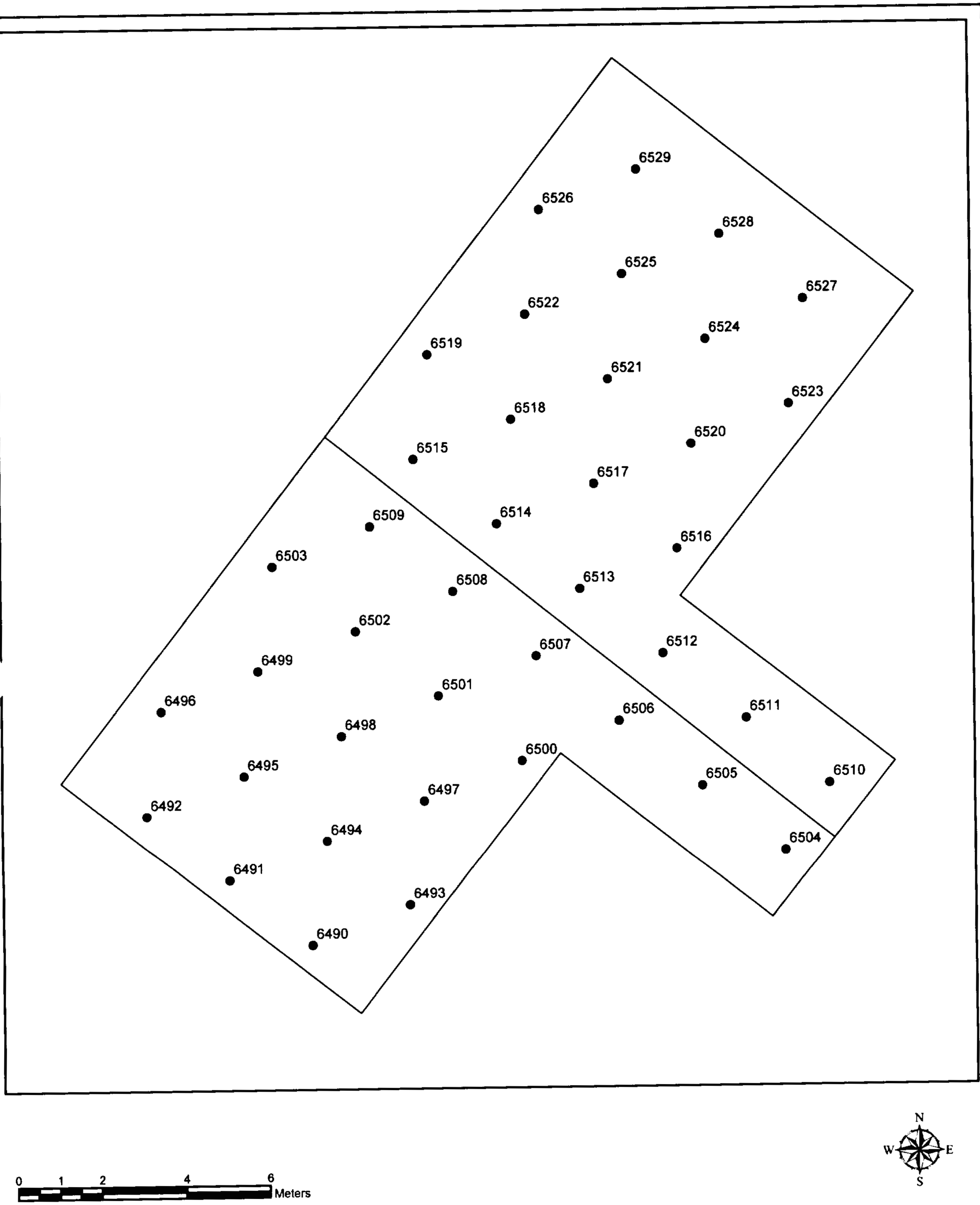
Concrete Pad #1
Systematic Sample Points

BTD-APG

Date: 11-2-04
Project #: 01-3030-39
File Name:
Prepared By: JTM

Figure E-8



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	BTD-APG	File Name: Prepared By: JTM	

Appendix F: Daily Instrument/Building Summary

BTD Daily Instrument and Building Summary

Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
5/3/2003	2929	163827	43-10-1	171322	Y	Instrument QC Files	Daily QC/response checks
5/5/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Building Armor Reclamation Facility (BARF) setup
5/5/2003	Model 3	79511	44-9	137499	Y	Instrument Log	BARF setup
5/5/2003	Model 3	89973	44-9	084781	Y	Instrument Log	BARF setup
5/5/2003	2224-1	162426	43-93	193921	Y	Instrument Log	BARF setup
5/6/2003	Model 3	89973	44-9	084781	Y	Instrument Log	BARF setup
5/7/2003	Model 3	89973	44-9	084781	Y	Instrument Log	BARF setup
5/7/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF setup; Chi-square counts
5/8/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF setup
5/8/2003	Model 3	89973	44-9	084781	Y	Instrument Log	BARF setup
5/8/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF setup
5/8/2003	2224	183048	43-68	161781	Y	Instrument Log	BARF setup
5/9/2003	Model 3	89973	44-9	084781	Y	Instrument Log	BARF setup
5/9/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF setup
5/9/2003	Model 3	79511	44-9	137499	Y	Instrument Log	BARF setup
5/9/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF setup
5/12/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF static, smears, floors N & S rooms; floor surveys N & S rooms; smears S room and lower 2m of E, S, W walls of S room.
5/12/2003	Model 3	89973	44-9	084781	Y	Instrument QC Files	
5/12/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF static, smears, floors N & S rooms; floor surveys N & S rooms; smears S room and lower 2m of E, S, W walls of S room.
5/12/2003	Micro Rem	C853F	–	–	Y	Instrument QC Files	
5/12/2003	Model 3	79511	44-9	137499	Y	Instrument Log	BARF static, smears, floors N & S rooms; floor surveys N & S rooms; smears S room and lower 2m of E, S, W walls of S room.
5/13/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF Finish N room floor survey, static readings on lower 2m of walls S & N rooms; S room lower 2m west wall , half of lower 2m S wall survey complete
5/13/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF Finish N room floor survey, static readings on lower 2m of walls S & N rooms; S room lower 2m west wall , half of lower 2m S wall survey complete
5/13/2003	Model 3	79511	44-9	137499	Y	Instrument QC Files	
5/13/2003	Model 3	89973	44-9	084781	Y	Instrument QC Files	
5/13/2003	Micro Rem	C853F	–	–	Y	Instrument QC Files	
5/14/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF finish S room S, N, E walls lower 2m; plus N room N, E, W wall lower 2m; upper wall /ceiling surveys completed S room
5/14/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF finish S room S, N, E walls lower 2m; plus N room N, E, W wall lower 2m; upper wall /ceiling surveys completed S room
5/14/2003	2224-1	162426	43-93	193921	Y	Instrument Log	BARF finish S room S, N, E walls lower 2m; plus N room N, E, W wall lower 2m; upper wall /ceiling surveys completed S room
5/14/2003	Model 3	89973	44-9	084781	Y	Instrument QC Files	
5/14/2003	Micro Rem	C853F	–	–	Y	Instrument QC Files	
5/15/2003	2360	193675	43-37	161687	Y	Instrument Log	BARF Wash Rack (WR) #2 Survey lower 2m S wall of N room (BARF); upper walls & ceiling of N room (BARF); lower 2m wall (WR#2)
5/15/2003	2224-1	162426	43-93	193921	Y	Instrument QC Files	
5/15/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF WR#2 Survey lower 2m S wall of N room (BARF); upper walls & ceiling of N room (BARF); lower 2m wall (WR#2)
5/15/2003	Model 3	89973	44-9	084781	Y	Instrument QC Files	
5/15/2003	Micro Rem	C853F	–	–	Y	Instrument QC Files	
5/19/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Disassemble WR#2
5/19/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Disassemble WR#2
5/19/2003	2224-1	162426	43-93	193921	Y	Instrument Log	Disassemble WR#2
5/19/2003	Micro Rem	C853F	–	–	Y	Instrument QC Files	

BTD Daily Instrument and Building Summary

Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
5/20/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Disassemble WR#2
5/20/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Disassemble WR#2
5/20/2003	Model 3	89973	44-9	084781	Y	Instrument Log	Disassemble WR#2
5/20/2003	2224-1	162426	43-93	193921	Y	Instrument Log	Disassemble WR#2
5/21/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Disassemble WR#2
5/21/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Disassemble WR#2
5/21/2003	Model 3	89973	44-9	084781	Y	Instrument Log	Disassemble WR#2
5/22/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Disassemble WR#2
5/22/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Disassemble WR#2
5/22/2003	Model 3	89973	44-9	084781	Y	Instrument Log	Disassemble WR#2
5/22/2003	2224-1	162426	43-93	193921	Y	Instrument Log	Disassemble WR#2
5/28/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Continue disassemble WR#2
5/28/2003	Model 3	89973	44-9	084781	Y	Instrument QC Files	
5/28/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Continue disassemble WR#2
5/28/2003	2224-1	162426	43-93	193921	Y	Instrument Log	Continue disassemble WR#2
5/28/2003	2224-1	162425	43-93	182403	Y	Instrument Log	Continue disassemble WR#2
5/29/2003	2224-1	162425	43-93	182403	Y	Instrument Log	Continue disassemble WR#2
5/29/2003	2224-1	162426	43-93	193921	Y	Instrument QC Files	
5/29/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Continue disassemble WR#2
5/29/2003	Model 3	79511	44-9	137499	Y	Instrument QC Files	
5/29/2003	Model 3	89973	44-9	084781	Y	Instrument QC Files	
5/30/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Continue disassemble WR#2 (note out of scope work items in wkly SRs
6/2/2003	2929	163827	43-10-1	171322	Y	Instrument Log	BARF bias fixed rate counts 13 locations, DU Test Enclosure Building demo
6/2/2003	2360	193675	43-37	161687	Y	Instrument Log	
6/3/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#2, DU Test Enclosure Building demo
6/4/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#2, 100% scan walls (EW, 1/2 WW); DU Test Enclosure Building demo
6/4/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#2, 100% scan walls (EW, 1/2 WW); DU Test Enclosure Building demo
6/4/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#2, 100% scan walls (EW, 1/2 WW); DU Test Enclosure Building demo
6/4/2003	Model 3	89973	44-9	084781	Y	Instrument Log	WR#2, 100% scan walls (EW, 1/2 WW); DU Test Enclosure Building demo
6/4/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#2, 100% scan walls (EW, 1/2 WW); DU Test Enclosure Building demo
6/5/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#2 plasma cutter hot spots + scan WW & NW; DU Test Enclosure Building demo
6/6/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#2 scan floor; DU Test Enclosure Building demo EW & WW
6/6/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#2 scan floor; DU Test Enclosure Building demo EW & WW
6/6/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#2 scan floor; DU Test Enclosure Building demo EW & WW
6/6/2003	Model 3	89973	44-9	084781	Y	Instrument Log	WR#2 scan floor; DU Test Enclosure Building demo EW & WW
6/6/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#2 scan floor; DU Test Enclosure Building demo EW & WW
6/9/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#2 scan floor, walls; equip moved to WR#3, scan 1/2 WW; DU Test Enclosure Building demo
6/9/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#2 scan floor, walls; equip moved to WR#3, scan 1/2 WW; DU Test Enclosure Building demo
6/9/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#2 scan floor, walls; equip moved to WR#3, scan 1/2 WW; DU Test Enclosure Building demo
6/9/2003	Model 3	89973	44-9	084781	Y	Instrument Log	WR#2 scan floor, walls; equip moved to WR#3, scan 1/2 WW; DU Test Enclosure Building demo
6/9/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#2 scan floor, walls; equip moved to WR#3, scan 1/2 WW; DU Test Enclosure Building demo
6/10/2003	2224-1	162426	43-93	193921	Y	Instrument Log	DU Test Enclosure Building demo
6/10/2003	Model 3	79511	44-9	137499	Y	Instrument Log	DU Test Enclosure Building demo
6/10/2003	Model 3	89973	44-9	084781	Y	Instrument Log	taken out of service, light leak
6/10/2003	2929	163827	43-10-1	171322	Y	Instrument Log	DU Test Enclosure Building demo
6/11/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 complete scan WW, 1/2 EW; continue DU Test Enclosure Building demo
6/11/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#3 complete scan WW, 1/2 EW; continue DU Test Enclosure Building demo
6/11/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#3 complete scan WW, 1/2 EW; continue DU Test Enclosure Building demo
6/11/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#3 complete scan WW, 1/2 EW; continue DU Test Enclosure Building demo

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Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
6/11/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#3 complete scan WW, 1/2 EW; continue DU Test Enclosure Building demo
6/12/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 finish scan EW, NW, SW; continue DU Test Enclosure Building demo
6/12/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#3 finish scan EW, NW, SW; continue DU Test Enclosure Building demo
6/12/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#3 finish scan EW, NW, SW; continue DU Test Enclosure Building demo
6/12/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#3 finish scan EW, NW, SW; continue DU Test Enclosure Building demo
6/12/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#3 finish scan EW, NW, SW; continue DU Test Enclosure Building demo
6/13/2003	2224-1	162425	43-93	182403	Y	Instrument Log	continue DU Test Enclosure Building demo, clean floor WR#3 (out of scope)
6/13/2003	2224-1	162426	43-93	193921	Y	Instrument Log	continue DU Test Enclosure Building demo, clean floor WR#3 (out of scope)
6/13/2003	Model 3	79511	44-9	137499	Y	Instrument Log	continue DU Test Enclosure Building demo, clean floor WR#3 (out of scope)
6/16/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#3 finish 25% of floor scan; continue DU Test Enclosure Building demo
6/16/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 finish 25% of floor scan; continue DU Test Enclosure Building demo
6/19/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 finish 50% of floor scan
6/19/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#3 finish 50% of floor scan
6/19/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#3 finish 50% of floor scan
6/19/2003	Model 3	79498	44-9	073106	Y	Instrument Log	WR#3 finish 50% of floor scan
6/19/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#3 finish 50% of floor scan
6/19/2003	Micro Rem	C853F	–	–	Y	Instrument Log	WR#3 finish 50% of floor scan
6/20/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 finish 100% floor scan; continue DU Test Enclosure Building demo
6/20/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#3 finish 100% floor scan; continue DU Test Enclosure Building demo
6/20/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#3 finish 100% floor scan; continue DU Test Enclosure Building demo
6/20/2003	Model 3	79498	44-9	073106	Y	Instrument Log	WR#3 finish 100% floor scan; continue DU Test Enclosure Building demo
6/20/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#3 finish 100% floor scan; continue DU Test Enclosure Building demo
6/23/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 complete scans, start static counts
6/24/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 complete 1/2 static counts
6/25/2003	2360	193675	43-37	161687	Y	Instrument Log	WR#3 complete static counts & those accessible in WR#2; continue demo Rust Vault
6/26/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#2/3 static counts upper walls/ceilings; demo Rust Vault; Transonic X-Ray2 roof
6/26/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#2/3 static counts upper walls/ceilings; demo Rust Vault; Transonic X-Ray2 roof
6/26/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#2/3 static counts upper walls/ceilings; demo Rust Vault; Transonic X-Ray2 roof
6/27/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#2/3 complete all static counts; police junk around both vaults; transonic X-Ray2 roof
6/27/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#2/3 complete all static counts; police junk around both vaults; transonic X-Ray2 roof
6/27/2003	Model 3	79498	44-9	073106	Y	Instrument Log	WR#2/3 complete all static counts; police junk around both vaults; transonic X-Ray2 roof
6/27/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#2/3 complete all static counts; police junk around both vaults; transonic X-Ray2 roof
6/27/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#2/3 complete all static counts; police junk around both vaults; transonic X-Ray2 roof
7/8/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Crane/WashRack#2 scanned; continue demo Vaults
7/9/2003	2224-1	162425	43-93	182403	Y	Instrument Log	WR#3 count smears; continue demo Vaults; survey Sabot Stripper and Backstop Plate
7/9/2003	2224-1	162426	43-93	193921	Y	Instrument Log	WR#3 count smears; continue demo Vaults; survey Sabot Stripper and Backstop Plate
7/9/2003	Model 3	79498	44-9	073106	Y	Instrument Log	WR#3 count smears; continue demo Vaults; survey Sabot Stripper and Backstop Plate
7/9/2003	Model 3	79511	44-9	137499	Y	Instrument Log	WR#3 count smears; continue demo Vaults; survey Sabot Stripper and Backstop Plate
7/9/2003	2929	163827	43-10-1	171322	Y	Instrument Log	WR#3 count smears; continue demo Vaults; survey Sabot Stripper and Backstop Plate
7/10/2003	2224-1	162425	43-93	182403	Y	Instrument Log	Survey of electrical boxes; complete demo of Vaults; cut first section of HEPA removed
7/10/2003	2224-1	162426	43-93	193921	Y	Instrument Log	Survey of electrical boxes; complete demo of Vaults; cut first section of HEPA removed
7/10/2003	Model 3	79498	44-9	073106	Y	Instrument Log	Survey of electrical boxes; complete demo of Vaults; cut first section of HEPA removed
7/10/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Survey of electrical boxes; complete demo of Vaults; cut first section of HEPA removed
7/10/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Survey of electrical boxes; complete demo of Vaults; cut first section of HEPA removed
7/11/2003	Model 3	79511	44-9	137499	Y	Instrument Log	second section of HEPA removed and loadeed into intermodal container
7/14/2003	Model 3	79511	44-9	137499	Y	Instrument Log	remove plywood from interior of shed east of DU Test Enclosure Bldg; cut up HEPA system from BARF
7/15/2003	Model 3	79511	44-9	137499	Y	Instrument Log	prepare for gamma walkover surveying (GWS); continue demo
7/16/2003	Model 3	79511	44-9	137499	Y	Instrument Log	prepare for GWS; continue demo
7/17/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU20/part of SU17; continue demo

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Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
7/18/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU17, straighten out Super Sacks
7/21/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU7; start excavation DU Test Enclosure Building
7/22/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Down (range activities)
7/23/2003	Model 3	79511	44-9	137499	Y	Instrument Log	DU Test Enclosure Building excavation stop (found 105mm HEAT round); down rest of day after 0930
7/24/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Down (range activities)
7/25/2003	Model 3	79511	44-9	137499	Y	Instrument Log	*Excavate DU Test Enclosure Building* (200 cubic yards of soil)
7/28/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Daily QC
7/29/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU24 75% complete; continue excavation DU Test Enclosure Building
7/30/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU24 & 28; expose concrete footers DU Test Enclosure Building
7/31/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU 6; hand dig hot spots SU7; excavation DU Test Enclosure Building
8/7/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU6; soil samples from SU17 & 23; excavation, grading DU Test Enclosure Building
8/8/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU1; soil samples from SU7 & 8 & 24; hot spots SU6 removed, ready to be resurveyed
8/11/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU6 after remediation; soil sampling SU1
8/12/2003	2224-1	162425	43-93	182403	Y	Instrument Log	GWS SU6 complete; continue demo footers DU Test Enclosure Building
8/12/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU6 complete; continue demo footers *DU Test Enclosure Building*
8/12/2003	Micro Rem	C853F	–	–	Y	Instrument Log	GWS SU6 complete; continue demo footers DU Test Enclosure Building
8/13/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Soil sampling SU6; continue demo footers DU Test Enclosure Building
8/13/2003	Micro Rem	C853F	–	–	Y	Instrument Log	Soil sampling SU6; continue demo footers DU Test Enclosure Building
8/14/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU5 done, start SU3; soil sampling SU4&5
8/14/2003	Micro Rem	C853F	–	–	Y	Instrument Log	GWS SU5 done, start SU3; soil sampling SU4&5
8/15/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU2&3&12 complete, GWS SU11 60% complete
8/15/2003	Micro Rem	C853F	–	–	Y	Instrument Log	GWS SU2&3&12 complete, GWS SU11 60% complete
8/18/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU11&13&14&15 complete
8/18/2003	Micro Rem	C853F	–	–	Y	Instrument Log	GWS SU11&13&14&15 complete
8/19/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU21-25 complete
8/19/2003	Micro Rem	C853F	–	–	Y	Instrument Log	GWS SU21-25 complete
8/20/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Remediate hot spots SUs 11 to 15; sampled SU21 &15; continue demo footers/stockpile
8/21/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Sample soil SUs 13&14; demo crew found 4.2 chemical mortar (phosgene, CNS, or Chlorine); wait for EOD
8/22/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Remediate SUs 2, 9, 10; sampled SU11 &12
8/23/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Daily QC
8/24/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Daily QC
8/25/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Finish remediation SU9, GWS SU9, sample SU3, remediate SU2
8/26/2003	Model 3	79511	44-9	137499	Y	Instrument Log	Sample SU9, GWS SU10, remediate SU10
8/26/2003	2929	163827	43-10-1	171322	Y	Instrument Log	Sample SU9, GWS SU10, remediate SU10
8/27/2003	Model 3	79511	44-9	137499	Y	Instrument Log	GWS SU2, remediate SU2 & SU25; post GWS SU2 & SU25; sample SU2
2/10/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/10/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/10/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/10/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/11/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/11/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/11/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/11/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/12/2004	2929	180830	43-10-1	207849	N	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/12/2004	Model 3	135696	44-9	145224	N	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/12/2004	Model 3	89973	44-9	084781	N	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/12/2004	Micro Rem	B837Y	–	–	N	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/16/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5

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Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
2/16/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/17/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/17/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/17/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/17/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/18/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/18/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/18/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/18/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/19/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/19/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/19/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/20/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/20/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/20/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/20/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/23/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/23/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/23/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/23/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/24/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/24/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/24/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/24/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/25/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/25/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/25/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/25/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/26/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/26/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/26/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/26/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/27/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/27/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/27/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
2/27/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/1/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/1/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/1/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/1/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/2/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/2/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/2/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/2/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/3/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/3/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/3/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/3/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/4/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5

BTD Daily Instrument and Building Summary

Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
3/4/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/4/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/4/2004	Micro Rem	B837Y	–	–	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/5/2004	Model 3	135696	44-9	145224	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/5/2004	Model 3	89973	44-9	084781	Y	Instrument Log	Soil removal, rail shipments, handling RAD waste to demob 3/5
3/29/2004	2224-1	162426	43-93	193921	Y	Instrument Log	excavate SU16 & SU22
3/29/2004	2360	193675	43-37	161687	Y	Instrument Log	excavate SU16 & SU22
3/30/2004	2360	193675	43-37	161687	Y	QC Files, Radiological Survey Maps	Wash Rack #3 survey, smear counting
3/30/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Wash Rack #3 survey, smear counting
3/30/2004	2224-1	162426	43-93	193921	Y	Instrument Log	Wash Rack #3 survey, smear counting
3/31/2004	2360	193675	43-37	161687	Y	QC Files, Radiological Survey Maps	Wash Rack #2 smear survey, Demob
3/31/2004	2929	180830	43-10-1	207849	Y	Instrument Log	Wash Rack #2 smear survey, Demob
3/31/2004	2224-1	162426	43-93	193921	Y	Instrument Log	Wash Rack #2 smear survey, Demob
6/2/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Project mobilization, set-up, and logistics
6/2/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Project mobilization, set-up, and logistics
6/2/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Project mobilization, set-up, and logistics
6/2/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Project mobilization, set-up, and logistics
6/2/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Project mobilization, set-up, and logistics
6/3/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Health & Safety audit, receive and inspect rental equipment, project logistics
6/3/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Health & Safety audit, receive and inspect rental equipment, project logistics
6/3/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Health & Safety audit, receive and inspect rental equipment, project logistics
6/3/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Health & Safety audit, receive and inspect rental equipment, project logistics
6/3/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Health & Safety audit, receive and inspect rental equipment, project logistics
6/4/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Gamma walkover survey in SU #25, remediate hotspots within SU #16
6/4/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Gamma walkover survey in SU #25, remediate hotspots within SU #16
6/4/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Gamma walkover survey in SU #25, remediate hotspots within SU #16
6/4/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Gamma walkover survey in SU #25, remediate hotspots within SU #16
6/4/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Gamma walkover survey in SU #25, remediate hotspots within SU #16
6/6/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Attempt water removal and drying of SU #16 and concrete pad, partial GWS of SU #25
6/6/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Attempt water removal and drying of SU #16 and concrete pad, partial GWS of SU #25
6/6/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Attempt water removal and drying of SU #16 and concrete pad, partial GWS of SU #25
6/6/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Attempt water removal and drying of SU #16 and concrete pad, partial GWS of SU #25
6/6/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Attempt water removal and drying of SU #16 and concrete pad, partial GWS of SU #25
6/7/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Surface clean concrete pads, complete GWS of SU #25
6/7/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Surface clean concrete pads, complete GWS of SU #25
6/7/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Surface clean concrete pads, complete GWS of SU #25
6/7/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Surface clean concrete pads, complete GWS of SU #25
6/7/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Surface clean concrete pads, complete GWS of SU #25
6/8/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Sand-blasting concrete pads, concrete pad surveying SU #9, pad layout and hotspot flagging
6/8/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Sand-blasting concrete pads, concrete pad surveying SU #9, pad layout and hotspot flagging
6/8/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Sand-blasting concrete pads, concrete pad surveying SU #9, pad layout and hotspot flagging
6/8/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Sand-blasting concrete pads, concrete pad surveying SU #9, pad layout and hotspot flagging
6/8/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Sand-blasting concrete pads, concrete pad surveying SU #9, pad layout and hotspot flagging
6/9/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Survey concrete pads of SUs #9 and #16, GWS of SU #16, soil sampling of SUs #25, #22, #2, #9, and #10
6/9/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Survey concrete pads of SUs #9 and #16, GWS of SU #16, soil sampling of SUs #25, #22, #2, #9, and #10
6/9/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Survey concrete pads of SUs #9 and #16, GWS of SU #16, soil sampling of SUs #25, #22, #2, #9, and #10
6/9/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Survey concrete pads of SUs #9 and #16, GWS of SU #16, soil sampling of SUs #25, #22, #2, #9, and #10

BTD Daily Instrument and Building Summary

Date	Instrument	S/N	Detector	S/N	QC File	Source of Info	Field Activity
6/9/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Survey concrete pads of SUs #9 and #16, GWS of SU #16, soil sampling of SUs #25, #22, #2, #9, and #10
6/10/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Remediate hotspots in SUs #25 and #22, collect additional data and flag bias locations in SU #16, scan smear samples
6/10/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Remediate hotspots in SUs #25 and #22, collect additional data and flag bias locations in SU #16, scan smear samples
6/10/2004	2929	171590	43-10-1	174813	Y	QC Files, Daily reports	Remediate hotspots in SUs #25 and #22, collect additional data and flag bias locations in SU #16, scan smear samples
6/10/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Remediate hotspots in SUs #25 and #22, collect additional data and flag bias locations in SU #16, scan smear samples
6/10/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Remediate hotspots in SUs #25 and #22, collect additional data and flag bias locations in SU #16, scan smear samples
6/10/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Remediate hotspots in SUs #25 and #22, collect additional data and flag bias locations in SU #16, scan smear samples
6/11/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Complete GWS of remediated hotspots in SUs #2, #9, and #10, remediate hotspot and finish soil sampling in SU #16
6/11/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Complete GWS of remediated hotspots in SUs #2, #9, and #10, remediate hotspot and finish soil sampling in SU #16
6/11/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Complete GWS of remediated hotspots in SUs #2, #9, and #10, remediate hotspot and finish soil sampling in SU #16
6/11/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Complete GWS of remediated hotspots in SUs #2, #9, and #10, remediate hotspot and finish soil sampling in SU #16
6/11/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Complete GWS of remediated hotspots in SUs #2, #9, and #10, remediate hotspot and finish soil sampling in SU #16
6/14/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Identify and fill data gaps via additional GWS in 12 areas, collect duplicate soil samples in four areas, scan smear samples
6/14/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Identify and fill data gaps via additional GWS in 12 areas, collect duplicate soil samples in four areas, scan smear samples
6/14/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Identify and fill data gaps via additional GWS in 12 areas, collect duplicate soil samples in four areas, scan smear samples
6/14/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Identify and fill data gaps via additional GWS in 12 areas, collect duplicate soil samples in four areas, scan smear samples
6/14/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Identify and fill data gaps via additional GWS in 12 areas, collect duplicate soil samples in four areas, scan smear samples
6/15/2004	Model 3	79498	44-9	073106	Y	QC Files, Daily reports	Complete data gap GWS, identify obstructed survey areas, intermodal container logistics
6/15/2004	Model 3	166511	44-9	073107	Y	QC Files, Daily reports	Complete data gap GWS, identify obstructed survey areas, intermodal container logistics
6/15/2004	2360	184938	43-37	178371	Y	QC Files, Daily reports	Complete data gap GWS, identify obstructed survey areas, intermodal container logistics
6/15/2004	2360	202398	43-93	211706	Y	QC Files, Daily reports	Complete data gap GWS, identify obstructed survey areas, intermodal container logistics
6/15/2004	Micro Rem	B985Y	–	–	Y	QC Files, Daily reports	Complete data gap GWS, identify obstructed survey areas, intermodal container logistics

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 Ceiling	RWP#	Survey # 32	Survey Type: Static/Smear

Smear Results DPM/100cm^2						AVG Scan Result		1 Min Fixed Result			Comments
No.	α	β	No.	α	β	α (cpm)	β (cpm)		α (cpm)	β (cpm)	
1	-0.6	0.9	26					1	0	108	East Wall
2	-0.6	-9.9	27					2	1	115	East Wall
3	0.9	4.5	28					3	2	98	East Wall
4	0.9	11.7	29					4	0	88	East Wall
5	-0.6	-31.4	30					5	1	92	North Wall
6	-0.6	6.3	31					6	0	96	Ceiling
7	0.9	-13.4	32					7	0	79	Ceiling
8	0.9	-9.9	33					8	2	93	Ceiling
9	-0.6	-8.1	34					9	0	87	Ceiling
10	-0.6	-22.4	35					10	0	95	South Wall
11	0.9	17.0	36					11	1	101	North Wall
12	-0.6	20.6	37					12	0	103	Ceiling
13	-0.6	-8.1	38					13	2	99	Ceiling
14	-0.6	-9.9	39					14	0	86	Ceiling
15	0.9	0.9	40					15	0	103	Ceiling
16	-0.6	8.1	41					16	1	93	South Wall
17	-0.6	-4.5	42					17	0	84	West Wall
18	0.9	-8.1	43					18	0	72	West Wall
19	0.9	4.5	44					19	0	89	West Wall
20	-0.6	8.1	45					20	2	71	West Wall
21			46					21			
22			47					22			
23			48					23			
24			49					24			
25			50					25			

Comments

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/30/2004* →	2929	180830	0.33	~~0.28~~ 0,20	4	965	~~12/15/04~~ 1/15/04
	6/26/03* →	2224	162426	0.2	(0.15)	~~3~~ 0	~~819~~ 0	(12/27/04)
Reviewed By:	Date:							

Key:

○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

*Note: Smear sample analysis via 2929 were analyzed in March 2004
direct frisks using 43-93 probe were taken during work in June 2003

No bkg determined Use 0 as conservative value.

Appendix G: Radiological Survey Maps

RADIOLOGICAL SURVEY MAP

Location: North Floor (BARF) | RWP# PC-RP64A | Survey # 2 | Survey Type: Fixed -Smears

Smear Results DPM/100cm^2 No	α	β	No.	α	β	1 Min Fixed Result	α (cpm)	β (cpm)		1 Min Fixed Result	α (cpm)	β (cpm)	Comments
NF1	4.06	31.67				NF1	10	648					
NF2	5.30	40.00				NF2	12	661					
NF3	4.06	81.67				NF3	7	847					
NF4	0.37	21.25				NF4	11	878		NF4 Dup	3	889	
NF5	0.37	0.00				NF5	30	800					
NF6	4.06	4.58				NF6	4	675					
NF7	6.53	42.08				NF7	17	992					
NF8	0.37	27.50				NF8	12	689					
NF9	0.37	46.25				NF9	6	670					
NF10	0.37	27.50				NF10	12	944					
NF11	1.60	37.92				NF11	13	828					
NF12	0.37	48.33				NF12	10	673					
NF13	4.06	52.50				NF13	7	815					
NF14	1.60	46.25				NF14	4	719					
NF15	4.06	0.00				NF15	7	755		NF15 Dup	1	803	
NF16	0.00	2.50				NF16	3	842					
NF17	1.60	21.25				NF17	10	926					
NF18	0.37	23.33				NF18	17	721					
NF19	0.37	21.25				NF19	10	1131					
NF20	0.37	15.00				NF20	6	808					
NF21	0.00	21.25				NF21	4	758					
NF22	1.60	29.58				NF22	9	722		NF22 Dup	5	724	
NF23	4.06	8.75				NF23	8	699					0.17
NF24	1.60	0.00				NF24	6	606					0.25

Surveyed By: kp Date: 5/12/2003

Reviewed By: [illegible signature] Date: 11/8/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg.	Cal. Due
2929	163827	~~0.4860~~	0.2400	7	828	1/21/2004
2360	193675	0.1207	0.2685	4	478	4/29/2004
2224-1	162425	~~0.30~~ 0.20 [illegible] HW	0.20			

Key

○	Smear	⁘	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location: North Room North Wall | RWP# | Survey # 7 | Survey Type: Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result				1 Min Fixed Result		Comments
No	α	β	No.	α	β			α (cpm)	β (cpm)		α (cpm)	β (cpm)	
NRNW1	1.52	5.42					NRNW1	12	697				
NRNW2	3.70	36.67					NRNW2	4	663				
NRNW3	1.52	26.25					NRNW3	4	624				
NRNW4	2.61	-0.83					NRNW4	2	635				
NRNW5	2.61	24.17					NRNW5	1	591				
NRNW6	0.43	45.00					NRNW6	3	560				
							D-NRNW1	10	619				
							NRNWU19	2	89				SCAN 0/90
							NRNWU20	2	97				SCAN 0/100

Surveyed By: by K Pagliaro Date: 5/13/2003

Reviewed By: [illegible] Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4000	0.2400	6	844	1/24/2004
2360	193675	0.1100 (circled; 0.17)	0.2500	3	560	4/29/2004
2224-1	162425	0.20	0.20	3	560	4/15/2004

Key			
○	Smear	⁘	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location:	North Room South Wall	RWP#		Survey #	9	Survey Type:	Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result					1 Min Fixed Result		
No.	α	β	No.	α	β			α (cpm)	β (cpm)			α (cpm)	β (cpm)	Comments
NRSW11	-0.65	17.92					NRSW11	4	678					
NRSW12	3.70	84.58					NRSW12	9	639					
NRSW13	-0.65	30.42					NRSW13	5	632					
NRSW14	2.61	61.67					NRSW14	3	583					
NRSW15	0.43	38.75					NRSW15	4	589					
NRSW16	1.52	34.58					NRSW16	5	659					
							D-NRSW12	10	677					
NRSWU12	1.72	17.50					NRSWU12	1	94					SCAN 0/80
NRSWU13	2.96	-17.92					NRSWU13	1	86					SCAN 0/90
NRSWU14	0.49	52.92					NRSWU14	2	84					SCAN 0/100
NRSWU15	2.96	27.92					NRSWU15	1	91					SCAN 0/100

Surveyed By: by K. Pugliaro | Date: 5/13/2003

Reviewed By: [signature] | Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4060 (0.17)	0.2400	6	844	1/24/2004
2360	193675	0.1100	0.2500	3	560	4/29/2004
22244	162425	0.20	0.20	3	560	7/15/04

Key			
○	Smear	-.-	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location: North Room East Wall | RWP# | Survey # 8 | Survey Type: Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result				1 Min Fixed Result		Comments
No.	α	β	No.	α	β			α (cpm)	β (cpm)			α (cpm)	β (cpm)	
NREW7	2.61	30.42					NREW7	2	711					
NREW8	0.43	34.58					NREW8	5	676					
NREW9	1.52	15.83					NREW9	6	673					
NREW10	-0.65	3.33					NREW10	7	691					
							D-NREW10	4	594					
NREWU18	0.5	7.1					NREWU18	2	94					SCAN 0/80

Surveyed By: K. Pagliaro Date: 5/13/2003

Reviewed By: HW Sigurd Date: ~~11/4/04~~ 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4060	0.2400	6	844	1/24/2004
2360	193676	0.1100 (0.17)	0.2500	3	560	4/29/2004
2224-1	162425	0.20	0.20	3	560	4/15/04

Key: ○ Smear; ∴ Boundary; □ Dose Rate mr/hr; ■ A/S Location; • Direct Reading DPM/100 cm^2; △ Grab Sample

RADIOLOGICAL SURVEY MAP

Location: NorthRoom West Wall | RWP# | Survey # 10 | Survey Type: Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result				1 Min Fixed Result		Comments
No.	α	β	No.	α	β		α (cpm)	β (cpm)			α (cpm)	β (cpm)	
NRWW17	2.61	9.58				NRWW17	7	699					
NRWW18	3.70	49.17				NRWW18	5	709					
NRWW19	-0.65	9.58				NRWW19	7	644					
NRWW20	3.70	32.50				NRWW20	4	547					
						D-NRWW17	4	699					

Surveyed By: by K. Pagliaro
Date: 5/13/2003

Reviewed By: [signature] Date: 11/5/04

0.17

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4069	0.2400	6	844	1/24/2004
2360	193675	0.1100	0.2500	3	560	4/29/2004

Key: Smear; Dose Rate mr/hr; Direct Reading DPM/100 cm^2; Grab Sample; Boundary; A/S Location

RADIOLOGICAL SURVEY MAP

Location:	North Room Ceiling	RWP#	Survey #	12	Survey Type:	Fixed -Smears

Smear Results DPM/100cm^2								1 Min Fixed Result				1 Min Fixed Result		
								α (cpm)	β (cpm)			α (cpm)	β (cpm)	Comments
No.	α	β	No.	α	β									
NRCU16	-0.74	9.17					NRCU16	0	85					SCAN 0/80
NRCU17	2.96	2.92					NRCU17	0	112					SCAN 0/100

Surveyed By: K. Pagliaro Date: 5/15/03

Reviewed By: [signature] Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4060	0.2400	7	828	1/24/2004
2224-1	162426	0.1919 (0.20)	0.1165 (0.20)	3	99 (360)	1/15/2004

Key			
○	Smear	∴	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location: South Floor (BARF) | RWP# PC-RP64A | Survey # 1 | Survey Type: Fixed -Smears

Smear Results DPM/100cm^2 No.	α	β	No.	α	β	1 Min Fixed Result No.	α (cpm)	β (cpm)	1 Min Fixed Result No.	α (cpm)	β (cpm)	Comments
SF1	5.30	50.42				SF1	4	791	SF1 Dup	14	764	
SF2	0.00	42.08				SF2	20	779				
SF3	0.37	25.42				SF3	9	700				
SF4	1.60	56.67				SF4	18	665				
SF5	1.60	27.50				SF5	10	681				
SF6	6.53	46.25				SF6	16	675				
SF7	0.37	17.08				SF7	9	660				
SF8	1.60	25.42				SF8	10	734				
SF9	1.60	42.08				SF9	8	819				
SF10	4.06	69.17				SF10	9	864				
SF11	5.30	71.25				SF11	11	922				
SF12	0.00	0.00				SF12	6	686	SF12 Dup	4	695	
SF13	0.37	71.25				SF13	10	687				
SF14	1.60	50.42				SF14	4	696				
SF15	1.60	15.00				SF15	9	783				
SF16	0.37	4.58				SF16	6	846				
SF17	0.00	40.00				SF17	11	730				
SF18	4.06	4.58				SF18	7	713				
SF19	1.60	21.25				SF19	11	633				
SF20	1.60	0.42				SF20	10	720				
SF21	1.60	4.58				SF21	10	1029				
SF22	0.37	42.08				SF22	5	853				
SF23	1.60	27.50				SF23	9	761				
SF24	2.83	25.42				SF24	7	734	SF24 Dup	10	745	

Surveyed By: kp Date 5/12/2003

Reviewed By: [illegible] Date: 11/8/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg	b Bkg	Cal. Due
2929	163827	0.4060	0.2400	7	828	1/21/2004
2360	193675	0.1207	0.2685	4	478	4/29/2004
2224-1	162 425	0.20	.120	3	560	4/15/2004

0.17 0.25

Key			
○	Smear	∵	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location:	South Room North Wall	RWP#		Survey #	3	Survey Type:	Fixed -Smears

Smear Results DPM/100cm^2

No.	α	β	No.	α	β
SRNW1	1.52	22.08			
SRNW2	2.61	-7.08			
SRNW3	0.43	24.17			
SRNW4	0.43	7.50			
SRNW5	-0.65	20.00			
SRNW6	1.52	-2.92			
SRNWU9	-0.87	-14.38			
SRNWU10	0.22	-14.38			
SRNWU11	0.22	8.54			

1 Min Fixed Result

	641	β (cpm)			α (cpm)	β (cpm)	Comments
SRNW1	7	642					
SRNW2	4	616					
SRNW3	4	586					
SRNW4	5	641					
SRNW5	4	620					
SRNW6	3	604					
D-SRNW1	5	656					
SRNWU9	0	70					Scan: 0/50
SRNWU10	3	87					Scan: 0/75
SRNWU11	0	77					Scan: 0/75
D-SRNWU11	1	89					

Surveyed By: by K. Pagliaro Date: 5/13/2003

Reviewed By: [signature] Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4080	0.2400	7	628	1/24/2004
2360	193675	0.1100 (0.17)	0.2500	3	560	4/29/2004
2224-1	162426	0.1919 (0.20)	0.1165 (0.120)	1 (3)	89 (560)	1/15/2004

Key

○	Smear	⁒	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location:	South Room South Wall	RWP#		Survey #	5	Survey Type:	Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result				1 Min Fixed Result		Comments
No.	α	β	No.	α	β			α (cpm)	β (cpm)		α (cpm)	β (cpm)	
SRSW11	1.41	-10.00					SRSW11	2	609				
SRSW12	0.33	33.75					SRSW12	3	686				
SRSW13	2.50	29.58					SRSW13	3	599				
SRSW14	2.50	21.25					SRSW14	1	606				
SRSW15	1.41	-7.92					SRSW15	3	626				
SRSW16	2.50	31.67					SRSW16	2	596				
SRSWU1	-1	-10					D-SRSW12	10	731				
SRSWU2	0	-31					SRSWU1	2	88				Scan : 0/90
SRSWU3	2	-14					SRSWU2	2	87				Scan: 0/90
							SRSWU3	1	92				Scan: 0/85

Surveyed By: by K. Pagliaro Date: ~~5/13/2003~~ 5/12/03

Reviewed By: [signature] Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4060	0.2400	7	828	1/24/2004
2360	193875	~~0.1100~~ 0.117	0.2500	3	560	4/28/2004
2224-1	162426	0.1919	0.1165	~~1~~ 3	~~99~~ 560	1/15/2004

Key			
○	Smear	⁛	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location: South Room East Wall | RWP# | Survey # 4 | Survey Type: Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result			1 Min Fixed Result		Comments
No.	α	β	No.	α	β			α (cpm)	β (cpm)	α (cpm)	β (cpm)	
SREW7	1.41	25.42					SREW7	1	649			
SREW8	-0.76	-3.75					SREW8	0	691			
SREW9	3.59	44.17					SREW9	3	700			
SREW10	0.33	12.92					SREW10	7	675			
SREWU5	0	-2					D - SREW10	6	674			
SREWU6	2	2					SREWU5	0	94			Scan : 0/100
							SREWU6	1	104			Scan : 0/100

Surveyed By: K Pugliaro Date: 5/13/2003

Reviewed By: [signature] Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	~~0.4060~~ 0.17	0.2400	7	828	1/24/2004
2360	193675	0.1100	0.2500	3	560	4/29/2004
2224-1	162426	0.1919	0.1165	~~7~~ 3	~~99~~ 560	1/15/2004

Key			
○	Smear	∴	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location: South Room West Wall						RWP#			Survey # 6		Survey Type: Fixed -Smears
Smear Results DPM/100cm^2							1 Min Fixed Result		1 Min Fixed Result		
No.	α	β	No.	α	β		α (cpm)	β (cpm)	α (cpm)	β (cpm)	Comments
SRWW17	-0.76	15.00				SRWW17	1	750			
SRWW18	1.41	42.08				SRWW18	3	681			
SRWW19	1.41	19.17				SRWW19	7	647			
SRWW20	-0.76	2.50				SRWW20	2	702			
SRWWU8	-1	-41				D-SRWW19	8	566			
						SRWWU8	0	80			Scan: 0/75

Bkg
α β
8/819 for 5/14/03
for 5/12/03

Surveyed By:	Date:	Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
by K. Peghiero	~~5/13/2003~~ 5/12/03 + 5/14/03	2929	163827	0.4060	0.2400	7	828	4/24/2004
		2360	193676	0.1100 (0.17)	0.2500	3	560	4/29/2004
Reviewed By: [signature]	Date: 11/5/04	2224-1	162426	0.1919 (0.20)	0.1165 (0.20)	~~1~~ 3	~~90~~ 330	1/15/2004

Key			
⬭	Smear	•-•	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location	South Room Ceiling	RWP#	Survey #	11	Survey Type:	Fixed -Smears

Smear Results DPM/100cm^2							1 Min Fixed Result				1 Min Fixed Result		Comments
No.	α	β	No.	α	β			α (cpm)	β (cpm)		α (cpm)	β (cpm)	
SRC4	1.30	-12.29					SRC4	0	105				Scan : 0/90
SRC7	-0.87	10.63					SRC7	1	100				Scan: 0/100

Surveyed By: by K Pagliaro Date: 5/14/2003

Reviewed By: [signature] Date: 11/5/04

Instrument	Serial #	a Eff.	b Eff.	a Bkg.	b Bkg	Cal. Due
2929	163827	0.4060	0.2400	7 (8)	828 (819)	1/24/2004
2224-1	162426	0.1919 (0.120)	0.1165 (0.120)	1	99	1/15/2004

Key			
○	Smear	⁘	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 North Floor	RWP#	Survey # 20	Survey Type: Static/Smear

Smear Results DPM/100cm^2

No.	α	β	No.	α	β
1	-0.3	11.8	26		
2	1.2	-0.7	27		
3	2.7	-9.7	28		
4	-0.3	-4.3	29		
5	-0.3	6.5	30		
6	-0.3	-0.7	31		
7	1.2	-11.5	32		
8	-0.3	-9.7	33		
9	1.2	15.4	34		
10	1.2	-13.3	35		
11	2.7	-4.3	36		
12	-0.3	-15.1	37		
13	1.2	19.0	38		
14	-0.3	6.5	39		
15	-0.3	-11.5	40		
16	-0.3	15.4	41		
17	1.2	-11.5	42		
18	-0.3	-15.1	43		
19	-0.3	-6.1	44		
20	-0.3	-13.3	45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

AVG Scan Result α (cpm) | β (cpm)

1 Min Fixed Result

	α (cpm)	β (cpm)	Comments
1	8	829	WR2-NF-1
2	7	1121	NF-2
3	10	1345	NF-3
4	9	1500	NF-4
5	5	729	NF-5
6	7	659	NF-6
7	5	580	NF-7
8	12	857	NF-8
9	5	871	NF-9
10	6	917	NF-10
11	4	593	NF-11
12	5	556	NF-12
13	4	696	NF-13
14	9	686	NF-14
15	15	778	NF-15
16	11	689	NF-16
17	7	627	NF-17
18	6	698	NF-18
19	12	612	NF-19
20	5	713	NF-20

STET HWS

8/19

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg	β Bkg	Cal. Due
KP	3/31/2004*	2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/27/2003*	2360	193675	0.17	0.25	4	854	4/29/04
Reviewed By: HW Siegrist	Date: 11/8/04							

Key

⬭	Smear	*-*	Boundary
☐	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 were ~~taken and~~ analyzed March 2004 (HWS)
Direct Frisk using floor Monitor 43-37 probe were taken and analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 South Floor	RWP#	Survey # 19	Survey Type: Static/Smear

Smear Results DPM/100cm^2						AVG Scan Result				1 Min Fixed Result		Comments
No.	α	β	No.	α	β		α (cpm)	β (cpm)			α (cpm)	β (cpm)	
1	-0.3	-6.1	26							1	5	594	WR 2-SF-1
2	-0.3	4.7	27							2	7	703	SF-2
3	-0.3	-7.9	28							3	4	687	SF-3
4	1.2	-11.5	29							4	10	673	SF-4
5	2.7	-31.2	30							5	9	692	SF-5
6	-0.3	-2.5	31							6	7	694	SF-6
7	-0.3	-9.7	32							7	7	741	SF-7
8	-0.3	-13.3	33							8	12	1272	SF-8
9	-0.3	11.8	34							9	7	1147	SF-9
10	-0.3	-0.7	35							10	5	921	SF-10
11	-0.3	-27.6	36							11	8	827	SF-11
12	-0.3	-4.3	37							12	3	712	SF-12
13	-0.3	-0.7	38							13	9	802	SF-13
14	2.7	8.2	39							14	6	753	SF-14
15	2.7	-7.9	40							15	11	769	SF-15
16	-0.3	-11.5	41							16	10	652	SF-16
17	-0.3	-4.3	42							17	5	696	SF-17
18	-0.3	-9.7	43							18	6	723	SF-18
19	1.2	-15.1	44							19	4	649	SF-19
20	1.2	-24.0	45							20	8	698	SF-20
21			46										
22			47										
23			48										
24			49										
25			50										

Comments

STET HWJ

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/31/2004*	2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/27/04*	2360	193675	0.17	0.25	~~4~~ 5	~~854~~ 819	4/29/04
Reviewed By: HW Siegrist	Date: 11/8/04							

Key			
○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

*Note: Smear Sample analysis via 2929 were ~~taken and~~ analyzed March 2004 HWJ
Direct Frisk using Floor Monitor 43-37 Probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 North Wall	RWP#	Survey # 21	Survey Type: Static/Smear

Smear Results DPM/100cm^2						AVG Scan Result				1 Min Fixed Result			Comments
No.	α	β	No.	α	β		α (cpm)	β (cpm)			α (cpm)	β (cpm)	
										1			
1			26							2			
2			27							3			
3			28							4			
4			29							5			
5			30							6			
6			31							7			
7			32							8			
8			33							9	14	543	North Wall
9	-0.3	26.2	34			WR2-NW-1				10			
10			35							11	9	523	North Wall
11	1.2	-11.5	36			WR2-NW-2				12			
12			37							13	8	530	North Wall
13	-0.3	-27.6	38			WR2-NW-3				14			
14			39							15	7	517	North wall
15	-0.3	-2.5	40			WR2-NW-4				16			
16			41							17			
17			42							18			
18			43							19			
19			44							20			
20			45										
21			46										
22			47										
23			48										
24			49										
25			50										

Comments

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/31/2004* →	2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/27/04* →	2360	193675	0.17	0.25	(4) 5	854	4/29/04
Reviewed By:	Date:							
HWsignature	11/8/04							

Key: ⬭ Smear; ▭ Dose Rate mr/hr; • Direct Reading DPM/100 cm^2; △ Grab Sample; *-* Boundary; ■ A/S Location

* Note: Smear sample analysis via 2929 were ~~taken~~ analyzed MARCH 2004
Direct Frisk using floor monitor 43-37 probe were taken + analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 South Wall	RWP#	Survey # 23	Survey Type: Static/Smear

Smear Results DPM/100cm^2

No.	α	β	No.	α	β	AVG Scan Result
1			26			
2			27			
3			28			
4			29			
5			30			
6			31			
7			32			
8			33			
9			34			
10	-0.3	-36.6	35			WR2-SW-1
11			36			
12	-0.3	-9.7	37			WR2-SW-2
13			38			
14	1.2	-4.3	39			WR2-SW-3
15			40			
16	1.2	-13.3	41			WR2-SW-4
17			42			
18			43			
19			44			
20			45			
21			46			
22			47			
23			48			
24			49			
25			50			

Comments

AVG Scan Result / 1 Min Fixed Result

AVG Scan α (cpm)	AVG Scan β (cpm)		No.	1 Min Fixed α (cpm)	1 Min Fixed β (cpm)	Comments
			1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			10	6	545	South wall
			11			
			12	5	525	South wall
			13			
			14	9	499	South wall
			15			
			16	11	573	South wall
			17			
			18			
			19			
			20			
			21			
			22			
			23			
			24			
			25			

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/31/2004* →	2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/27/2003* →	2360	193675	0.17	0.25	4	854	4/29/04

Reviewed By: HW [illegible] Date: 11/8/04

Key			
⬭	Smear	*-*	Boundary
☐	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 were ~~taken &~~ analyzed March 2004

Direct Frisk using floor monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 East Wall	RWP#	Survey # 22	Survey Type: Static/Smear

Smear Results DPM/100cm^2						AVG Scan Result				1 Min Fixed Result			
No.	α	β	No.	α	β		α (cpm)	β (cpm)			α (cpm)	β (cpm)	Comments
										1			
1			26							2			
2			27							3			
3			28							4			
4			29							5			
5			30							6			
6			31							7			
7			32							8			
8			33							9			
9			34							10			
10			35							11			
11			36							12			
12			37							13			
13			38							14			
14			39							15			
15			40							16			
16			41							17	11	561	East wall
17	1.2	6.5	42			WR2-EW-1				18	9	602	East wall
18	1.2	-29.4	43			WR2-EW-2				19	14	581	East wall
19	-0.3	-0.7	44			WR2-EW-3				20	9	574	East Wall
20	-0.3	-7.9	45			WR2-EW-4				21	6	550	East Wall
21	2.7	-15.1	46			WR2-EW-5				22	7	568	East wall
22	1.2	-6.1	47			WR2-EW-6				23	8	578	East Wall
23	1.2	-11.5	48			WR2-EW-7				24	5	583	East Wall
24	-0.3	-9.7	49			WR2-EW-8				25			
25			50										

Comments

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/31/2004*	→ 2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/27/03*	→ 2360	193675	0.17	0.25	~~(4)~~ 5	854	4/29/04
Reviewed By: [illegible]	Date: 11/8/04							

Key			
⬭	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 were ~~taken~~ [illegible] analyzed March 2004
Direct Frisk using Floor Monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 West Wall	RWP#	Survey # 24	Survey Type: Static/Smear

Smear Results DPM/100cm^2

No.	α	β	No.	α	β
1	-0.3	-0.7	26		
2	-0.3	-2.5	27		
3	-0.3	-11.5	28		
4	1.2	-4.3	29		
5	-0.3	10.0	30		
6	1.2	-7.9	31		
7	-0.3	-11.5	32		
8	1.2	-6.1	33		
9			34		
10			35		
11			36		
12			37		
13			38		
14			39		
15			40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

AVG Scan Result / 1 Min Fixed Result

	AVG Scan α (cpm)	AVG Scan β (cpm)		No.	1 Min Fixed α (cpm)	1 Min Fixed β (cpm)	Comments
WR2-WW-1				1	8	581	West Wall
-WW-2				2	12	589	↓
-WW-3				3	10	545	
-WW-4				4	11	503	
-WW-5				5	5	574	
-WW-6				6	10	560	
-WW-7				7	8	582	
-WW-8				8	8	555	
				9			
				10			
				11			
				12			
				13			
				14			
				15			
				16			
				17			
				18			
				19			
				20			
				21			
				22			
				23			
				24			
				25			

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/31/2004* →	2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/27/03* →	2360	193675	0.17	0.25	(4) 5	854	4/29/04
Reviewed By:	Date:							
[signature]	11/8/04							

Key

Symbol	Meaning	Symbol	Meaning
○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 were ~~taken and~~ they analyzed March 2004
Direct Frisk using floor monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 2 Ceiling	RWP#	Survey # 25	Survey Type: Static/Smear

Smear Results DPM/100cm^2

No.	α	β	No.	α	β
1	-0.3	-16.8	26		
2	1.2	-18.6	27		
3	-0.3	-15.0	28		
4	-0.3	-16.8	29		
5	2.7	-29.3	30		
6	-0.3	-18.6	31		
7	1.2	8.2	32		
8	-0.3	15.4	33		
9	-0.3	-6.1	34		
10	1.2	-2.5	35		
11	1.2	-16.8	36		
12	-0.3	-0.7	37		
13	-0.3	-11.4	38		
14	-0.3	-27.5	39		
15	-0.3	-40.0	40		
16	1.2	-38.2	41		
17	-0.3	-18.6	42		
18	1.2	-9.6	43		
19	-0.3	-7.9	44		
20	-0.3	-6.1	45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

AVG Scan Result / 1 Min Fixed Result

AVG Scan α (cpm)	AVG Scan β (cpm)		No.	1 Min Fixed α (cpm)	1 Min Fixed β (cpm)	Comments
			1	0	79	East Wall
			2	0	104	East Wall
			3	2	86	East Wall
			4	1	78	East Wall
			5	1	100	North Wall
			6	2	77	Ceiling
			7	0	84	Ceiling
			8	0	93	Ceiling
			9	0	96	Ceiling
			10	1	82	South Wall
			11	0	85	North Wall
			12	0	91	Ceiling
			13	1	92	Ceiling
			14	1	98	Ceiling
			15	2	97	Ceiling
			16	0	92	South Wall
			17	0	91	West Wall
			18	2	105	West Wall
			19	0	98	West Wall
			20	1	72	West Wall
			21			
			22			
			23			
			24			
			25			

0.20   0   0 use 0 bkg   No Bkg determined in field; conservatively

Surveyed By	Date	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal Due
KP	3/31/2004* →	2929	180830	0.33	0.28	2	994	12/15/04
by KP	6/26/03* →	2224	162426	0.2	0.15	4	819	12/27/04

Reviewed By: [signature] Date: 11/8/04

Key

Symbol	Meaning	Symbol	Meaning
⬭	Smear	*-*	Boundary
☐	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 were analyzed March 2004
direct frisk using floor monitor 43-89 probe were taken & analyzed during work in March 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 North Floor	RWP#	Survey # 27	Survey Type: Static/Smear

Smear Results (DPM/100cm^2)

No.	α	β	No.	α	β
1	0.9	-8.1	26		
2	-0.6	0.9	27		
3	-0.6	8.1	28		
4	-0.6	-11.7	29		
5	0.9	-13.4	30		
6	-0.6	-0.9	31		
7	-0.6	0.9	32		
8	-0.6	9.9	33		
9	-0.6	8.1	34		
10	-0.6	-9.9	35		
11	0.9	-13.4	36		
12	-0.6	-4.5	37		
13	0.9	20.6	38		
14	0.9	-6.3	39		
15	-0.6	-15.2	40		
16	0.9	-36.8	41		
17	-0.6	-11.7	42		
18	-0.6	-4.5	43		
19	0.9	-13.4	44		
20	-0.6	-2.7	45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

AVG Scan Result / 1 Min Fixed Result

AVG Scan α (cpm)	AVG Scan β (cpm)	No.	1 Min Fixed α (cpm)	1 Min Fixed β (cpm)	Comments
		1	3	525	WR3 -NF-1
		2	1	605	NF-2
		3	2	548	NF-3
		4	4	606	NF-4
		5	3	613	NF-5
		6	8	637	NF-6
		7	10	634	NF-7
		8	8	588	NF-8
		9	6	589	NF-9
		10	11	621 (circled) — 640	NF-10
		11	8	621	NF-11
		12	7	602	NF-12
		13	6	617	NF-13
		14	5	740	NF-14
		15	5	569	NF-15
		16	8	552	NF-16
		17	12	558	NF-17
		18	10	781	NF-18
		19	8	601	NF-19
		20	15	639	NF-20

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/30/2004* →	2929	180830	0.33	0.28	4	965	12/15/04
by KP	6/25/03* →	2360	193675	0.17	0.25	4	854	4/29/04

(α Bkg. annotation: STET HWJ 5)

Reviewed By: [signature] Date: 11/8/04

Key:

Symbol	Meaning	Symbol	Meaning
○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analys via 2929 were ~~taken~~ [initials] analyzed MARCH 2004

Direct Frisk Using floor monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 South Floor	RWP#	Survey # 26	Survey Type: Static/Smear

Smear Results DPM/100cm^2 No.	α	β	No.	α	β	AVG Scan Result α (cpm)	β (cpm)		1 Min Fixed Result No.	α (cpm)	β (cpm)	Comments
1	-0.6	9.9	26						1	5	808	WR3 -SF-1
2	-0.6	0.9	27						2	3	758	-2
3	-0.6	6.3	28						3	6	561	-3
4	-0.6	-36.8	29						4	7	1005	-4
5	-0.6	-26.0	30						5	2	258	-5
6	-0.6	-6.3	31						6	2	647	-6
7	-0.6	-42.1	32						7	3	665	-7
8	-0.6	-29.6	33						8	1	569	-8
9	-0.6	24.2	34						9	6	880	-9
10	-0.6	-0.9	35						10	4	940	-10
11	-0.6	8.1	36						11	2	558	-11
12	-0.6	4.5	37						12	3	551	-12
13	-0.6	-18.8	38						13	2	434	-13
14	-0.6	-31.4	39						14	4	1283	-14
15	-0.6	11.7	40						15	7	1076	-15
16	-0.6	-33.2	41						16	4	572	-16
17	-0.6	-8.1	42						17	4	620	-17
18	-0.6	9.9	43						18	4	576	-18
19	-0.6	-0.9	44						19	7	683	-19
20	-0.6	-4.5	45						20	4	664	-20
21			46						21			
22			47						22			
23			48						23			
24			49						24			
25			50						25			

Comments

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/30/2004*	2929	180830	0.33	0.28	4	965	12/15/04
KP	6/23/03*	2360	193675	0.17	0.25	(4) 5	(854) 866	4/29/04
Reviewed By: [illegible]	Date: 11/8/04							

Key

Symbol	Meaning	Symbol	Meaning
⬭	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 were ~~taken &~~ was analyzed March 2004
Direct frisk using floor monitor 43-37 were taken & analyzed during work in 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 North Wall	RWP#	Survey # 28	Survey Type: Static/Smear

Smear Results — DPM/100cm^2

No.	α	β	No.	α	β
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33		
9	-0.6	-164	34		
10			35		
11	-0.6	-26.0	36		
12			37		
13	2.4	-20.6	38		
14			39		
15	-0.6	2.7	40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

AVG Scan Result / 1 Min Fixed Result

AVG Scan α (cpm)	AVG Scan β (cpm)	No.	1 Min Fixed α (cpm)	1 Min Fixed β (cpm)	Comments
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9	4	757	North Wall
		10			
		11	5	781	North Wall
		12			
		13	9	988	North Wall
		14			
		15	6	794	North Wall
		16			
		17			
		18			
		19			
		20			

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/30/2004* →	2929	180830	0.33	0.28	4	965	12/15/04
by KP	6/25/04* →	2360	193675	0.17	0.25	~~4~~ 5	854	4/29/04
Reviewed By:	Date:							
HW Seyjat	11/8/04							

Key

○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear sample analysis via 2929 analyzed in March 2004
direct frisk using floor monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 South Wall	RWP#	Survey # 30	Survey Type: Static/Smear

Smear Results DPM/100cm^2

No.	α	β	No.	α	β
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33		
9			34		
10	-0.6	-4.5	35		
11			36		
12	-0.6	-8.1	37		
13			38		
14	2.4	-2.7	39		
15			40		
16	0.9	-27.8	41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

AVG Scan Result α (cpm) | β (cpm)

WR3 -SW -1
-2
-3
-4

No.	1 Min Fixed Result α (cpm)	β (cpm)	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10	5	861	South wall
11			
12	9	1206	South wall
13			
14	4	1102	South wall
15			
16	5	974	South wall
17			
18			
19			
20			
21			
22			
23			
24			
25			

Surveyed By:	Date:
KP	3/30/2004*
By KP	6/25/04*
Reviewed By:	Date:
[signature]	11/8/04

Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
2929	180830	0.33	0.28	4	965	12/15/04
2360	193675	0.17	0.25	(4) 5	854	4/29/04

Key

○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: Smear Sample analyzed via 2929 were analyzed in March 2004
Direct frisk using floor monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 East Wall	RWP#	Survey # 29	Survey Type: Static/Smear

Smear Results DPM/100cm^2

No.	α	β	No.	α	β
1	-0.6	38.5	26		
2	0.9	4.5	27		
3	2.4	-17.0	28		
4	-0.6	8.1	29		
5	-0.6	-8.1	30		
6	0.9	17.0	31		
7	-0.6	-6.3	32		
8	-0.6	-13.4	33		
9			34		
10			35		
11			36		
12			37		
13			38		
14			39		
15			40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		

Comments

	AVG Scan Result α (cpm)	AVG Scan Result β (cpm)	No.	1 Min Fixed Result α (cpm)	1 Min Fixed Result β (cpm)	Comments
WR3-EW-1			1	7	516	East wall
-2			2	5	558	
-3			3	5	539	
-4			4	2	617	
-5			5	6	1348	
-6			6	2	582	
-7			7	5	886	
-8			8	5	1212	
			9			
			10			
			11			
			12			
			13			
			14			
			15			
			16			
			17			
			18			
			19			
			20			
			21			
			22			
			23			
			24			
			25			

Surveyed By: KP / by KP — Date: 3/30/2004* / 6/25/04*

Reviewed By: [signature] — Date: 11/8/04

Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
2929	180830	0.33	0.28	4	965	12/15/04
2360	193675	0.17	0.25	4	854	4/29/04

Key

○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
*	Direct Reading DPM/100 cm^2		
△	Grab Sample		

* Note: smear sample analysis via 2929 were analyzed March 2004
Direct frisk using floor monitor 43-37 probe were taken & analyzed during work in June 2003

RADIOLOGICAL SURVEY MAP

Location: Wash Rack 3 West Wall	RWP#	Survey # 31	Survey Type: Static/Smear

Smear Results DPM/100cm^2						AVG Scan Result		1 Min Fixed Result			Comments
No.	α	β	No.	α	β	α (cpm)	β (cpm)	1	α (cpm)	β (cpm)	
1			26					2			
2			27					3			
3			28					4			
4			29					5			
5			30					6			
6			31					7			
7			32					8			
8			33					9			
9			34					10			
10			35					11			
11			36					12			
12			37					13			
13			38					14			
14			39					15			
15			40					16			
16			41					17	7	521	
17	-0.6	-11.7	42					18	5	538	
18	0.9	-15.2	43					19	3	508	
19	-0.6	15.2	44					20	3	448	
20	-0.6	-22.4	45					21	6	613	
21	0.9	-13.4	46					22	5	541	
22	-0.6	9.9	47					23	4	527	
23	-0.6	-13.4	48					24	4	542	
24	0.9	-8.1	49					25			
25			50								

Comments

Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due
KP	3/30/2004* →	2929	180830	0.33	0.28	4	965	12/15/04
by KP	6/25/03* →	2360	193675	0.17	0.25	(4) 5	854	4/29/04
Reviewed By:	Date:							
HW Sieginst	11/8/04							

Key			
○	Smear	*-*	Boundary
□	Dose Rate mr/hr	■	A/S Location
•	Direct Reading DPM/100 cm^2		
△	Grab Sample		

*Note: Smear sample analysis via 2929 were analyzed March 2004
direct frisk, using floor monitor, 43-37 probe, were taken & analyzed during work in June 2003

Appendix H: Survey Unit Worksheets and Data Summaries

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
BARF BUILDING NORTH FLOOR - SMEAR RESULTS

α eff	β eff
0.4060	0.2400

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm² α Flag	dpm/100 cm² β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm²) α	Sample (dpm/100 cm²) β	> α flag	> β flag	Tech. Initial
1	BARF NF 1	5/12/2003	7	828	4	98	0.4	41.4	2.00	49	4.1	32			KvH
2	BARF NF 2	5/12/2003	7	828	5	102	0.4	41.4	2.50	51	5.3	40			KvH
3	BARF NF 3	5/12/2003	7	828	4	122	0.4	41.4	2.00	61	4.1	82			KvH
4	BARF NF 4	5/12/2003	7	828	1	93	0.4	41.4	0.50	47	0.4	21			KvH
5	BARF NF 5	5/12/2003	7	828	1	78	0.4	41.4	0.50	39	0.4	-10			KvH
6	BARF NF 6	5/12/2003	7	828	4	85	0.4	41.4	2.00	43	4.1	5			KvH
7	BARF NF 7	5/12/2003	7	828	6	103	0.4	41.4	3.00	52	6.5	42			KvH
8	BARF NF 8	5/12/2003	7	828	1	96	0.4	41.4	0.50	48	0.4	28			KvH
9	BARF NF 9	5/12/2003	7	828	1	105	0.4	41.4	0.50	53	0.4	46			KvH
10	BARF NF 10	5/12/2003	7	828	1	96	0.4	41.4	0.50	48	0.4	28			KvH
11	BARF NF 11	5/12/2003	7	828	2	101	0.4	41.4	1.00	51	1.6	38			KvH
12	BARF NF 12	5/12/2003	7	828	1	106	0.4	41.4	0.50	53	0.4	48			KvH
13	BARF NF 13	5/12/2003	7	828	4	108	0.4	41.4	2.00	54	4.1	53			KvH
14	BARF NF 14	5/12/2003	7	828	2	105	0.4	41.4	1.00	53	1.6	46			KvH
15	BARF NF 15	5/12/2003	7	828	4	80	0.4	41.4	2.00	40	4.1	-6			KvH
16	BARF NF 16	5/12/2003	7	828	0	84	0.4	41.4	0.00	42	-0.9	3			KvH
17	BARF NF 17	5/12/2003	7	828	2	93	0.4	41.4	1.00	47	1.6	21			KvH
18	BARF NF 18	5/12/2003	7	828	1	94	0.4	41.4	0.50	47	0.4	23			KvH
19	BARF NF 19	5/12/2003	7	828	1	93	0.4	41.4	0.50	47	0.4	21			KvH
20	BARF NF 20	5/12/2003	7	828	1	90	0.4	41.4	0.50	45	0.4	15			KvH
21	BARF NF 21	5/12/2003	7	828	0	93	0.4	41.4	0.00	47	-0.9	21			KvH
22	BARF NF 22	5/12/2003	7	828	2	97	0.4	41.4	1.00	49	1.6	30			KvH
23	BARF NF 23	5/12/2003	7	828	4	87	0.4	41.4	2.00	44	4.1	9			KvH
24	BARF NF 24	5/12/2003	7	828	2	80	0.4	41.4	1.00	40	1.6	-6			KvH
25															

CABRERA SMEAR CO ING WORKSHEET (Rev 4)
BARF BUILDING SOUTH FLOOR - SMEAR RESULTS

α eff	β eff
0.4060	0.2400

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	BARF SF 1	5/12/2003	7	828	5	107	0.4	41.4	2.50	54	5.3	50			KvH
2	BARF SF 2	5/12/2003	7	828	0	103	0.4	41.4	0.00	52	-0.9	42			KvH
3	BARF SF 3	5/12/2003	7	828	1	95	0.4	41.4	0.50	48	0.4	25			KvH
4	BARF SF 4	5/12/2003	7	828	2	110	0.4	41.4	1.00	55	1.6	57			KvH
5	BARF SF 5	5/12/2003	7	828	2	96	0.4	41.4	1.00	48	1.6	28			KvH
6	BARF SF 6	5/12/2003	7	828	6	105	0.4	41.4	3.00	53	6.5	46			KvH
7	BARF SF 7	5/12/2003	7	828	1	91	0.4	41.4	0.50	46	0.4	17			KvH
8	BARF SF 8	5/12/2003	7	828	2	95	0.4	41.4	1.00	48	1.6	25			KvH
9	BARF SF 9	5/12/2003	7	828	2	103	0.4	41.4	1.00	52	1.6	42			KvH
10	BARF SF 10	5/12/2003	7	828	4	116	0.4	41.4	2.00	58	4.1	69			KvH
11	BARF SF 11	5/12/2003	7	828	5	117	0.4	41.4	2.50	59	5.3	71			KvH
12	BARF SF 12	5/12/2003	7	828	0	80	0.4	41.4	0.00	40	-0.9	-6			KvH
13	BARF SF 13	5/12/2003	7	828	1	117	0.4	41.4	0.50	59	0.4	71			KvH
14	BARF SF 14	5/12/2003	7	828	2	107	0.4	41.4	1.00	54	1.6	50			KvH
15	BARF SF 15	5/12/2003	7	828	2	90	0.4	41.4	1.00	45	1.6	15			KvH
16	BARF SF 16	5/12/2003	7	828	1	85	0.4	41.4	0.50	43	0.4	5			KvH
17	BARF SF 17	5/12/2003	7	828	0	102	0.4	41.4	0.00	51	-0.9	40			KvH
18	BARF SF 18	5/12/2003	7	828	4	85	0.4	41.4	2.00	43	4.1	5			KvH
19	BARF SF 19	5/12/2003	7	828	2	93	0.4	41.4	1.00	47	1.6	21			KvH
20	BARF SF 20	5/12/2003	7	828	2	83	0.4	41.4	1.00	42	1.6	0			KvH
21	BARF SF 21	5/12/2003	7	828	2	85	0.4	41.4	1.00	43	1.6	5			KvH
22	BARF SF 22	5/12/2003	7	828	1	103	0.4	41.4	0.50	52	0.4	42			KvH
23	BARF SF 23	5/12/2003	7	828	2	96	0.4	41.4	1.00	48	1.6	28			KvH
24	BARF SF 24	5/12/2003	7	828	3	95	0.4	41.4	1.50	48	2.8	25			KvH
25															

CABRERA SMEAR COU[illegible]NG WORKSHEET (Rev 4)
BARF BUILDING NORTH ROOM LOWER WALLS - SMEAR RESULTS

α eff	β eff
0.4060	0.2400

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	BARF NRNW 1	5/13/2003	6	844	2	87	0.3	42.2	1.00	44	1.7	5			KvH
2	BARF NRNW 2	5/13/2003	6	844	4	102	0.3	42.2	2.00	51	4.2	37			KvH
3	BARF NRNW 3	5/13/2003	6	844	2	97	0.3	42.2	1.00	49	1.7	26			KvH
4	BARF NRNW 4	5/13/2003	6	844	3	84	0.3	42.2	1.50	42	3.0	-1			KvH
5	BARF NRNW 5	5/13/2003	6	844	3	96	0.3	42.2	1.50	48	3.0	24			KvH
6	BARF NRNW 6	5/13/2003	6	844	1	106	0.3	42.2	0.50	53	0.5	45			KvH
7	BARF NREW 7	5/13/2003	6	844	3	99	0.3	42.2	1.50	50	3.0	30			KvH
8	BARF NREW 8	5/13/2003	6	844	1	101	0.3	42.2	0.50	51	0.5	35			KvH
9	BARF NREW 9	5/13/2003	6	844	2	92	0.3	42.2	1.00	46	1.7	16			KvH
10	BARF NREW 10	5/13/2003	6	844	0	86	0.3	42.2	0.00	43	-0.7	3			KvH
11	BARF NRSW 11	5/13/2003	6	844	0	93	0.3	42.2	0.00	47	-0.7	18			KvH
12	BARF NRSW 12	5/13/2003	6	844	4	125	0.3	42.2	2.00	63	4.2	85			KvH
13	BARF NRSW 13	5/13/2003	6	844	0	99	0.3	42.2	0.00	50	-0.7	30			KvH
14	BARF NRSW 14	5/13/2003	6	844	3	114	0.3	42.2	1.50	57	3.0	62			KvH
15	BARF NRSW 15	5/13/2003	6	844	1	103	0.3	42.2	0.50	52	0.5	39			KvH
16	BARF NRSW 16	5/13/2003	6	844	2	101	0.3	42.2	1.00	51	1.7	35			KvH
17	BARF NRWW 17	5/13/2003	6	844	3	89	0.3	42.2	1.50	45	3.0	10			KvH
18	BARF NRWW 18	5/13/2003	6	844	4	108	0.3	42.2	2.00	54	4.2	49			KvH
19	BARF NRWW 19	5/13/2003	6	844	0	89	0.3	42.2	0.00	45	-0.7	10			KvH
20	BARF NRWW 20	5/13/2003	6	844	4	100	0.3	42.2	2.00	50	4.2	33			KvH
21	BARF WWNRB 1	6/2/2003	3	829	5	88	0.2	41.5	2.50	44	5.8	11			AC
22	BARF WWNRB 2	6/2/2003	3	829	0	90	0.2	41.5	0.00	45	-0.4	15			AC
23															

CABRERA SMEAR CO(ING WORKSHEET (Rev 4)
BARF BUILDING SOUTH ROOM LOWER WALLS - SMEAR RESULTS

α eff	β eff
0.4060	0.2400

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	BARF SREW 10	5/12/2003	7	828	1	89	0.4	41.4	0.50	45	0.4	13			KvH
2	BARF SREW 9	5/12/2003	7	828	4	104	0.4	41.4	2.00	52	4.1	44			KvH
3	BARF SREW 7	5/12/2003	7	828	2	95	0.4	41.4	1.00	48	1.6	25			KvH
4	BARF SREW 8	5/12/2003	7	828	0	81	0.4	41.4	0.00	41	-0.9	-4			KvH
5	BARF SRWW 18	5/12/2003	7	828	2	103	0.4	41.4	1.00	52	1.6	42			KvH
6	BARF SRWW 17	5/12/2003	7	828	0	90	0.4	41.4	0.00	45	-0.9	15			KvH
7	BARF SRWW 20	5/12/2003	7	828	0	84	0.4	41.4	0.00	42	-0.9	3			KvH
8	BARF SRWW 19	5/12/2003	7	828	2	92	0.4	41.4	1.00	46	1.6	19			KvH
9	BARF SRSW 11	5/12/2003	7	828	2	78	0.4	41.4	1.00	39	1.6	-10			KvH
10	BARF SRSW 12	5/12/2003	7	828	1	99	0.4	41.4	0.50	50	0.4	34			KvH
11	BARF SRSW 13	5/12/2003	7	828	3	97	0.4	41.4	1.50	49	2.8	30			KvH
12	BARF SRSW 14	5/12/2003	7	828	3	93	0.4	41.4	1.50	47	2.8	21			KvH
13	BARF SRSW 15	5/12/2003	7	828	2	79	0.4	41.4	1.00	40	1.6	-8			KvH
14	BARF SRSW 16	5/12/2003	7	828	3	98	0.4	41.4	1.50	49	2.8	32			KvH
15	BARF SRNW 1	5/13/2003	6	844	2	95	0.3	42.2	1.00	48	1.7	22			KvH
16	BARF SRNW 2	5/13/2003	6	844	3	81	0.3	42.2	1.50	41	3.0	-7			KvH
17	BARF SRNW 3	5/13/2003	6	844	1	96	0.3	42.2	0.50	48	0.5	24			KvH
18	BARF SRNW 4	5/13/2003	6	844	1	88	0.3	42.2	0.50	44	0.5	7			KvH
19	BARF SRNW 5	5/13/2003	6	844	0	94	0.3	42.2	0.00	47	-0.7	20			KvH
20	BARF SRNW 6	5/13/2003	6	844	2	83	0.3	42.2	1.00	42	1.7	-3			KvH
21	BARF EWSRB	6/2/2003	3	829	0	85	0.2	41.5	0.00	43	-0.4	4			AC
22	BARF NWSRB	6/2/2003	3	829	3	80	0.2	41.5	1.50	40	3.3	-6			AC
23	BARF WWSRB 1	6/2/2003	3	829	3	111	0.2	41.5	1.50	56	3.3	59			AC
24	BARF WWSRB 2	6/2/2003	3	829	1	97	0.2	41.5	0.50	49	0.9	29			AC
25	BARF WWSRB 3	6/2/2003	3	829	2	89	0.2	41.5	1.00	45	2.1	13			RS
26															

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
BARF BUILDING CEILING AND UPPER WALLS - SMEAR RESULTS

α eff	β eff
0.4060	0.2400

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm^2	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	BARF SRSWU 1	5/14/2003	8	819	0	77	0.4	41.0	0.00	39	-1.0	-10			KvH
2	BARF SRSWU 2	5/14/2003	8	819	1	67	0.4	41.0	0.50	34	0.2	-31			KvH
3	BARF SRSWU 3	5/14/2003	8	819	3	75	0.4	41.0	1.50	38	2.7	-14			KvH
4	BARF SRWWU 8	5/14/2003	8	819	0	62	0.4	41.0	0.00	31	-1.0	-41			KvH
5	BARF SRC 4	5/14/2003	8	819	2	76	0.4	41.0	1.00	38	1.5	-12			KvH
6	BARF SRC 7	5/14/2003	8	819	0	87	0.4	41.0	0.00	44	-1.0	11			KvH
7	BARF SREWU 5	5/14/2003	8	819	1	81	0.4	41.0	0.50	41	0.2	-2			KvH
8	BARF SREWU 6	5/14/2003	8	819	3	83	0.4	41.0	1.50	42	2.7	2			KvH
9	BARF SREWU 9	5/14/2003	8	819	0	75	0.4	41.0	0.00	38	-1.0	-14			KvH
10	BARF SRNWU 10	5/14/2003	8	819	1	75	0.4	41.0	0.50	38	0.2	-14			KvH
11	BARF SRNWU 11	5/14/2003	8	819	1	86	0.4	41.0	0.50	43	0.2	9			KvH
12	BARF SRNWU 12	5/15/2003	6	796	2	88	0.3	39.8	1.00	44	1.7	18			KvH
13	BARF SRNWU 13	5/15/2003	6	796	3	71	0.3	39.8	1.50	36	3.0	-18			KvH
14	BARF SRNWU 14	5/15/2003	6	796	1	105	0.3	39.8	0.50	53	0.5	53			KvH
15	BARF SRNWU 15	5/15/2003	6	796	3	93	0.3	39.8	1.50	47	3.0	28			KvH
16	BARF SRNWU 19	5/15/2003	6	796	0	75	0.3	39.8	0.00	38	-0.7	-10			KvH
17	BARF SRNWU 20	5/15/2003	6	796	4	90	0.3	39.8	2.00	45	4.2	22			KvH
18	BARF SRNWU 18	5/15/2003	6	796	1	83	0.3	39.8	0.50	42	0.5	7			KvH
19	BARF NRCU 16	5/15/2003	6	796	0	84	0.3	39.8	0.00	42	-0.7	9			KvH
20	BARF NRCU 17	5/15/2003	6	796	3	81	0.3	39.8	1.50	41	3.0	3			KvH
21	BARF CB 1	6/2/2003	3	829	3	101	0.2	41.5	1.50	51	3.3	38			KvH
22	BARF CB 2	6/2/2003	3	829	2	88	0.2	41.5	1.00	44	2.1	11			KvH
23	BARF CB 3	6/2/2003	3	829	1	96	0.2	41.5	0.50	48	0.9	27			KvH
24															KvH
25															

CABRERA STATIC CO(.'ING WORKSHEET (Rev 5)
BARF NORTH FLOOR - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	NF1	5/12/2003	4	478	10	648	0.2	23.9	10.00	648	9.9	429			KP
2	NF2	5/12/2003	4	478	12	661	0.2	23.9	12.00	661	11.9	438			KP
3	NF3	5/12/2003	4	478	7	847	0.2	23.9	7.00	847	6.9	566			KP
4	NF4	5/12/2003	4	478	11	878	0.2	23.9	11.00	878	10.9	587			KP
5	NF5	5/12/2003	4	478	30	800	0.2	23.9	30.00	800	30.1	533			KP
6	NF6	5/12/2003	4	478	4	675	0.2	23.9	4.00	675	3.8	447			KP
7	NF7	5/12/2003	4	478	17	992	0.2	23.9	17.00	992	17.0	665			KP
8	NF8	5/12/2003	4	478	12	689	0.2	23.9	12.00	689	11.9	457			KP
9	NF9	5/12/2003	4	478	6	670	0.2	23.9	6.00	670	5.9	444			KP
10	NF10	5/12/2003	4	478	12	944	0.2	23.9	12.00	944	11.9	632			KP
11	NF11	5/12/2003	4	478	13	828	0.2	23.9	13.00	828	12.9	553			KP
12	NF12	5/12/2003	4	478	10	673	0.2	23.9	10.00	673	9.9	446			KP
13	NF13	5/12/2003	4	478	7	815	0.2	23.9	7.00	815	6.9	544			KP
14	NF14	5/12/2003	4	478	4	719	0.2	23.9	4.00	719	3.8	478			KP
15	NF15	5/12/2003	4	478	7	755	0.2	23.9	7.00	755	6.9	502			KP
16	NF16	5/12/2003	4	478	3	842	0.2	23.9	3.00	842	2.8	562			KP
17	NF17	5/12/2003	4	478	10	926	0.2	23.9	10.00	926	9.9	620			KP
18	NF18	5/12/2003	4	478	17	721	0.2	23.9	17.00	721	17.0	479			KP
19	NF19	5/12/2003	4	478	10	1131	0.2	23.9	10.00	1131	9.9	761			KP
20	NF20	5/12/2003	4	478	6	808	0.2	23.9	6.00	808	5.9	539			KP
21	NF21	5/12/2003	4	478	4	758	0.2	23.9	4.00	758	3.8	505			KP
22	NF22	5/12/2003	4	478	9	722	0.2	23.9	9.00	722	8.9	480			KP
23	NF23	5/12/2003	4	478	8	699	0.2	23.9	8.00	699	7.9	464			KP
24	NF24	5/12/2003	4	478	6	606	0.2	23.9	6.00	606	5.9	400			KP

CABRERA STATIC COU[illegible]NG WORKSHEET (Rev 5)
BARF SOUTH FLOOR - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)	α eff	β eff	Static Count Time (min)	Daily Background Count Time (min)	dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
582	0.1700	0.2500	1.0	20.0	100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	SF1	5/12/2003	4	478	4	791	0.2	23.9	4.00	791	3.8	527			KP
2	SF2	5/12/2003	4	478	20	779	0.2	23.9	20.00	779	20.0	519			KP
3	SF3	5/12/2003	4	478	9	700	0.2	23.9	9.00	700	8.9	465			KP
4	SF4	5/12/2003	4	478	18	665	0.2	23.9	18.00	665	18.0	441			KP
5	SF5	5/12/2003	4	478	10	681	0.2	23.9	10.00	681	9.9	452			KP
6	SF6	5/12/2003	4	478	16	675	0.2	23.9	16.00	675	16.0	447			KP
7	SF7	5/12/2003	4	478	9	660	0.2	23.9	9.00	660	8.9	437			KP
8	SF8	5/12/2003	4	478	10	734	0.2	23.9	10.00	734	9.9	488			KP
9	SF9	5/12/2003	4	478	8	819	0.2	23.9	8.00	819	7.9	546			KP
10	SF10	5/12/2003	4	478	9	864	0.2	23.9	9.00	864	8.9	577			KP
11	SF11	5/12/2003	4	478	11	922	0.2	23.9	11.00	922	10.9	617			KP
12	SF12	5/12/2003	4	478	6	686	0.2	23.9	6.00	686	5.9	455			KP
13	SF13	5/12/2003	4	478	10	687	0.2	23.9	10.00	687	9.9	456			KP
14	SF14	5/12/2003	4	478	4	696	0.2	23.9	4.00	696	3.8	462			KP
15	SF15	5/12/2003	4	478	9	783	0.2	23.9	9.00	783	8.9	522			KP
16	SF16	5/12/2003	4	478	6	846	0.2	23.9	6.00	846	5.9	565			KP
17	SF17	5/12/2003	4	478	11	730	0.2	23.9	11.00	730	10.9	485			KP
18	SF18	5/12/2003	4	478	7	713	0.2	23.9	7.00	713	6.9	474			KP
19	SF19	5/12/2003	4	478	11	633	0.2	23.9	11.00	633	10.9	419			KP
20	SF20	5/12/2003	4	478	10	720	0.2	23.9	10.00	720	9.9	478			KP
21	SF21	5/12/2003	4	478	10	1029	0.2	23.9	10.00	1029	9.9	691			KP
22	SF22	5/12/2003	4	478	5	853	0.2	23.9	5.00	853	4.9	570			KP
23	SF23	5/12/2003	4	478	9	761	0.2	23.9	9.00	761	8.9	507			KP
24	SF24	5/12/2003	4	478	7	734	0.2	23.9	7.00	734	6.9	488			KP

CABRERA STATIC CO[illegible]ING WORKSHEET (Rev 5)
BARF NORTH ROOM LOWER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)	α eff	β eff	Static Count Time (min)	Daily Background Count Time (min)	dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
582	0.1700	0.2500	1.0	20.0	100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	NRNW1	5/13/2003	3	560	12	697	0.2	28.0	12.00	697	12.0	460			KP
2	NRNW2	5/13/2003	3	560	4	663	0.2	28.0	4.00	663	3.9	436			KP
3	NRNW3	5/13/2003	3	560	4	624	0.2	28.0	4.00	624	3.9	410			KP
4	NRNW4	5/13/2003	3	560	2	635	0.2	28.0	2.00	635	1.9	417			KP
5	NRNW5	5/13/2003	3	560	1	591	0.2	28.0	1.00	591	0.9	387			KP
6	NRNW6	5/13/2003	3	560	3	560	0.2	28.0	3.00	560	2.9	366			KP
7	D-NRNW1	5/13/2003	3	560	10	619	0.2	28.0	10.00	619	10.0	406			KP
8	NREW7	5/13/2003	3	560	2	711	0.2	28.0	2.00	711	1.9	469			KP
9	NREW8	5/13/2003	3	560	5	676	0.2	28.0	5.00	676	4.9	445			KP
10	NREW9	5/13/2003	3	560	6	673	0.2	28.0	6.00	673	5.9	443			KP
11	NREW10	5/13/2003	3	560	7	691	0.2	28.0	7.00	691	6.9	456			KP
12	D-NREW10	5/13/2003	3	560	4	594	0.2	28.0	4.00	594	3.9	389			KP
13	NRSW11	5/13/2003	3	560	4	678	0.2	28.0	4.00	678	3.9	447			KP
14	NRSW12	5/13/2003	3	560	9	639	0.2	28.0	9.00	639	8.9	420			KP
15	NRSW13	5/13/2003	3	560	5	632	0.2	28.0	5.00	632	4.9	415			KP
16	NRSW14	5/13/2003	3	560	3	583	0.2	28.0	3.00	583	2.9	381			KP
17	NRSW15	5/13/2003	3	560	4	589	0.2	28.0	4.00	589	3.9	386			KP
18	NRSW16	5/13/2003	3	560	5	659	0.2	28.0	5.00	659	4.9	434			KP
19	D-NRSW12	5/13/2003	3	560	10	677	0.2	28.0	10.00	677	10.0	446			KP
20	NRWW17	5/13/2003	3	560	7	699	0.2	28.0	7.00	699	6.9	461			KP
21	NRWW18	5/13/2003	3	560	5	709	0.2	28.0	5.00	709	4.9	468			KP
22	NRWW19	5/13/2003	3	560	7	644	0.2	28.0	7.00	644	6.9	423			KP
23	NRWW20	5/13/2003	3	560	4	547	0.2	28.0	4.00	547	3.9	357			KP
24	D-NRWW17	5/13/2003	3	560	4	699	0.2	28.0	4.00	699	3.9	461			KP

CABRERA STATIC CO(ING WORKSHEET (Rev 5)

BARF SOUTH ROOM LOWER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)	α eff	β eff	Static Count Time (min)	Daily Background Count Time (min)	α Flag (dpm/100 cm^2)	β Flag (dpm/100 cm^2)
582	0.1700	0.2500	1.0	20.0	100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	SRNW1	5/13/2003	3	560	7	642	0.2	28.0	7.00	642	6.9	422			KP
2	SRNW2	5/13/2003	3	560	4	616	0.2	28.0	4.00	616	3.9	404			KP
3	SRNW3	5/13/2003	3	560	4	586	0.2	28.0	4.00	586	3.9	384			KP
4	SRNW4	5/13/2003	3	560	5	641	0.2	28.0	5.00	641	4.9	421			KP
5	SRNW5	5/13/2003	3	560	4	620	0.2	28.0	4.00	620	3.9	407			KP
6	SRNW6	5/13/2003	3	560	3	604	0.2	28.0	3.00	604	2.9	396			KP
7	D-SRNW1	5/13/2003	3	560	5	655	0.2	28.0	5.00	655	4.9	431			KP
8	SREW7	5/12/2003	3	560	1	649	0.2	28.0	1.00	649	0.9	427			KP
9	SREW8	5/12/2003	3	560	0	691	0.2	28.0	0.00	691	-0.2	456			KP
10	SREW9	5/12/2003	3	560	3	700	0.2	28.0	3.00	700	2.9	462			KP
11	SREW10	5/12/2003	3	560	7	675	0.2	28.0	7.00	675	6.9	445			KP
12	D - SREW10	5/12/2003	3	560	6	674	0.2	28.0	6.00	674	5.9	444			KP
13	SRSW11	5/12/2003	3	560	2	609	0.2	28.0	2.00	609	1.9	399			KP
14	SRSW12	5/12/2003	3	560	3	686	0.2	28.0	3.00	686	2.9	452			KP
15	SRSW13	5/12/2003	3	560	3	599	0.2	28.0	3.00	599	2.9	392			KP
16	SRSW14	5/12/2003	3	560	1	606	0.2	28.0	1.00	606	0.9	397			KP
17	SRSW15	5/12/2003	3	560	3	626	0.2	28.0	3.00	626	2.9	411			KP
18	SRSW16	5/12/2003	3	560	2	596	0.2	28.0	2.00	596	1.9	390			KP
19	D-SRSW12	5/12/2003	3	560	10	731	0.2	28.0	10.00	731	10.0	483			KP
20	SRWW17	5/12/2003	3	560	1	750	0.2	28.0	1.00	750	0.9	496			KP
21	SRWW18	5/12/2003	3	560	3	681	0.2	28.0	3.00	681	2.9	449			KP
22	SRWW19	5/12/2003	3	560	7	647	0.2	28.0	7.00	647	6.9	425			KP
23	SRWW20	5/12/2003	3	560	2	702	0.2	28.0	2.00	702	1.9	463			KP
24	D-SRWW19	5/12/2003	3	560	8	566	0.2	28.0	8.00	566	7.9	370			KP

CABRERA STATIC COU[illegible]NG WORKSHEET (Rev 5)
BARF CEILING AND UPPER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
100

α eff	β eff
0.2000	0.2000

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	NRCU16	5/15/2003	1	99	0	85	0.1	5.0	0.00	85	-0.3	400			AC
2	NRCU17	5/15/2003	1	99	0	112	0.1	5.0	0.00	112	-0.3	535			AC
3	SRC4	5/14/2003	1	99	0	105	0.1	5.0	0.00	105	-0.3	500			AC
4	SRC7	5/14/2003	1	99	1	100	0.1	5.0	1.00	100	4.8	475			AC
5	NRNWU19	5/13/2003	3	560	2	89	0.2	28.0	2.00	89	9.3	305			KP
6	NRNWU20	5/13/2003	3	560	2	97	0.2	28.0	2.00	97	9.3	345			KP
7	NREWU18	5/13/2003	3	560	2	94	0.2	28.0	2.00	94	9.3	330			KP
8	NRSWU12	5/13/2003	3	560	1	94	0.2	28.0	1.00	94	4.3	330			KP
9	NRSWU13	5/13/2003	3	560	1	86	0.2	28.0	1.00	86	4.3	290			KP
10	NRSWU14	5/13/2003	3	560	2	84	0.2	28.0	2.00	84	9.3	280			KP
11	NRSWU15	5/13/2003	3	560	1	91	0.2	28.0	1.00	91	4.3	315			KP
12	SRNWU9	5/13/2003	3	560	0	70	0.2	28.0	0.00	70	-0.8	210			KP
13	SRNWU10	5/13/2003	3	560	3	87	0.2	28.0	3.00	87	14.3	295			KP
14	SRNWU11	5/13/2003	3	560	0	77	0.2	28.0	0.00	77	-0.8	245			KP
15	D-SRNWU11	5/13/2003	3	560	1	89	0.2	28.0	1.00	89	4.3	305			KP
16	SREWU5	5/12/2003	3	560	0	94	0.2	28.0	0.00	94	-0.8	330			KP
17	SREWU6	5/12/2003	3	560	1	104	0.2	28.0	1.00	104	4.3	380			KP
18	SRSWU1	5/12/2003	3	560	2	88	0.2	28.0	2.00	88	9.3	300			KP
19	SRSWU2	5/12/2003	3	560	2	97	0.2	28.0	2.00	97	9.3	345			KP
20	SRSWU3	5/12/2003	3	560	1	92	0.2	28.0	1.00	92	4.3	320			KP
21	SRWWU8	5/12/2003	3	560	0	80	0.2	28.0	0.00	80	-0.8	260			KP

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
BARF BIAS LOCATIONS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	CB1	6/2/2003	5	560	3	547	0.3	28.0	3.00	547	2.8	357			AC
2	CB2	6/2/2003	5	560	7	728	0.3	28.0	7.00	728	6.8	481			AC
3	CB3	6/2/2003	5	560	4	589	0.3	28.0	4.00	589	3.8	386			AC
4	BB1	6/2/2003	5	560	8	593	0.3	28.0	8.00	593	7.8	388			AC
5	BB2	6/2/2003	5	560	7	574	0.3	28.0	7.00	574	6.8	375			AC
6	DB	6/2/2003	5	560	4	590	0.3	28.0	4.00	590	3.8	386			AC
7	EWSRB	6/2/2003	5	560	1	488	0.3	28.0	1.00	488	0.8	316			AC
8	NWSRB	6/2/2003	5	560	6	466	0.3	28.0	6.00	466	5.8	301			AC
9	WWNRB1	6/2/2003	5	560	8	626	0.3	28.0	8.00	626	7.8	411			AC
10	WWNRB2	6/2/2003	5	560	5	538	0.3	28.0	5.00	538	4.8	351			AC
11	WWSRB1	6/2/2003	5	560	4	484	0.3	28.0	4.00	484	3.8	313			AC
12	WWSRB2	6/2/2003	5	560	7	530	0.3	28.0	7.00	530	6.8	345			AC
13	WWSRB3	6/2/2003	5	560	7	527	0.3	28.0	7.00	527	6.8	343			AC

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
CONCRETE PAD #1 (SU09) NORTH - SMEAR RESULTS

α eff	β eff
0.3850	0.2650

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm^2	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	6550	6/10/2004	8	1456	1	143	0.4	72.8	0.50	72	0.3	-5			JAC
2	6551	6/10/2004	8	1456	1	150	0.4	72.8	0.50	75	0.3	8			JAC
3	6552	6/10/2004	8	1456	0	165	0.4	72.8	0.00	83	-1.0	37			JAC
4	6553	6/10/2004	8	1456	0	140	0.4	72.8	0.00	70	-1.0	-11			JAC
5	6554	6/10/2004	8	1456	0	129	0.4	72.8	0.00	65	-1.0	-31			JAC
6	6555	6/10/2004	8	1456	4	141	0.4	72.8	2.00	71	4.2	-9			JAC
7	6556	6/10/2004	8	1456	1	132	0.4	72.8	0.50	66	0.3	-26			JAC
8	6557	6/10/2004	8	1456	2	136	0.4	72.8	1.00	68	1.6	-18			JAC
9	6558	6/10/2004	8	1456	1	138	0.4	72.8	0.50	69	0.3	-14			JAC
10	6559	6/10/2004	8	1456	0	112	0.4	72.8	0.00	56	-1.0	-63			JAC
11	6560	6/10/2004	8	1456	1	135	0.4	72.8	0.50	68	0.3	-20			JAC
12	6561	6/10/2004	8	1456	1	129	0.4	72.8	0.50	65	0.3	-31			JAC
13	6562	6/10/2004	8	1456	0	149	0.4	72.8	0.00	75	-1.0	6			JAC
14	6563	6/10/2004	8	1456	1	141	0.4	72.8	0.50	71	0.3	-9			JAC
15	6564	6/10/2004	8	1456	0	133	0.4	72.8	0.00	67	-1.0	-24			JAC
16	6565	6/10/2004	8	1456	1	136	0.4	72.8	0.50	68	0.3	-18			JAC
17	6566	6/10/2004	8	1456	1	152	0.4	72.8	0.50	76	0.3	12			JAC
18	6567	6/10/2004	8	1456	0	157	0.4	72.8	0.00	79	-1.0	22			JAC
19	6568	6/10/2004	8	1456	0	133	0.4	72.8	0.00	67	-1.0	-24			JAC
20	6569	6/10/2004	8	1456	0	155	0.4	72.8	0.00	78	-1.0	18			JAC
21															

CABRERA SMEAR COU(NG WORKSHEET (Rev 4)
CONCRETE PAD #1 (SU09) SOUTH - SMEAR RESULTS

α eff	β eff
0.3850	0.2650

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm² α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	6530	6/10/2004	8	1456	0	139	0.4	72.8	0.00	70	-1.0	-12			JAC
2	6531	6/10/2004	8	1456	1	141	0.4	72.8	0.50	71	0.3	-9			JAV
3	6532	6/10/2004	8	1456	1	124	0.4	72.8	0.50	62	0.3	-41			JAV
4	6533	6/10/2004	8	1456	0	129	0.4	72.8	0.00	65	-1.0	-31			JAV
5	6534	6/10/2004	8	1456	0	130	0.4	72.8	0.00	65	-1.0	-29			JAV
6	6535	6/10/2004	8	1456	1	150	0.4	72.8	0.50	75	0.3	8			JAV
7	6536	6/10/2004	8	1456	0	139	0.4	72.8	0.00	70	-1.0	-12			JAV
8	6537	6/10/2004	8	1456	0	126	0.4	72.8	0.00	63	-1.0	-37			JAV
9	6538	6/10/2004	8	1456	2	134	0.4	72.8	1.00	67	1.6	-22			JAV
10	6539	6/10/2004	8	1456	0	141	0.4	72.8	0.00	71	-1.0	-9			JAV
11	6540	6/10/2004	8	1456	0	160	0.4	72.8	0.00	80	-1.0	27			JAV
12	6541	6/10/2004	8	1456	2	130	0.4	72.8	1.00	65	1.6	-29			JAV
13	6542	6/10/2004	8	1456	1	132	0.4	72.8	0.50	66	0.3	-26			JAC
14	6543	6/10/2004	8	1456	2	157	0.4	72.8	1.00	79	1.6	22			JAC
15	6544	6/10/2004	8	1456	0	122	0.4	72.8	0.00	61	-1.0	-45			JAC
16	6545	6/10/2004	8	1456	0	137	0.4	72.8	0.00	69	-1.0	-16			JAC
17	6546	6/10/2004	8	1456	0	159	0.4	72.8	0.00	80	-1.0	25			JAC
18	6547	6/10/2004	8	1456	0	141	0.4	72.8	0.00	71	-1.0	-9			JAC
19	6548	6/10/2004	8	1456	1	133	0.4	72.8	0.50	67	0.3	-24			JAC
20	6549	6/10/2004	8	1456	0	136	0.4	72.8	0.00	68	-1.0	-18			JAC
21															

CABRERA STATIC CO(,NG WORKSHEET (Rev 5)

CONCRETE PAD #1 (SU09) SOUTH - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
126

α eff	β eff
0.1879	0.3200

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	6530	6/10/2004	3	200	3	200	0.2	10.0	3.00	200	12.0	471			JAC
2	6531	6/10/2004	3	200	0	404	0.2	10.0	0.00	404	-0.6	977			JAC
3	6532	6/10/2004	3	200	2	196	0.2	10.0	2.00	196	7.8	461			JAC
4	6533	6/10/2004	3	200	2	226	0.2	10.0	2.00	226	7.8	536			JAC
5	6534	6/10/2004	3	200	2	200	0.2	10.0	2.00	200	7.8	471			JAC
6	6535	6/10/2004	3	200	4	383	0.2	10.0	4.00	383	16.3	925			JAC
7	6536	6/10/2004	3	200	0	178	0.2	10.0	0.00	178	-0.6	417			JAC
8	6537	6/10/2004	3	200	2	168	0.2	10.0	2.00	168	7.8	392			JAC
9	6538	6/10/2004	3	200	2	155	0.2	10.0	2.00	155	7.8	360			JAC
10	6539	6/10/2004	3	200	3	151	0.2	10.0	3.00	151	12.0	350			JAC
11	6540	6/10/2004	3	200	2	143	0.2	10.0	2.00	143	7.8	330			JAC
12	6541	6/10/2004	3	200	2	208	0.2	10.0	2.00	208	7.8	491			JAC
13	6542	6/10/2004	3	200	2	214	0.2	10.0	2.00	214	7.8	506			JAC
14	6543	6/10/2004	3	200	0	229	0.2	10.0	0.00	229	-0.6	543			JAC
15	6544	6/10/2004	3	200	0	198	0.2	10.0	0.00	198	-0.6	466			JAC
16	6545	6/10/2004	3	200	0	184	0.2	10.0	0.00	184	-0.6	432			JAC
17	6546	6/10/2004	3	200	0	172	0.2	10.0	0.00	172	-0.6	402			JAC
18	6547	6/10/2004	3	200	0	150	0.2	10.0	0.00	150	-0.6	347			JAC
19	6548	6/10/2004	3	200	3	201	0.2	10.0	3.00	201	12.0	474			JAC
20	6549	6/10/2004	3	200	1	146	0.2	10.0	1.00	146	3.6	337			JAC
21															
22															

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
CONCRETE PAD #1 (SU09) NORTH - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
126

α eff	β eff
0.1879	0.3200

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	6550	6/10/2004	3	200	2	293	0.2	10.0	2.00	293	7.8	702			JAC
2	6551	6/10/2004	3	200	3	364	0.2	10.0	3.00	364	12.0	878			JAC
3	6552	6/10/2004	3	200	8	723	0.2	10.0	8.00	723	33.2	1768			JAC
4	6553	6/10/2004	3	200	3	220	0.2	10.0	3.00	220	12.0	521			JAC
5	6554	6/10/2004	3	200	4	300	0.2	10.0	4.00	300	16.3	719			JAC
6	6555	6/10/2004	3	200	4	318	0.2	10.0	4.00	318	16.3	764			JAC
7	6556	6/10/2004	3	200	0	153	0.2	10.0	0.00	153	-0.6	355			JAC
8	6557	6/10/2004	3	200	4	151	0.2	10.0	4.00	151	16.3	350			JAC
9	6558	6/10/2004	3	200	2	213	0.2	10.0	2.00	213	7.8	503			JAC
10	6559	6/10/2004	3	200	2	187	0.2	10.0	2.00	187	7.8	439			JAC
11	6560	6/10/2004	3	200	0	136	0.2	10.0	0.00	136	-0.6	313			JAC
12	6561	6/10/2004	3	200	1	169	0.2	10.0	1.00	169	3.6	394			JAC
13	6562	6/10/2004	3	200	1	149	0.2	10.0	1.00	149	3.6	345			JAC
14	6563	6/10/2004	3	200	0	160	0.2	10.0	0.00	160	-0.6	372			JAC
15	6564	6/10/2004	3	200	1	169	0.2	10.0	1.00	169	3.6	394			JAC
16	6565	6/10/2004	3	200	1	198	0.2	10.0	1.00	198	3.6	466			JAC
17	6566	6/10/2004	3	200	0	179	0.2	10.0	0.00	179	-0.6	419			JAC
18	6567	6/10/2004	3	200	3	229	0.2	10.0	3.00	229	12.0	543			JAC
19	6568	6/10/2004	3	200	3	165	0.2	10.0	3.00	165	12.0	384			JAC
20	6569	6/10/2004	3	200	1	205	0.2	10.0	1.00	205	3.6	484			JAC
21															
22															
23															

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
CONCRETE PAD #2 (SU16) NORTH - SMEAR RESULTS

α eff	β eff
0.3850	0.2650

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	6510	6/10/2004	8	1456	1	154	0.4	72.8	0.50	77	0.3	16			JAC
2	6511	6/10/2004	8	1456	1	154	0.4	72.8	0.50	77	0.3	16			JAV
3	6512	6/10/2004	8	1456	1	159	0.4	72.8	0.50	80	0.3	25			JAV
4	6513	6/10/2004	8	1456	0	149	0.4	72.8	0.00	75	-1.0	6			JAV
5	6514	6/10/2004	8	1456	0	144	0.4	72.8	0.00	72	-1.0	-3			JAV
6	6515	6/10/2004	8	1456	0	137	0.4	72.8	0.00	69	-1.0	-16			JAV
7	6516	6/10/2004	8	1456	0	106	0.4	72.8	0.00	53	-1.0	-75			JAV
8	6517	6/10/2004	8	1456	2	149	0.4	72.8	1.00	75	1.6	6			JAC
9	6518	6/10/2004	8	1456	0	146	0.4	72.8	0.00	73	-1.0	1			JAC
10	6519	6/10/2004	8	1456	1	133	0.4	72.8	0.50	67	0.3	-24			JAC
11	6520	6/10/2004	8	1456	1	117	0.4	72.8	0.50	59	0.3	-54			JAC
12	6521	6/10/2004	8	1456	1	150	0.4	72.8	0.50	75	0.3	8			JAC
13	6522	6/10/2004	8	1456	1	144	0.4	72.8	0.50	72	0.3	-3			JAC
14	6523	6/10/2004	8	1456	3	155	0.4	72.8	1.50	78	2.9	18			JAC
15	6524	6/10/2004	8	1456	0	146	0.4	72.8	0.00	73	-1.0	1			JAC
16	6525	6/10/2004	8	1456	0	165	0.4	72.8	0.00	83	-1.0	37			JAC
17	6526	6/10/2004	8	1456	1	130	0.4	72.8	0.50	65	0.3	-29			JAC
18	6527	6/10/2004	8	1456	0	145	0.4	72.8	0.00	73	-1.0	-1			JAC
19	6528	6/10/2004	8	1456	0	138	0.4	72.8	0.00	69	-1.0	-14			JAC
20	6529	6/10/2004	8	1456	1	131	0.4	72.8	0.50	66	0.3	-28			JAC
21															

CABRERA SMEAR COU NG WORKSHEET (Rev 4)
CONCRETE PAD #2 (SU16) SOUTH - SMEAR RESULTS

α eff	β eff
0.3850	0.2650

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	6490	6/10/2004	8	1456	2	151	0.4	72.8	1.00	76	1.6	10			JAC
2	6491	6/10/2004	8	1456	1	140	0.4	72.8	0.50	70	0.3	-11			JAC
3	6492	6/10/2004	8	1456	0	132	0.4	72.8	0.00	66	-1.0	-26			JAC
4	6493	6/10/2004	8	1456	0	145	0.4	72.8	0.00	73	-1.0	-1			JAC
5	6494	6/10/2004	8	1456	1	163	0.4	72.8	0.50	82	0.3	33			JAC
6	6495	6/10/2004	8	1456	1	125	0.4	72.8	0.50	63	0.3	-39			JAC
7	6496	6/10/2004	8	1456	1	138	0.4	72.8	0.50	69	0.3	-14			JAC
8	6497	6/10/2004	8	1456	0	150	0.4	72.8	0.00	75	-1.0	8			JAC
9	6498	6/10/2004	8	1456	0	124	0.4	72.8	0.00	62	-1.0	-41			JAC
10	6499	6/10/2004	8	1456	1	136	0.4	72.8	0.50	68	0.3	-18			JAC
11	6500	6/10/2004	8	1456	1	112	0.4	72.8	0.50	56	0.3	-63			JAC
12	6501	6/10/2004	8	1456	1	129	0.4	72.8	0.50	65	0.3	-31			JAC
13	6502	6/10/2004	8	1456	2	143	0.4	72.8	1.00	72	1.6	-5			JAC
14	6503	6/10/2004	8	1456	2	137	0.4	72.8	1.00	69	1.6	-16			JAC
15	6504	6/10/2004	8	1456	0	159	0.4	72.8	0.00	80	-1.0	25			JAC
16	6505	6/10/2004	8	1456	2	158	0.4	72.8	1.00	79	1.6	23			JAC
17	6506	6/10/2004	8	1456	1	118	0.4	72.8	0.50	59	0.3	-52			JAC
18	6507	6/10/2004	8	1456	1	142	0.4	72.8	0.50	71	0.3	-7			JAC
19	6508	6/10/2004	8	1456	0	159	0.4	72.8	0.00	80	-1.0	25			JAC
20	6509	6/10/2004	8	1456	0	146	0.4	72.8	0.00	73	-1.0	1			JAC
21															

CABRERA STATIC COU[illegible]ING WORKSHEET (Rev 5)
CONCRETE PAD #2 (SU16) SOUTH - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
126

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	6490	6/10/2004	3	200	1	168	0.2	10.0	1.00	168	4.0	502			JAC
2	6491	6/10/2004	3	200	1	182	0.2	10.0	1.00	182	4.0	546			JAC
3	6492	6/10/2004	3	200	2	121	0.2	10.0	2.00	121	8.6	352			JAC
4	6493	6/10/2004	3	200	1	114	0.2	10.0	1.00	114	4.0	330			JAC
5	6494	6/10/2004	3	200	3	107	0.2	10.0	3.00	107	13.3	308			JAC
6	6495	6/10/2004	3	200	1	121	0.2	10.0	1.00	121	4.0	352			JAC
7	6496	6/10/2004	3	200	2	119	0.2	10.0	2.00	119	8.6	346			JAC
8	6497	6/10/2004	3	200	2	129	0.2	10.0	2.00	129	8.6	378			JAC
9	6498	6/10/2004	3	200	1	129	0.2	10.0	1.00	129	4.0	378			JAC
10	6499	6/10/2004	3	200	3	137	0.2	10.0	3.00	137	13.3	403			JAC
11	6500	6/10/2004	3	200	1	139	0.2	10.0	1.00	139	4.0	410			JAC
12	6501	6/10/2004	3	200	3	129	0.2	10.0	3.00	129	13.3	378			JAC
13	6502	6/10/2004	3	200	1	112	0.2	10.0	1.00	112	4.0	324			JAC
14	6503	6/10/2004	3	200	1	142	0.2	10.0	1.00	142	4.0	419			JAC
15	6504	6/10/2004	3	200	1	341	0.2	10.0	1.00	341	4.0	1051			JAC
16	6505	6/10/2004	3	200	2	306	0.2	10.0	2.00	306	8.6	940			JAC
17	6506	6/10/2004	3	200	4	229	0.2	10.0	4.00	229	18.0	695			JAC
18	6507	6/10/2004	3	200	3	158	0.2	10.0	3.00	158	13.3	470			JAC
19	6508	6/10/2004	3	200	1	109	0.2	10.0	1.00	109	4.0	314			JAC
20	6509	6/10/2004	3	200	1	103	0.2	10.0	1.00	103	4.0	295			JAC

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
CONCRETE PAD #2 (SU16) NORTH - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
126

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	6510	6/10/2004	4	800	4	289	0.2	40.0	4.00	289	17.7	790			JAC
2	6511	6/10/2004	4	800	3	336	0.2	40.0	3.00	336	13.1	940			JAC
3	6512	6/10/2004	4	800	4	306	0.2	40.0	4.00	306	17.7	844			JAC
4	6513	6/10/2004	4	800	1	291	0.2	40.0	1.00	291	3.7	797			JAC
5	6514	6/10/2004	4	800	3	144	0.2	40.0	3.00	144	13.1	330			JAC
6	6515	6/10/2004	4	800	2	116	0.2	40.0	2.00	116	8.4	241			JAC
7	6516	6/10/2004	4	800	6	230	0.2	40.0	6.00	230	27.1	603			JAC
8	6517	6/10/2004	4	800	3	128	0.2	40.0	3.00	128	13.1	279			JAC
9	6518	6/10/2004	4	800	2	135	0.2	40.0	2.00	135	8.4	302			JAC
10	6519	6/10/2004	4	800	2	143	0.2	40.0	2.00	143	8.4	327			JAC
11	6520	6/10/2004	4	800	4	137	0.2	40.0	4.00	137	17.7	308			JAC
12	6521	6/10/2004	4	800	0	116	0.2	40.0	0.00	116	-0.9	241			JAC
13	6522	6/10/2004	4	800	4	176	0.2	40.0	4.00	176	17.7	432			JAC
14	6523	6/10/2004	4	800	5	156	0.2	40.0	5.00	156	22.4	368			JAC
15	6524	6/10/2004	4	800	0	156	0.2	40.0	0.00	156	-0.9	368			JAC
16	6525	6/10/2004	4	800	0	90	0.2	40.0	0.00	90	-0.9	159			JAC
17	6526	6/10/2004	4	800	1	163	0.2	40.0	1.00	163	3.7	390			JAC
18	6527	6/10/2004	4	800	5	158	0.2	40.0	5.00	158	22.4	375			JAC
19	6528	6/10/2004	4	800	0	147	0.2	40.0	0.00	147	-0.9	340			JAC
20	6529	6/10/2004	4	800	3	160	0.2	40.0	3.00	160	13.1	381			JAC

CABRERA SMEAR COU NG WORKSHEET (Rev 4)
WASH RACK #2 NORTH FLOOR - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR2-NF-1	3/31/2004	2	994	0	106	0.1	49.7	0.00	53	-0.3	12			KP
2	WR2-NF-2	3/31/2004	2	994	1	99	0.1	49.7	0.50	50	1.2	-1			KP
3	WR2-NF-3	3/31/2004	2	994	2	94	0.1	49.7	1.00	47	2.7	-10			KP
4	WR2-NF-4	3/31/2004	2	994	0	97	0.1	49.7	0.00	49	-0.3	-4			KP
5	WR2-NF-5	3/31/2004	2	994	0	103	0.1	49.7	0.00	52	-0.3	6			KP
6	WR2-NF-6	3/31/2004	2	994	0	99	0.1	49.7	0.00	50	-0.3	-1			KP
7	WR2-NF-7	3/31/2004	2	994	1	93	0.1	49.7	0.50	47	1.2	-11			KP
8	WR2-NF-8	3/31/2004	2	994	0	94	0.1	49.7	0.00	47	-0.3	-10			KP
9	WR2-NF-9	3/31/2004	2	994	1	108	0.1	49.7	0.50	54	1.2	15			KP
10	WR2-NF-10	3/31/2004	2	994	1	92	0.1	49.7	0.50	46	1.2	-13			KP
11	WR2-NF-11	3/31/2004	2	994	2	97	0.1	49.7	1.00	49	2.7	-4			KP
12	WR2-NF-12	3/31/2004	2	994	0	91	0.1	49.7	0.00	46	-0.3	-15			KP
13	WR2-NF-13	3/31/2004	2	994	1	110	0.1	49.7	0.50	55	1.2	19			KP
14	WR2-NF-14	3/31/2004	2	994	0	103	0.1	49.7	0.00	52	-0.3	6			KP
15	WR2-NF-15	3/31/2004	2	994	0	93	0.1	49.7	0.00	47	-0.3	-11			KP
16	WR2-NF-16	3/31/2004	2	994	0	108	0.1	49.7	0.00	54	-0.3	15			KP
17	WR2-NF-17	3/31/2004	2	994	1	93	0.1	49.7	0.50	47	1.2	-11			KP
18	WR2-NF-18	3/31/2004	2	994	0	91	0.1	49.7	0.00	46	-0.3	-15			KP
19	WR2-NF-19	3/31/2004	2	994	0	96	0.1	49.7	0.00	48	-0.3	-6			KP
20	WR2-NF-20	3/31/2004	2	994	0	92	0.1	49.7	0.00	46	-0.3	-13			KP

CABRERA SMEAR CO(,NG WORKSHEET (Rev 4)
WASH RACK #2 SOUTH FLOOR - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR2-SF-1	3/31/2004	2	994	0	96	0.1	49.7	0.00	48	-0.3	-6			KP
2	WR2-SF-2	3/31/2004	2	994	0	102	0.1	49.7	0.00	51	-0.3	5			KP
3	WR2-SF-3	3/31/2004	2	994	0	95	0.1	49.7	0.00	48	-0.3	-8			KP
4	WR2-SF-4	3/31/2004	2	994	1	93	0.1	49.7	0.50	47	1.2	-11			KP
5	WR2-SF-5	3/31/2004	2	994	2	82	0.1	49.7	1.00	41	2.7	-31			KP
6	WR2-SF-6	3/31/2004	2	994	0	98	0.1	49.7	0.00	49	-0.3	-3			KP
7	WR2-SF-7	3/31/2004	2	994	0	94	0.1	49.7	0.00	47	-0.3	-10			KP
8	WR2-SF-8	3/31/2004	2	994	0	92	0.1	49.7	0.00	46	-0.3	-13			KP
9	WR2-SF-9	3/31/2004	2	994	0	106	0.1	49.7	0.00	53	-0.3	12			KP
10	WR2-SF-10	3/31/2004	2	994	0	99	0.1	49.7	0.00	50	-0.3	-1			KP
11	WR2-SF-11	3/31/2004	2	994	0	84	0.1	49.7	0.00	42	-0.3	-28			KP
12	WR2-SF-12	3/31/2004	2	994	0	97	0.1	49.7	0.00	49	-0.3	-4			KP
13	WR2-SF-13	3/31/2004	2	994	0	99	0.1	49.7	0.00	50	-0.3	-1			KP
14	WR2-SF-14	3/31/2004	2	994	2	104	0.1	49.7	1.00	52	2.7	8			KP
15	WR2-SF-15	3/31/2004	2	994	2	95	0.1	49.7	1.00	48	2.7	-8			KP
16	WR2-SF-16	3/31/2004	2	994	0	93	0.1	49.7	0.00	47	-0.3	-11			KP
17	WR2-SF-17	3/31/2004	2	994	0	97	0.1	49.7	0.00	49	-0.3	-4			KP
18	WR2-SF-18	3/31/2004	2	994	0	94	0.1	49.7	0.00	47	-0.3	-10			KP
19	WR2-SF-19	3/31/2004	2	994	1	91	0.1	49.7	0.50	46	1.2	-15			KP
20	WR2-SF-20	3/31/2004	2	994	1	86	0.1	49.7	0.50	43	1.2	-24			KP

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
WASH RACK #2 CEILING AND UPPER WALLS - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm² α Flag	dpm/100 cm² β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm²) α	Sample (dpm/100 cm²) β	> α flag	> β flag	Tech. Initial
1	WR2-C-1	3/31/2004	2	994	0	90	0.1	49.7	0.00	45	-0.3	-17			KP
2	WR2-C-2	3/31/2004	2	994	1	89	0.1	49.7	0.50	45	1.2	-19			KP
3	WR2-C-3	3/31/2004	2	994	0	91	0.1	49.7	0.00	46	-0.3	-15			KP
4	WR2-C-4	3/31/2004	2	994	0	90	0.1	49.7	0.00	45	-0.3	-17			KP
5	WR2-C-5	3/31/2004	2	994	2	83	0.1	49.7	1.00	42	2.7	-29			KP
6	WR2-C-6	3/31/2004	2	994	0	89	0.1	49.7	0.00	45	-0.3	-19			KP
7	WR2-C-7	3/31/2004	2	994	1	104	0.1	49.7	0.50	52	1.2	8			KP
8	WR2-C-8	3/31/2004	2	994	0	108	0.1	49.7	0.00	54	-0.3	15			KP
9	WR2-C-9	3/31/2004	2	994	0	96	0.1	49.7	0.00	48	-0.3	-6			KP
10	WR2-C-10	3/31/2004	2	994	1	98	0.1	49.7	0.50	49	1.2	-3			KP
11	WR2-C-11	3/31/2004	2	994	1	90	0.1	49.7	0.50	45	1.2	-17			KP
12	WR2-C-12	3/31/2004	2	994	0	99	0.1	49.7	0.00	50	-0.3	-1			KP
13	WR2-C-13	3/31/2004	2	994	0	93	0.1	49.7	0.00	47	-0.3	-11			KP
14	WR2-C-14	3/31/2004	2	994	0	84	0.1	49.7	0.00	42	-0.3	-28			KP
15	WR2-C-15	3/31/2004	2	994	0	77	0.1	49.7	0.00	39	-0.3	-40			KP
16	WR2-C-16	3/31/2004	2	994	1	78	0.1	49.7	0.50	39	1.2	-38			KP
17	WR2-C-17	3/31/2004	2	994	0	89	0.1	49.7	0.00	45	-0.3	-19			KP
18	WR2-C-18	3/31/2004	2	994	1	94	0.1	49.7	0.50	47	1.2	-10			KP
19	WR2-C-19	3/31/2004	2	994	0	95	0.1	49.7	0.00	48	-0.3	-8			KP
20	WR2-C-20	3/31/2004	2	994	0	96	0.1	49.7	0.00	48	-0.3	-6			KP

CABRERA SMEAR COU[illegible]NG WORKSHEET (Rev 4)
WASH RACK #2 LOWER WALLS - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR2-NW-1	3/31/2004	2	994	0	114	0.1	49.7	0.00	57	-0.3	26			KP
2	WR2-NW-2	3/31/2004	2	994	1	93	0.1	49.7	0.50	47	1.2	-11			KP
3	WR2-NW-3	3/31/2004	2	994	0	84	0.1	49.7	0.00	42	-0.3	-28			KP
4	WR2-NW-4	3/31/2004	2	994	0	98	0.1	49.7	0.00	49	-0.3	-3			KP
5	WR2-SW-1	3/31/2004	2	994	0	79	0.1	49.7	0.00	40	-0.3	-36			KP
6	WR2-SW-2	3/31/2004	2	994	0	94	0.1	49.7	0.00	47	-0.3	-10			KP
7	WR2-SW-3	3/31/2004	2	994	1	97	0.1	49.7	0.50	49	1.2	-4			KP
8	WR2-SW-4	3/31/2004	2	994	1	92	0.1	49.7	0.50	46	1.2	-13			KP
9	WR2-EW-1	3/31/2004	2	994	1	103	0.1	49.7	0.50	52	1.2	6			KP
10	WR2-EW-2	3/31/2004	2	994	1	83	0.1	49.7	0.50	42	1.2	-29			KP
11	WR2-EW-3	3/31/2004	2	994	0	99	0.1	49.7	0.00	50	-0.3	-1			KP
12	WR2-EW-4	3/31/2004	2	994	0	95	0.1	49.7	0.00	48	-0.3	-8			KP
13	WR2-EW-5	3/31/2004	2	994	2	91	0.1	49.7	1.00	46	2.7	-15			KP
14	WR2-EW-6	3/31/2004	2	994	1	96	0.1	49.7	0.50	48	1.2	-6			KP
15	WR2-EW-7	3/31/2004	2	994	1	93	0.1	49.7	0.50	47	1.2	-11			KP
16	WR2-EW-8	3/31/2004	2	994	0	94	0.1	49.7	0.00	47	-0.3	-10			KP
17	WR2-WW-1	3/31/2004	2	994	0	99	0.1	49.7	0.00	50	-0.3	-1			KP
18	WR2-WW-2	3/31/2004	2	994	0	98	0.1	49.7	0.00	49	-0.3	-3			KP
19	WR2-WW-3	3/31/2004	2	994	0	93	0.1	49.7	0.00	47	-0.3	-11			KP
20	WR2-WW-4	3/31/2004	2	994	1	97	0.1	49.7	0.50	49	1.2	-4			KP
21	WR2-WW-5	3/31/2004	2	994	0	105	0.1	49.7	0.00	53	-0.3	10			KP
22	WR2-WW-6	3/31/2004	2	994	1	95	0.1	49.7	0.50	48	1.2	-8			KP
23	WR2-WW-7	3/31/2004	2	994	0	93	0.1	49.7	0.00	47	-0.3	-11			KP
24	WR2-WW-8	3/31/2004	2	994	1	96	0.1	49.7	0.50	48	1.2	-6			KP

CABRERA STATIC CO ING WORKSHEET (Rev 5)
WASH RACK #2 NORTH FLOOR - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR2-NF-1	6/27/2003	4	819	8	829	0.2	41.0	8.00	829	7.9	542			KP
2	WR2-NF-2	6/27/2003	4	819	7	1121	0.2	41.0	7.00	1121	6.9	742			KP
3	WR2-NF-3	6/27/2003	4	819	10	1345	0.2	41.0	10.00	1345	9.9	896			KP
4	WR2-NF-4	6/27/2003	4	819	9	1500	0.2	41.0	9.00	1500	8.9	1003			KP
5	WR2-NF-5	6/27/2003	4	819	5	729	0.2	41.0	5.00	729	4.9	473			KP
6	WR2-NF-6	6/27/2003	4	819	7	659	0.2	41.0	7.00	659	6.9	425			KP
7	WR2-NF-7	6/27/2003	4	819	5	580	0.2	41.0	5.00	580	4.9	370			KP
8	WR2-NF-8	6/27/2003	4	819	12	857	0.2	41.0	12.00	857	11.9	561			KP
9	WR2-NF-9	6/27/2003	4	819	5	871	0.2	41.0	5.00	871	4.9	570			KP
10	WR2-NF-10	6/27/2003	4	819	6	917	0.2	41.0	6.00	917	5.9	602			KP
11	WR2-NF-11	6/27/2003	4	819	4	593	0.2	41.0	4.00	593	3.8	379			KP
12	WR2-NF-12	6/27/2003	4	819	5	556	0.2	41.0	5.00	556	4.9	354			KP
13	WR2-NF-13	6/27/2003	4	819	4	696	0.2	41.0	4.00	696	3.8	450			KP
14	WR2-NF-14	6/27/2003	4	819	9	686	0.2	41.0	9.00	686	8.9	443			KP
15	WR2-NF-15	6/27/2003	4	819	15	778	0.2	41.0	15.00	778	15.0	507			KP
16	WR2-NF-16	6/27/2003	4	819	11	689	0.2	41.0	11.00	689	10.9	445			KP
17	WR2-NF-17	6/27/2003	4	819	7	627	0.2	41.0	7.00	627	6.9	403			KP
18	WR2-NF-18	6/27/2003	4	819	6	698	0.2	41.0	6.00	698	5.9	452			KP
19	WR2-NF-19	6/27/2003	4	819	12	612	0.2	41.0	12.00	612	11.9	392			KP
20	WR2-NF-20	6/27/2003	4	819	5	713	0.2	41.0	5.00	713	4.9	462			KP

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
WASH RACK #2 SOUTH FLOOR - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR2-SF-1	6/27/2003	4	819	5	594	0.2	41.0	5.00	594	4.9	380			KP
2	WR2-SF-2	6/27/2003	4	819	7	703	0.2	41.0	7.00	703	6.9	455			KP
3	WR2-SF-3	6/27/2003	4	819	4	687	0.2	41.0	4.00	687	3.8	444			KP
4	WR2-SF-4	6/27/2003	4	819	10	673	0.2	41.0	10.00	673	9.9	434			KP
5	WR2-SF-5	6/27/2003	4	819	9	692	0.2	41.0	9.00	692	8.9	447			KP
6	WR2-SF-6	6/27/2003	4	819	7	694	0.2	41.0	7.00	694	6.9	449			KP
7	WR2-SF-7	6/27/2003	4	819	7	741	0.2	41.0	7.00	741	6.9	481			KP
8	WR2-SF-8	6/27/2003	4	819	12	1272	0.2	41.0	12.00	1272	11.9	846			KP
9	WR2-SF-9	6/27/2003	4	819	7	1147	0.2	41.0	7.00	1147	6.9	760			KP
10	WR2-SF-10	6/27/2003	4	819	5	921	0.2	41.0	5.00	921	4.9	605			KP
11	WR2-SF-11	6/27/2003	4	819	8	827	0.2	41.0	8.00	827	7.9	540			KP
12	WR2-SF-12	6/27/2003	4	819	3	712	0.2	41.0	3.00	712	2.8	461			KP
13	WR2-SF-13	6/27/2003	4	819	9	802	0.2	41.0	9.00	802	8.9	523			KP
14	WR2-SF-14	6/27/2003	4	819	6	753	0.2	41.0	6.00	753	5.9	489			KP
15	WR2-SF-15	6/27/2003	4	819	11	769	0.2	41.0	11.00	769	10.9	500			KP
16	WR2-SF-16	6/27/2003	4	819	10	652	0.2	41.0	10.00	652	9.9	420			KP
17	WR2-SF-17	6/27/2003	4	819	5	696	0.2	41.0	5.00	696	4.9	450			KP
18	WR2-SF-18	6/27/2003	4	819	6	723	0.2	41.0	6.00	723	5.9	469			KP
19	WR2-SF-19	6/27/2003	4	819	4	649	0.2	41.0	4.00	649	3.8	418			KP
20	WR2-SF-20	6/27/2003	4	819	8	698	0.2	41.0	8.00	698	7.9	452			KP

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CABRERA STATIC CO ING WORKSHEET (Rev 5)
WASH RACK #2 CEILING AND UPPER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
100

α eff	β eff
0.2000	0.2000

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	East Wall	6/26/2003	0	0	0	79	0.0	0.0	0.00	79	0.0	395			KP
2	East Wall	6/26/2003	0	0	0	104	0.0	0.0	0.00	104	0.0	520			KP
3	East Wall	6/26/2003	0	0	2	86	0.0	0.0	2.00	86	10.0	430			KP
4	East Wall	6/26/2003	0	0	1	78	0.0	0.0	1.00	78	5.0	390			KP
5	North Wall	6/26/2003	0	0	1	100	0.0	0.0	1.00	100	5.0	500			KP
6	Ceiling	6/26/2003	0	0	2	77	0.0	0.0	2.00	77	10.0	385			KP
7	Ceiling	6/26/2003	0	0	0	84	0.0	0.0	0.00	84	0.0	420			KP
8	Ceiling	6/26/2003	0	0	0	93	0.0	0.0	0.00	93	0.0	465			KP
9	Ceiling	6/26/2003	0	0	0	96	0.0	0.0	0.00	96	0.0	480			KP
10	South Wall	6/26/2003	0	0	1	82	0.0	0.0	1.00	82	5.0	410			KP
11	North Wall	6/26/2003	0	0	0	85	0.0	0.0	0.00	85	0.0	425			KP
12	Ceiling	6/26/2003	0	0	0	91	0.0	0.0	0.00	91	0.0	455			KP
13	Ceiling	6/26/2003	0	0	1	92	0.0	0.0	1.00	92	5.0	460			KP
14	Ceiling	6/26/2003	0	0	1	98	0.0	0.0	1.00	98	5.0	490			KP
15	Ceiling	6/26/2003	0	0	2	97	0.0	0.0	2.00	97	10.0	485			KP
16	South Wall	6/26/2003	0	0	0	92	0.0	0.0	0.00	92	0.0	460			KP
17	West Wall	6/26/2003	0	0	0	91	0.0	0.0	0.00	91	0.0	455			KP
18	West Wall	6/26/2003	0	0	2	105	0.0	0.0	2.00	105	10.0	525			KP
19	West Wall	6/26/2003	0	0	0	98	0.0	0.0	0.00	98	0.0	490			KP
20	West Wall	6/26/2003	0	0	1	72	0.0	0.0	1.00	72	5.0	360			KP

CABRERA STATIC COU[illegible]NG WORKSHEET (Rev 5)
WASH RACK #2 LOWER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	North Wall	6/25/2003	5	854	14	543	0.3	42.7	14.00	543	13.9	344			KP
2	North Wall	6/25/2003	5	854	9	523	0.3	42.7	9.00	523	8.8	330			KP
3	North Wall	6/25/2003	5	854	8	530	0.3	42.7	8.00	530	7.8	335			KP
4	North Wall	6/25/2003	5	854	7	517	0.3	42.7	7.00	517	6.8	326			KP
5	East Wall	6/25/2003	5	854	11	561	0.3	42.7	11.00	561	10.9	356			KP
6	East Wall	6/25/2003	5	854	9	602	0.3	42.7	9.00	602	8.8	384			KP
7	East Wall	6/25/2003	5	854	14	581	0.3	42.7	14.00	581	13.9	370			KP
8	East Wall	6/25/2003	5	854	9	574	0.3	42.7	9.00	574	8.8	365			KP
9	East Wall	6/25/2003	5	854	6	550	0.3	42.7	6.00	550	5.8	349			KP
10	East Wall	6/25/2003	5	854	7	568	0.3	42.7	7.00	568	6.8	361			KP
11	East Wall	6/25/2003	5	854	8	578	0.3	42.7	8.00	578	7.8	368			KP
12	East Wall	6/25/2003	5	854	5	583	0.3	42.7	5.00	583	4.8	371			KP
13	South Wall	6/25/2003	5	854	6	545	0.3	42.7	6.00	545	5.8	345			KP
14	South Wall	6/25/2003	5	854	5	525	0.3	42.7	5.00	525	4.8	331			KP
15	South Wall	6/25/2003	5	854	9	499	0.3	42.7	9.00	499	8.8	314			KP
16	South Wall	6/25/2003	5	854	11	573	0.3	42.7	11.00	573	10.9	364			KP
17	West Wall	6/25/2003	5	854	8	581	0.3	42.7	8.00	581	7.8	370			KP
18	West Wall	6/25/2003	5	854	12	589	0.3	42.7	12.00	589	11.9	375			KP
19	West Wall	6/25/2003	5	854	10	545	0.3	42.7	10.00	545	9.9	345			KP
20	West Wall	6/25/2003	5	854	11	503	0.3	42.7	11.00	503	10.9	316			KP
21	West Wall	6/25/2003	5	854	5	574	0.3	42.7	5.00	574	4.8	365			KP
22	West Wall	6/25/2003	5	854	10	560	0.3	42.7	10.00	560	9.9	356			KP
23	West Wall	6/25/2003	5	854	8	582	0.3	42.7	8.00	582	7.8	371			KP
24	West Wall	6/25/2003	5	854	8	555	0.3	42.7	8.00	555	7.8	352			KP

CABRERA SMEAR CO[illegible]ING WORKSHEET (Rev 4)
WASH RACK #3 NORTH FLOOR - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR3-NF-1	3/30/2004	4	965	1	92	0.2	48.3	0.50	46	0.9	-8			KP
2	WR3-NF-2	3/30/2004	4	965	0	97	0.2	48.3	0.00	49	-0.6	1			KP
3	WR3-NF-3	3/30/2004	4	965	0	101	0.2	48.3	0.00	51	-0.6	8			KP
4	WR3-NF-4	3/30/2004	4	965	0	90	0.2	48.3	0.00	45	-0.6	-12			KP
5	WR3-NF-5	3/30/2004	4	965	1	89	0.2	48.3	0.50	45	0.9	-13			KP
6	WR3-NF-6	3/30/2004	4	965	0	96	0.2	48.3	0.00	48	-0.6	-1			KP
7	WR3-NF-7	3/30/2004	4	965	0	97	0.2	48.3	0.00	49	-0.6	1			KP
8	WR3-NF-8	3/30/2004	4	965	0	102	0.2	48.3	0.00	51	-0.6	10			KP
9	WR3-NF-9	3/30/2004	4	965	0	101	0.2	48.3	0.00	51	-0.6	8			KP
10	WR3-NF-10	3/30/2004	4	965	0	91	0.2	48.3	0.00	46	-0.6	-10			KP
11	WR3-NF-11	3/30/2004	4	965	1	89	0.2	48.3	0.50	45	0.9	-13			KP
12	WR3-NF-12	3/30/2004	4	965	0	94	0.2	48.3	0.00	47	-0.6	-4			KP
13	WR3-NF-13	3/30/2004	4	965	1	108	0.2	48.3	0.50	54	0.9	21			KP
14	WR3-NF-14	3/30/2004	4	965	1	93	0.2	48.3	0.50	47	0.9	-6			KP
15	WR3-NF-15	3/30/2004	4	965	0	88	0.2	48.3	0.00	44	-0.6	-15			KP
16	WR3-NF-16	3/30/2004	4	965	1	76	0.2	48.3	0.50	38	0.9	-37			KP
17	WR3-NF-17	3/30/2004	4	965	0	90	0.2	48.3	0.00	45	-0.6	-12			KP
18	WR3-NF-18	3/30/2004	4	965	0	94	0.2	48.3	0.00	47	-0.6	-4			KP
19	WR3-NF-19	3/30/2004	4	965	1	89	0.2	48.3	0.50	45	0.9	-13			KP
20	WR3-NF-20	3/30/2004	4	965	0	95	0.2	48.3	0.00	48	-0.6	-3			KP

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
WASH RACK #3 SOUTH FLOOR - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR3-SF-1	3/30/2004	4	965	0	102	0.2	48.3	0.00	51	-0.6	10			KP
2	WR3-SF-2	3/30/2004	4	965	0	97	0.2	48.3	0.00	49	-0.6	1			KP
3	WR3-SF-3	3/30/2004	4	965	0	100	0.2	48.3	0.00	50	-0.6	6			KP
4	WR3-SF-4	3/30/2004	4	965	0	76	0.2	48.3	0.00	38	-0.6	-37			KP
5	WR3-SF-5	3/30/2004	4	965	0	82	0.2	48.3	0.00	41	-0.6	-26			KP
6	WR3-SF-6	3/30/2004	4	965	0	93	0.2	48.3	0.00	47	-0.6	-6			KP
7	WR3-SF-7	3/30/2004	4	965	0	73	0.2	48.3	0.00	37	-0.6	-42			KP
8	WR3-SF-8	3/30/2004	4	965	0	80	0.2	48.3	0.00	40	-0.6	-29			KP
9	WR3-SF-9	3/30/2004	4	965	0	110	0.2	48.3	0.00	55	-0.6	24			KP
10	WR3-SF-10	3/30/2004	4	965	0	96	0.2	48.3	0.00	48	-0.6	-1			KP
11	WR3-SF-11	3/30/2004	4	965	0	101	0.2	48.3	0.00	51	-0.6	8			KP
12	WR3-SF-12	3/30/2004	4	965	0	99	0.2	48.3	0.00	50	-0.6	4			KP
13	WR3-SF-13	3/30/2004	4	965	0	86	0.2	48.3	0.00	43	-0.6	-19			KP
14	WR3-SF-14	3/30/2004	4	965	0	79	0.2	48.3	0.00	40	-0.6	-31			KP
15	WR3-SF-15	3/30/2004	4	965	0	103	0.2	48.3	0.00	52	-0.6	12			KP
16	WR3-SF-16	3/30/2004	4	965	0	78	0.2	48.3	0.00	39	-0.6	-33			KP
17	WR3-SF-17	3/30/2004	4	965	0	92	0.2	48.3	0.00	46	-0.6	-8			KP
18	WR3-SF-18	3/30/2004	4	965	0	102	0.2	48.3	0.00	51	-0.6	10			KP
19	WR3-SF-19	3/30/2004	4	965	0	96	0.2	48.3	0.00	48	-0.6	-1			KP
20	WR3-SF-20	3/30/2004	4	965	0	94	0.2	48.3	0.00	47	-0.6	-4			KP
21															

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
WASH RACK #3 CEILING AND UPPER WALLS - SMEAR RESULTS

α eff	β eff
0.3328	0.2789

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm²	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm²)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR3-C-1	3/30/2004	4	965	0	97	0.2	48.3	0.00	49	-0.6	1			KP
2	WR3-C-2	3/30/2004	4	965	0	91	0.2	48.3	0.00	46	-0.6	-10			KP
3	WR3-C-3	3/30/2004	4	965	1	99	0.2	48.3	0.50	50	0.9	4			KP
4	WR3-C-4	3/30/2004	4	965	1	103	0.2	48.3	0.50	52	0.9	12			KP
5	WR3-C-5	3/30/2004	4	965	0	79	0.2	48.3	0.00	40	-0.6	-31			KP
6	WR3-C-6	3/30/2004	4	965	0	100	0.2	48.3	0.00	50	-0.6	6			KP
7	WR3-C-7	3/30/2004	4	965	1	89	0.2	48.3	0.50	45	0.9	-13			KP
8	WR3-C-8	3/30/2004	4	965	1	91	0.2	48.3	0.50	46	0.9	-10			KP
9	WR3-C-9	3/30/2004	4	965	0	92	0.2	48.3	0.00	46	-0.6	-8			KP
10	WR3-C-10	3/30/2004	4	965	0	84	0.2	48.3	0.00	42	-0.6	-22			KP
11	WR3-C-11	3/30/2004	4	965	1	106	0.2	48.3	0.50	53	0.9	17			KP
12	WR3-C-12	3/30/2004	4	965	0	108	0.2	48.3	0.00	54	-0.6	21			KP
13	WR3-C-13	3/30/2004	4	965	0	92	0.2	48.3	0.00	46	-0.6	-8			KP
14	WR3-C-14	3/30/2004	4	965	0	91	0.2	48.3	0.00	46	-0.6	-10			KP
15	WR3-C-15	3/30/2004	4	965	1	97	0.2	48.3	0.50	49	0.9	1			KP
16	WR3-C-16	3/30/2004	4	965	0	101	0.2	48.3	0.00	51	-0.6	8			KP
17	WR3-C-17	3/30/2004	4	965	0	94	0.2	48.3	0.00	47	-0.6	-4			KP
18	WR3-C-18	3/30/2004	4	965	1	92	0.2	48.3	0.50	46	0.9	-8			KP
19	WR3-C-19	3/30/2004	4	965	1	99	0.2	48.3	0.50	50	0.9	4			KP
20	WR3-C-20	3/30/2004	4	965	0	101	0.2	48.3	0.00	51	-0.6	8			KP
21															

CABRERA STATIC COU ..NG WORKSHEET (Rev 5)

WASH RACK #3 NORTH FLOOR - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	WR3-NF-1	6/25/2003	5	854	3	525	0.3	42.7	3.00	525	2.8	331			KP
2	WR3-NF-2	6/25/2003	5	854	1	605	0.3	42.7	1.00	605	0.8	386			KP
3	WR3-NF-3	6/25/2003	5	854	2	548	0.3	42.7	2.00	548	1.8	347			KP
4	WR3-NF-4	6/25/2003	5	854	4	606	0.3	42.7	4.00	606	3.8	387			KP
5	WR3-NF-5	6/25/2003	5	854	3	613	0.3	42.7	3.00	613	2.8	392			KP
6	WR3-NF-6	6/25/2003	5	854	8	637	0.3	42.7	8.00	637	7.8	408			KP
7	WR3-NF-7	6/25/2003	5	854	10	634	0.3	42.7	10.00	634	9.9	406			KP
8	WR3-NF-8	6/25/2003	5	854	8	588	0.3	42.7	8.00	588	7.8	375			KP
9	WR3-NF-9	6/25/2003	5	854	6	589	0.3	42.7	6.00	589	5.8	375			KP
10	WR3-NF-10	6/25/2003	5	854	11	640	0.3	42.7	11.00	640	10.9	411			KP
11	WR3-NF-11	6/25/2003	5	854	8	621	0.3	42.7	8.00	621	7.8	397			KP
12	WR3-NF-12	6/25/2003	5	854	7	602	0.3	42.7	7.00	602	6.8	384			KP
13	WR3-NF-13	6/25/2003	5	854	6	617	0.3	42.7	6.00	617	5.8	395			KP
14	WR3-NF-14	6/25/2003	5	854	5	740	0.3	42.7	5.00	740	4.8	479			KP
15	WR3-NF-15	6/25/2003	5	854	5	569	0.3	42.7	5.00	569	4.8	362			KP
16	WR3-NF-16	6/25/2003	5	854	8	552	0.3	42.7	8.00	552	7.8	350			KP
17	WR3-NF-17	6/25/2003	5	854	12	558	0.3	42.7	12.00	558	11.9	354			KP
18	WR3-NF-18	6/25/2003	5	854	10	781	0.3	42.7	10.00	781	9.9	507			KP
19	WR3-NF-19	6/25/2003	5	854	8	601	0.3	42.7	8.00	601	7.8	384			KP
20	WR3-NF-20	6/25/2003	5	854	15	639	0.3	42.7	15.00	639	14.9	410			KP

CABRERA SMEAR COU(.NG WORKSHEET (Rev 4)
WASH RACK #3 LOWER WALLS - SMEAR RESULTS

α eff	β eff
0.3300	0.2800

Sample Count Time (min)	Daily Background Count Time (min)
2.0	20.0

dpm/100 cm^2	
α Flag	β Flag
10	500

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	WR3-NW-1	3/30/2004	4	965	0	5	0.2	48.3	0.00	3	-0.6	-163			KP
2	WR3-NW-2	3/30/2004	4	965	0	82	0.2	48.3	0.00	41	-0.6	-26			KP
3	WR3-NW-3	3/30/2004	4	965	2	85	0.2	48.3	1.00	43	2.4	-21			KP
4	WR3-NW-4	3/30/2004	4	965	0	98	0.2	48.3	0.00	49	-0.6	3			KP
5	WR3-EW-1	3/30/2004	4	965	0	118	0.2	48.3	0.00	59	-0.6	38			KP
6	WR3-EW-2	3/30/2004	4	965	1	99	0.2	48.3	0.50	50	0.9	4			KP
7	WR3-EW-3	3/30/2004	4	965	2	87	0.2	48.3	1.00	44	2.4	-17			KP
8	WR3-EW-4	3/30/2004	4	965	0	101	0.2	48.3	0.00	51	-0.6	8			KP
9	WR3-EW-5	3/30/2004	4	965	0	92	0.2	48.3	0.00	46	-0.6	-8			KP
10	WR3-EW-6	3/30/2004	4	965	1	106	0.2	48.3	0.50	53	0.9	17			KP
11	WR3-EW-7	3/30/2004	4	965	0	93	0.2	48.3	0.00	47	-0.6	-6			KP
12	WR3-EW-8	3/30/2004	4	965	0	89	0.2	48.3	0.00	45	-0.6	-13			KP
13	WR3-SW-1	3/30/2004	4	965	0	94	0.2	48.3	0.00	47	-0.6	-4			KP
14	WR3-SW-2	3/30/2004	4	965	0	92	0.2	48.3	0.00	46	-0.6	-8			KP
15	WR3-SW-3	3/30/2004	4	965	2	95	0.2	48.3	1.00	48	2.4	-3			KP
16	WR3-SW-4	3/30/2004	4	965	1	81	0.2	48.3	0.50	41	0.9	-28			KP
17	WR3-WW-1	3/30/2004	4	965	0	90	0.2	48.3	0.00	45	-0.6	-12			KP
18	WR3-WW-2	3/30/2004	4	965	1	88	0.2	48.3	0.50	44	0.9	-15			KP
19	WR3-WW-3	3/30/2004	4	965	0	105	0.2	48.3	0.00	53	-0.6	15			KP
20	WR3-WW-4	3/30/2004	4	965	0	84	0.2	48.3	0.00	42	-0.6	-22			KP
21	WR3-WW-5	3/30/2004	4	965	1	89	0.2	48.3	0.50	45	0.9	-13			KP
22	WR3-WW-6	3/30/2004	4	965	0	102	0.2	48.3	0.00	51	-0.6	10			KP
23	WR3-WW-7	3/30/2004	4	965	0	89	0.2	48.3	0.00	45	-0.6	-13			KP
24	WR3-WW-8	3/30/2004	4	965	1	92	0.2	48.3	0.50	46	0.9	-8			KP
25															

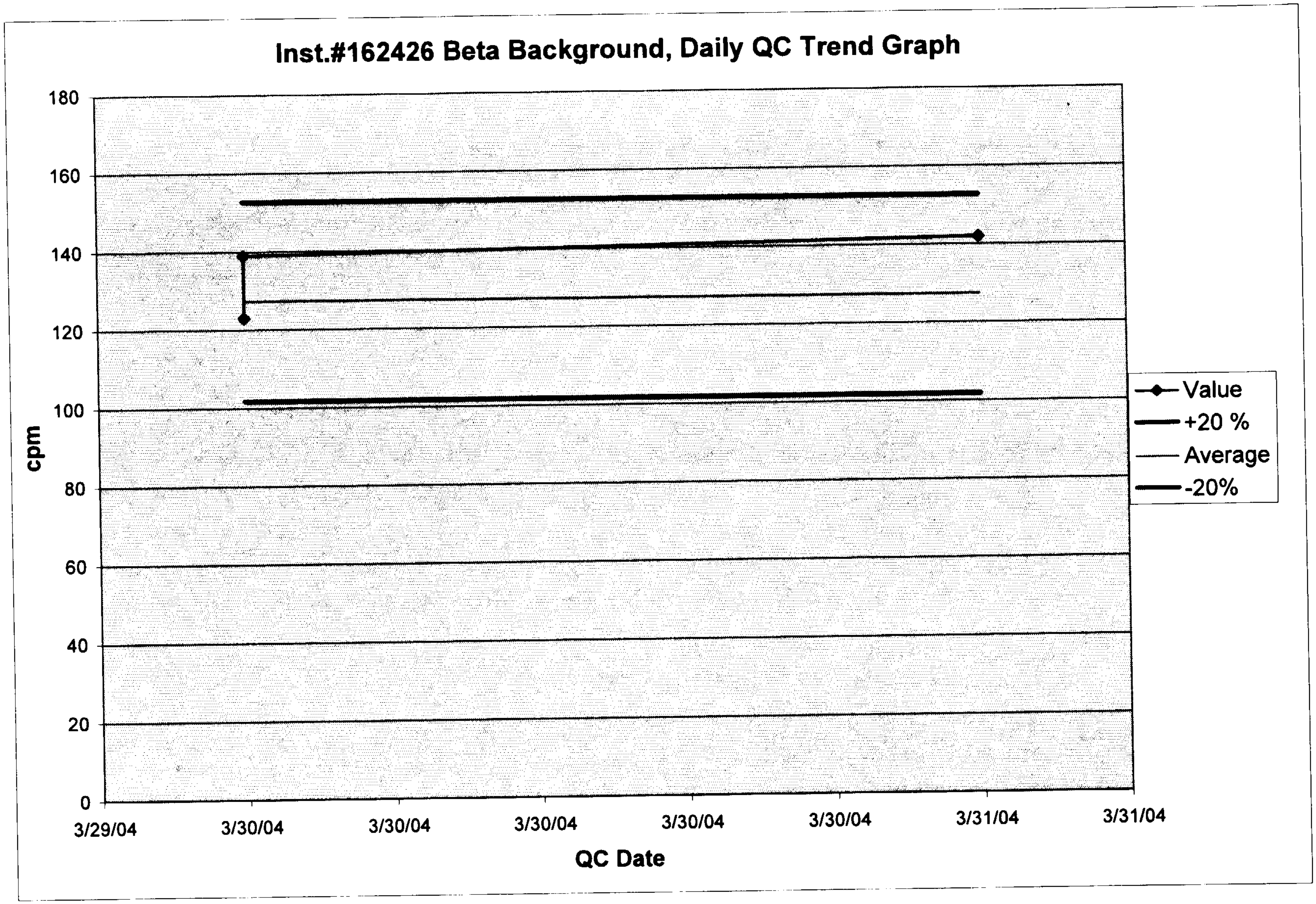
Appendix I: Survey Instrument Quality Control and Calibration Certificates

Inst.#79498 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
6/17/2003	2,600	[redacted]
6/19/2003	2,650	[redacted]
6/20/2003	2,600	[redacted]
6/22/2003	2,500	[redacted]
6/27/2003	2,600	[redacted]
6/30/2003	2,450	[redacted]
7/9/2003	2,500	[redacted]
7/10/2003	2,400	[redacted]

Inst.#79498 Tc-99		Source Ser. #	3974-02
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
6/16/2003	2,600		
6/16/2003	2,700		
6/16/2003	2,550		
6/16/2003	2,500		
6/16/2003	2,600		
6/16/2003	2,650		
6/16/2003	2,700		
6/16/2003	2,600		
6/16/2003	2,500		
6/16/2003	2,300		
	Average		
	2570		

Inst.#162426 Beta Background		
QC Daily Source		
Date	Result (cpm)	P/F
3/30/2004	123	[redacted]
3/30/2004	139	[redacted]
3/31/2004	142	[redacted]

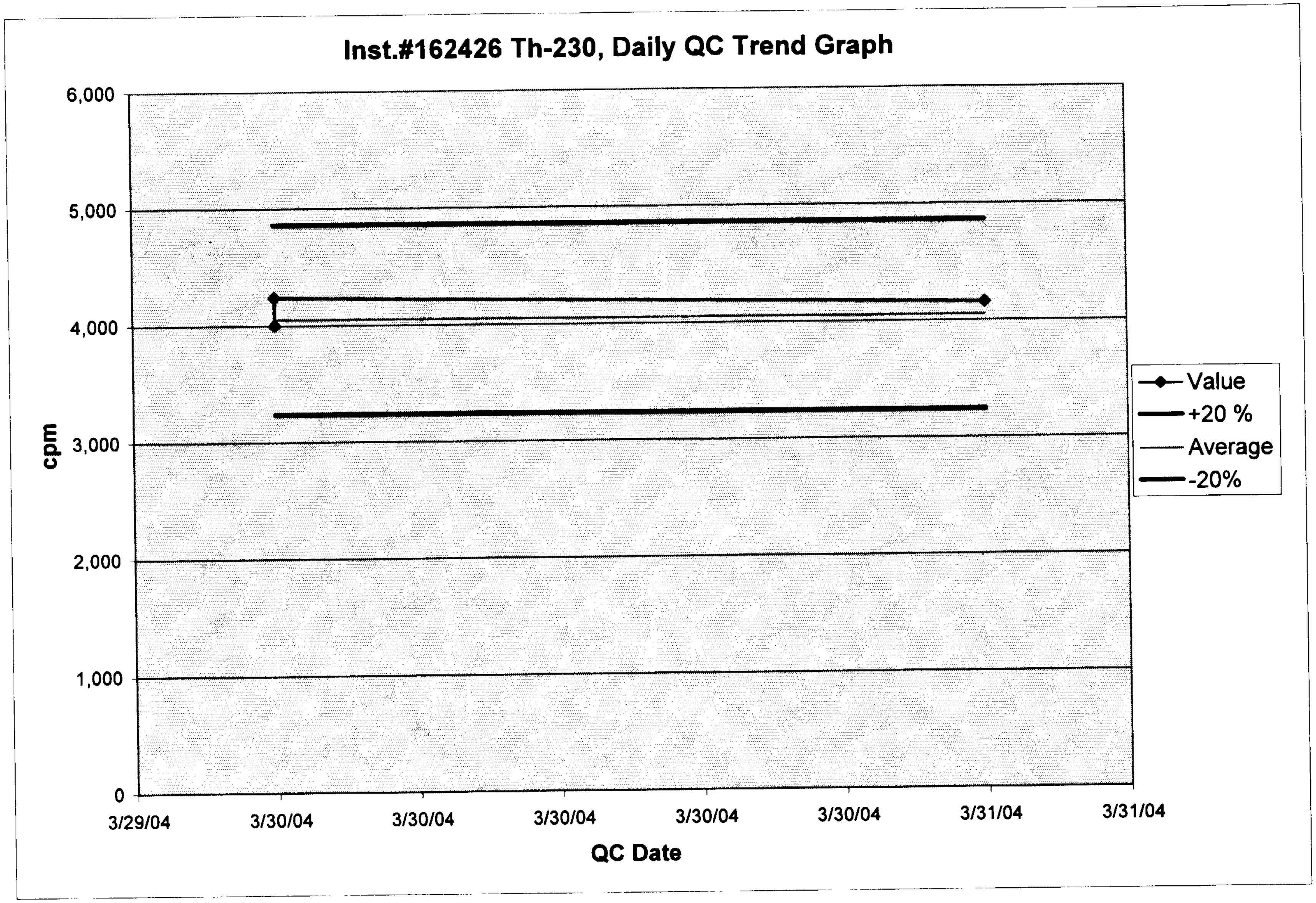
Inst.#162426 Beta Background		Source Ser. #	BKG
Initial Source Readings		Nuclide	
Date	Result (cpm)		
3/29/2004	124		
3/29/2004	113		
3/29/2004	119		
3/29/2004	117		
3/29/2004	152		
3/29/2004	139		
3/29/2004	122		
3/29/2004	131		
3/29/2004	138		
3/29/2004	118		
	Average		
	127		



Inst.#162426 Beta Background, Daily QC Trend Graph
180
160
140
120
100
80
60
40
20
0
cpm
3/29/04
3/30/04
3/30/04
3/30/04
3/30/04
3/30/04
3/31/04
3/31/04
QC Date
Value
+20 %
Average
-20%

Inst.#162426 Th-230		
QC Daily Source		
Date	Result (cpm)	P/F
3/30/2004	4,000	[redacted]
3/30/2004	4,237	[redacted]
3/31/2004	4,158	[redacted]

Inst.#162426 Th-230		Source Ser. #	2888-01
Initial Source Readings		Nuclide	Th-230
Date	Result (cpm)		
3/29/2004	3,948		
3/29/2004	4,080		
3/29/2004	4,151		
3/29/2004	4,062		
3/29/2004	4,067		
3/29/2004	4,021		
3/29/2004	3,996		
3/29/2004	4,060		
3/29/2004	4,155		
3/29/2004	3,972		
	Average		
	4051		

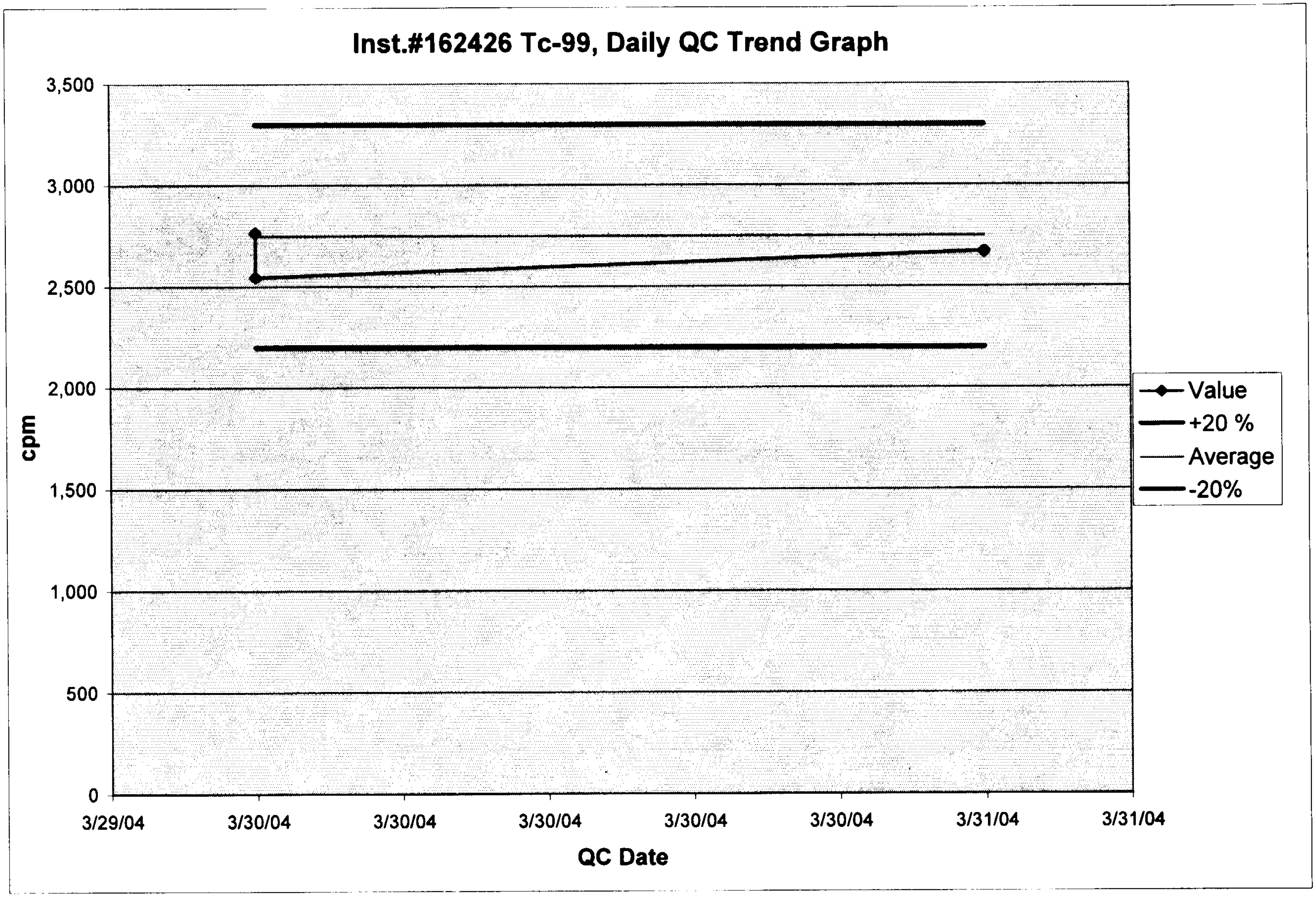


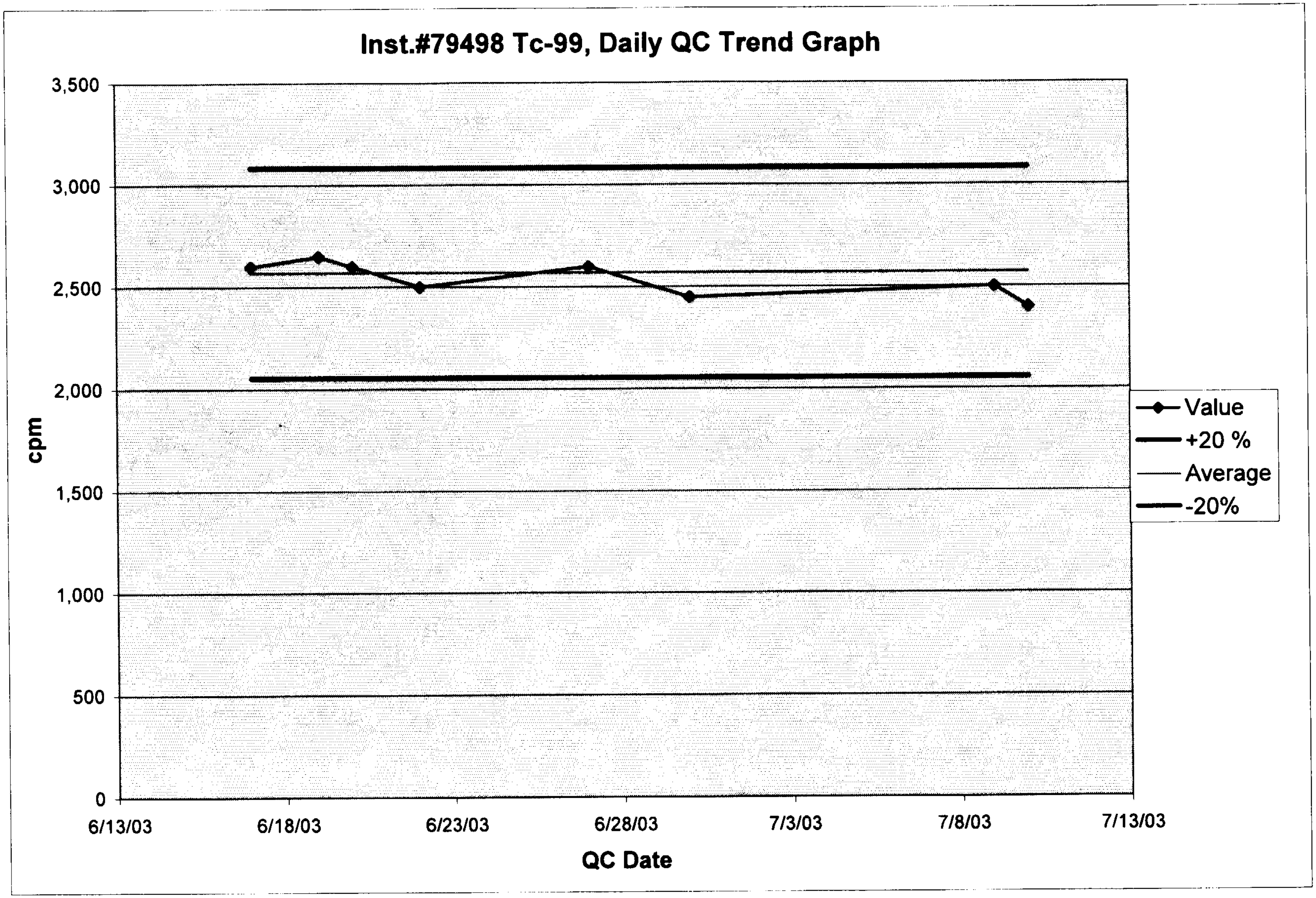
Inst.#162426 Th-230, Daily QC Trend Graph
6,000
5,000
4,000
3,000
2,000
1,000
0
cpm
3/29/04
3/30/04
3/30/04
3/30/04
3/30/04
3/30/04
3/31/04
3/31/04
QC Date
Value
+20 %
Average
-20%

Inst.#162426 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
3/30/2004	2,764	
3/30/2004	2,545	
3/31/2004	2,671	

Inst.#162426 Tc-99	
Initial Source Readings	
Date	Result (cpm)
3/29/2004	2,664
3/29/2004	2,684
3/29/2004	2,859
3/29/2004	2,704
3/29/2004	2,718
3/29/2004	2,807
3/29/2004	2,788
3/29/2004	2,745
3/29/2004	2,724
3/29/2004	2,796
	Average
	2749

Source Ser. #	2889-01
Nuclide	Tc-99

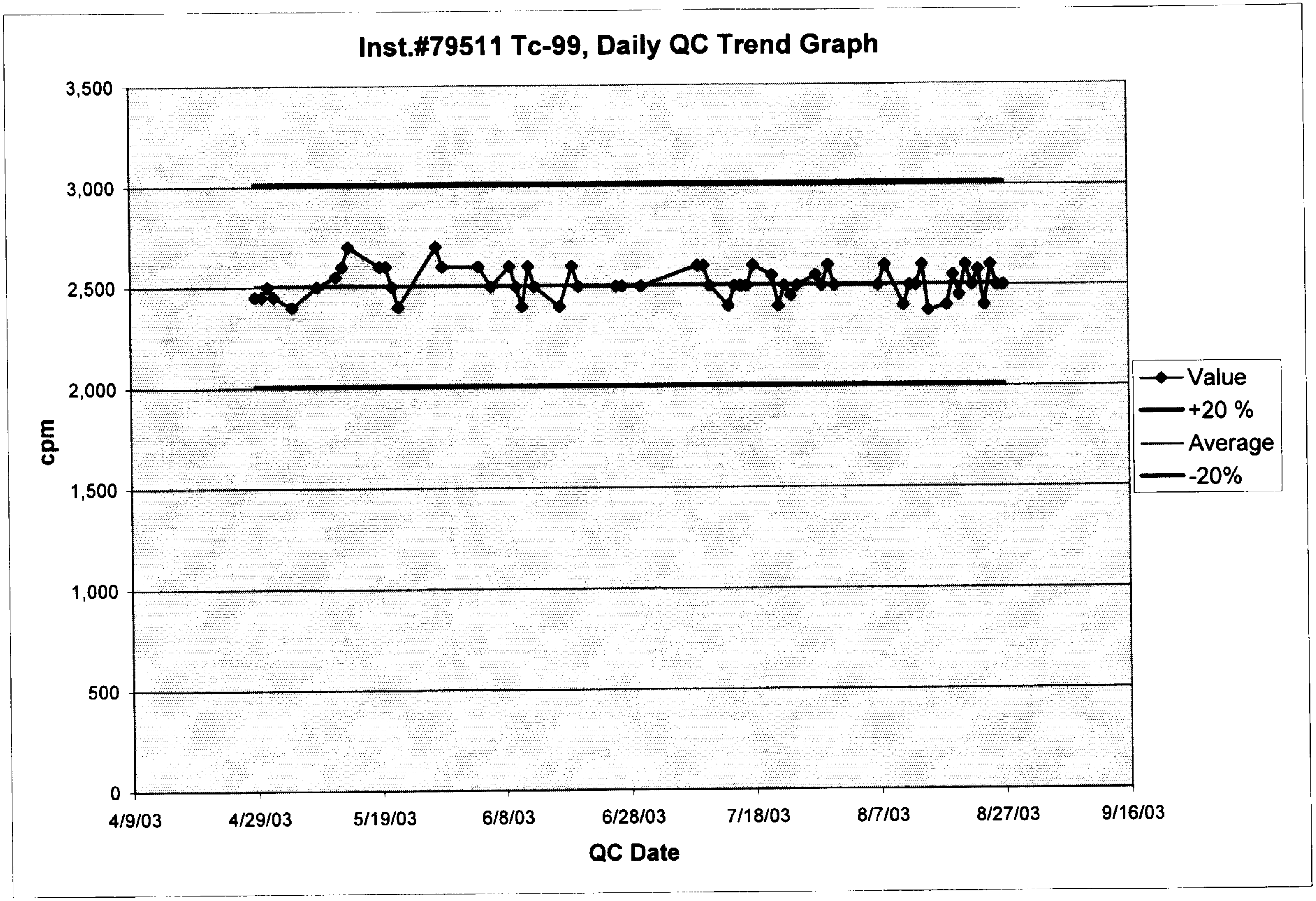

Inst.#162426 Tc-99, Daily QC Trend Graph
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
3/29/04
3/30/04
3/30/04
3/30/04
3/30/04
3/30/04
3/31/04
3/31/04
QC Date
Value
+20 %
Average
-20%



Inst.#79498 Tc-99, Daily QC Trend Graph
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
6/13/03
6/18/03
6/23/03
6/28/03
7/3/03
7/8/03
7/13/03
QC Date
Value
+20 %
Average
-20%

Inst.#79511 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
4/29/2003	2,450	[redacted]
4/30/2003	2,450	[redacted]
5/1/2003	2,500	[redacted]
5/2/2003	2,450	[redacted]
5/5/2003	2,400	[redacted]
5/9/2003	2,500	[redacted]
5/12/2003	2,550	[redacted]
5/13/2003	2,600	[redacted]
5/14/2003	2,700	[redacted]
5/19/2003	2,600	[redacted]
5/20/2003	2,600	[redacted]
5/21/2003	2,500	[redacted]
5/22/2003	2,400	[redacted]
5/28/2003	2,700	[redacted]
5/29/2003	2,600	[redacted]
6/4/2003	2,600	[redacted]
6/6/2003	2,500	[redacted]
6/9/2003	2,600	[redacted]
6/10/2003	2,500	[redacted]
6/11/2003	2,400	[redacted]
6/12/2003	2,600	[redacted]
6/13/2003	2,500	[redacted]
6/17/2003	2,400	[redacted]
6/19/2003	2,600	[redacted]
6/20/2003	2,500	[redacted]
6/26/2003	2,500	[redacted]
6/27/2003	2,500	[redacted]
6/30/2003	2,500	[redacted]
7/9/2003	2,600	[redacted]
7/10/2003	2,600	[redacted]
7/11/2003	2,500	[redacted]
7/14/2003	2,400	[redacted]
7/15/2003	2,500	[redacted]
7/16/2003	2,500	[redacted]
7/17/2003	2,500	[redacted]
7/18/2003	2,600	[redacted]
7/21/2003	2,550	[redacted]
7/22/2003	2,400	[redacted]
7/23/2003	2,500	[redacted]
7/24/2003	2,450	[redacted]
7/25/2003	2,500	[redacted]
7/28/2003	2,550	[redacted]
7/29/2003	2,500	[redacted]
7/30/2003	2,600	[redacted]
7/31/2003	2,500	[redacted]
8/7/2003	2,500	[redacted]
8/8/2003	2,600	[redacted]
8/11/2003	2,400	[redacted]
8/12/2003	2,500	[redacted]
8/13/2003	2,500	[redacted]
8/14/2003	2,600	[redacted]
8/15/2003	2,375	[redacted]
8/18/2003	2,400	[redacted]
8/19/2003	2,550	[redacted]
8/20/2003	2,450	[redacted]
8/21/2003	2,600	[redacted]
8/22/2003	2,500	[redacted]
8/23/2003	2,575	[redacted]
8/24/2003	2,400	[redacted]
8/25/2003	2,600	[redacted]
8/26/2003	2,500	[redacted]
8/27/2003	2,500	[redacted]

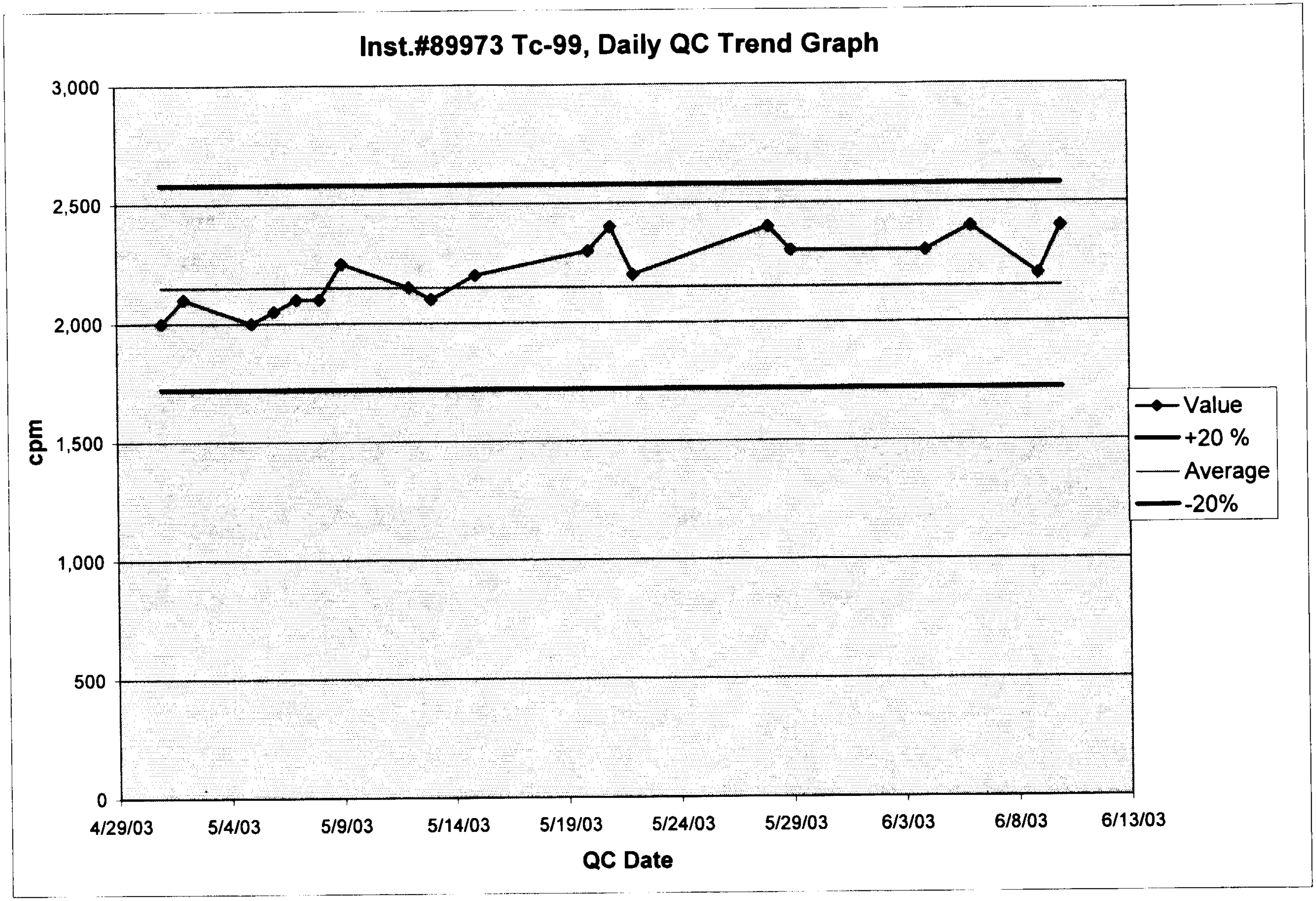
Inst.#79511 Tc-99		Source Ser. #	3974-02
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
4/28/2003	2,500		
4/28/2003	2,650		
4/28/2003	2,450		
4/28/2003	2,500		
4/28/2003	2,500		
4/28/2003	2,450		
4/28/2003	2,550		
4/28/2003	2,500		
4/28/2003	2,550		
4/28/2003	2,450		
[redacted]	Average		
	2510		



Inst.#79511 Tc-99, Daily QC Trend Graph
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
4/9/03
4/29/03
5/19/03
6/8/03
6/28/03
7/18/03
8/7/03
8/27/03
9/16/03
QC Date
Value
+20 %
Average
-20%

Inst.#89973 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
5/1/2003	2,000	
5/2/2003	2,100	
5/5/2003	2,000	
5/6/2003	2,050	
5/7/2003	2,100	
5/8/2003	2,100	
5/9/2003	2,250	
5/12/2003	2,150	
5/13/2003	2,100	
5/15/2003	2,200	
5/20/2003	2,300	
5/21/2003	2,400	
5/22/2003	2,200	
5/28/2003	2,400	
5/29/2003	2,300	
6/4/2003	2,300	
6/6/2003	2,400	
6/9/2003	2,200	
6/10/2003	2,400	

Inst.#89973 Tc-99		Source Ser. #	3974-02
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
5/1/2003	2,200		
5/1/2003	2,200		
5/1/2003	2,000		
5/1/2003	2,200		
5/1/2003	2,200		
5/1/2003	2,000		
5/1/2003	2,200		
5/1/2003	2,200		
5/1/2003	2,100		
5/1/2003	2,200		
	Average		
	2150		

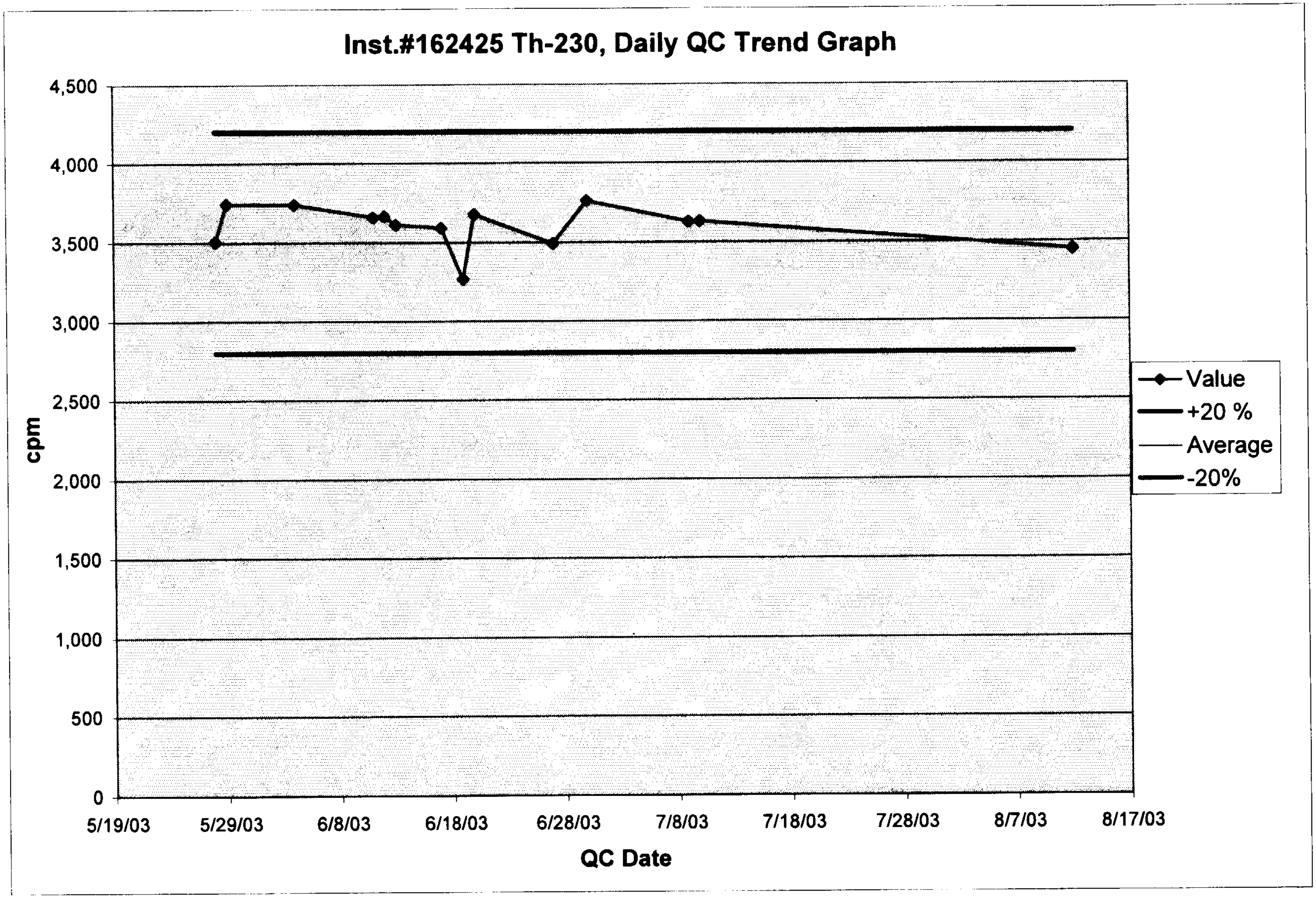


Inst.#89973 Tc-99, Daily QC Trend Graph
3,000
2,500
2,000
1,500
1,000
500
0
cpm
4/29/03
5/4/03
5/9/03
5/14/03
5/19/03
5/24/03
5/29/03
6/3/03
6/8/03
6/13/03
QC Date
Value
+20 %
Average
-20%

Inst.#162425 Th-230		
QC Daily Source		
Date	Result (cpm)	P/F
5/28/2003	3,503	[redacted]
5/29/2003	3,742	[redacted]
6/4/2003	3,740	[redacted]
6/11/2003	3,658	[redacted]
6/12/2003	3,664	[redacted]
6/13/2003	3,610	[redacted]
6/17/2003	3,591	[redacted]
6/19/2003	3,266	[redacted]
6/20/2003	3,676	[redacted]
6/27/2003	3,490	[redacted]
6/30/2003	3,760	[redacted]
7/9/2003	3,626	[redacted]
7/10/2003	3,628	[redacted]
8/12/2003	3,450	[redacted]

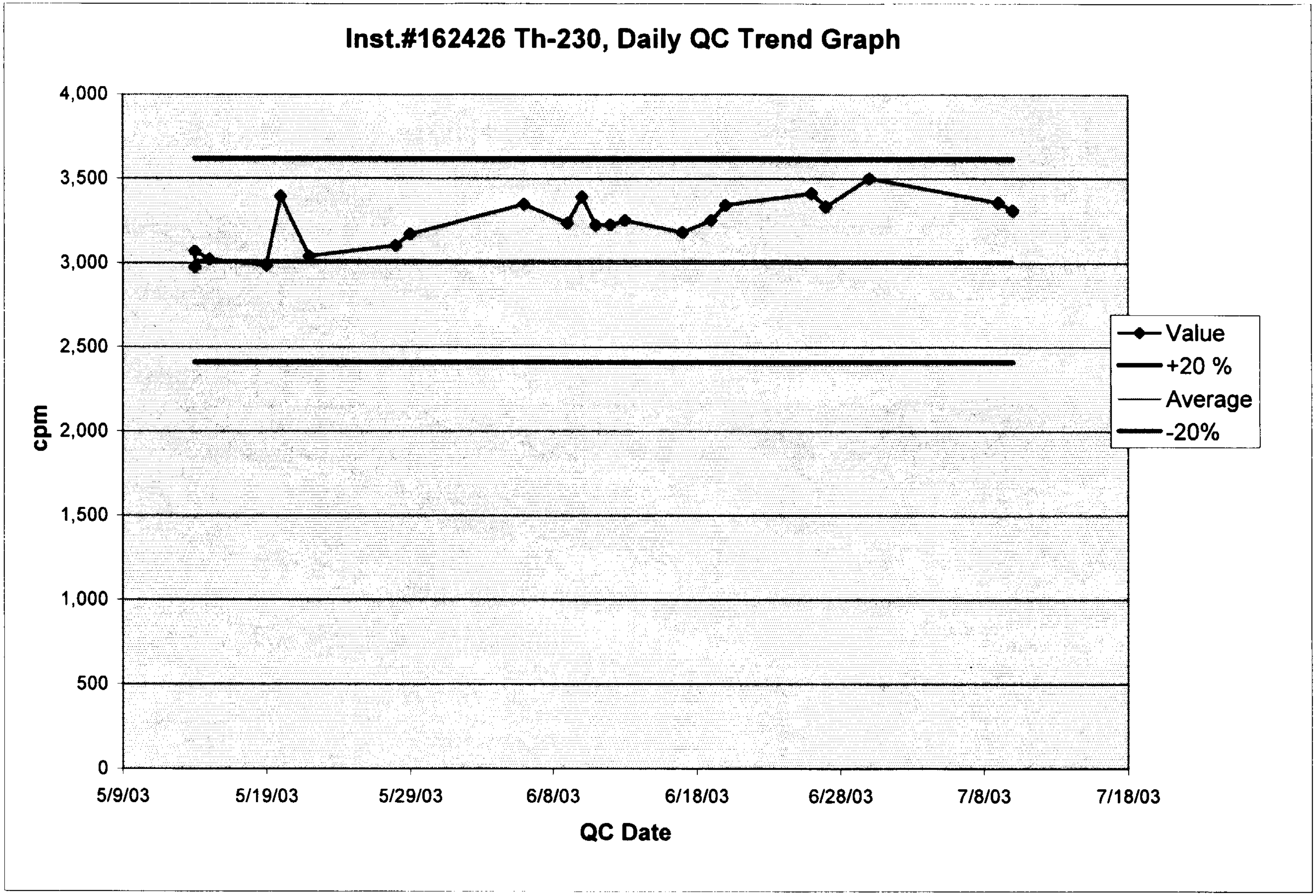
Inst.#162425 Th-230	
Initial Source Readings	
Date	Result (cpm)
5/28/2003	3,443
5/28/2003	3,459
5/28/2003	3,557
5/28/2003	3,446
5/28/2003	3,570
5/28/2003	3,493
5/28/2003	3,531
5/28/2003	3,459
5/28/2003	3,532
5/28/2003	3,503
[redacted]	Average
	3499

Source Ser. #	3972-02
Nuclide	Th-230


Inst.#162425 Th-230, Daily QC Trend Graph
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
5/19/03
5/29/03
6/8/03
6/18/03
6/28/03
7/8/03
7/18/03
7/28/03
8/7/03
8/17/03
QC Date
Value
+20 %
Average
-20%

Inst.#162426 Th-230		
QC Daily Source		
Date	Result (cpm)	P/F
5/14/2003	2,974	[redacted]
5/14/2003	3,067	
5/15/2003	3,021	
5/19/2003	2,986	
5/20/2003	3,396	
5/22/2003	3,039	
5/28/2003	3,103	
5/29/2003	3,171	
6/6/2003	3,351	
6/9/2003	3,239	
6/10/2003	3,394	
6/11/2003	3,225	
6/12/2003	3,228	
6/13/2003	3,254	
6/17/2003	3,183	
6/19/2003	3,256	
6/20/2003	3,345	
6/26/2003	3,417	
6/27/2003	3,337	
6/30/2003	3,503	
7/9/2003	3,360	
7/10/2003	3,314	

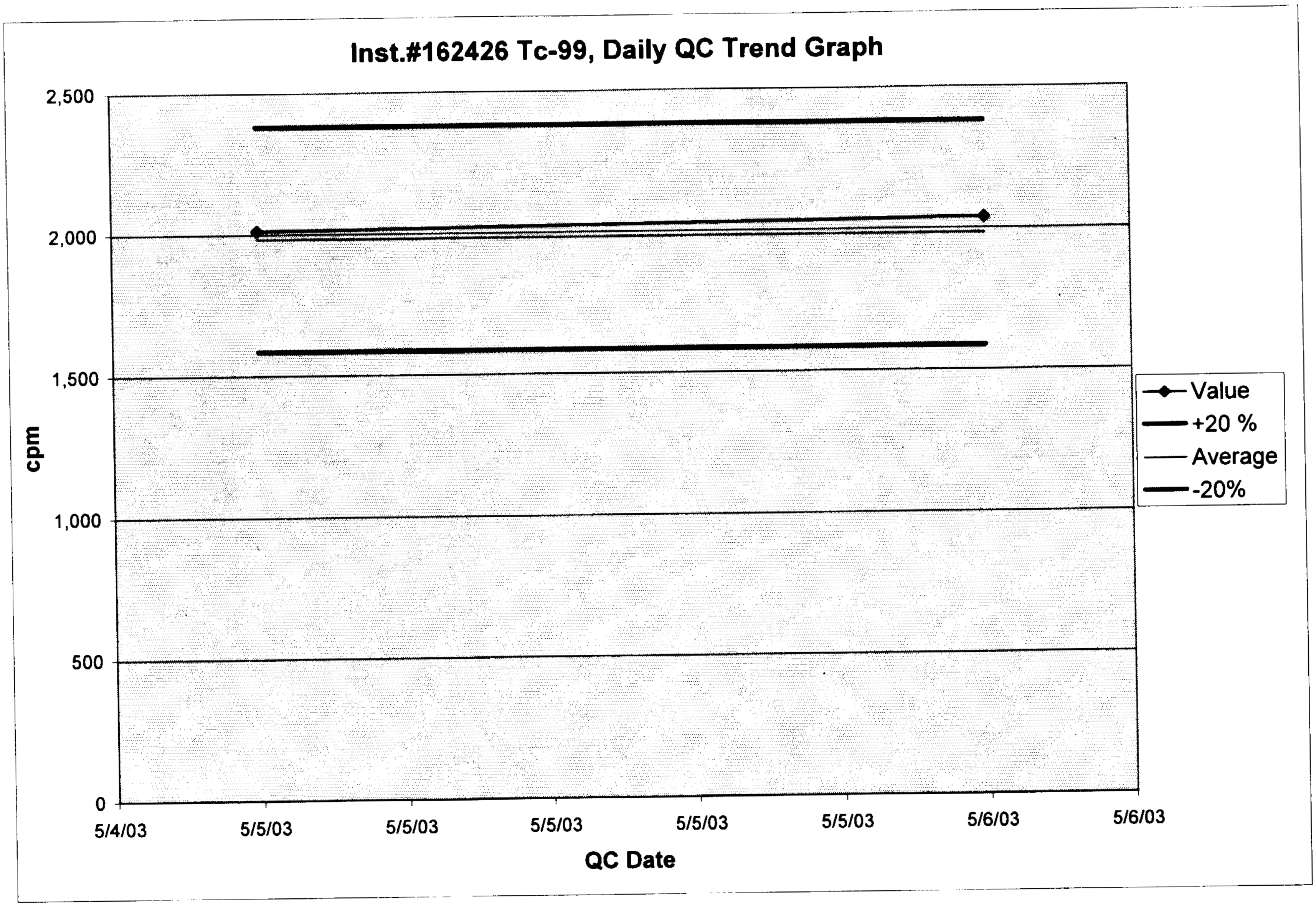
Inst.#162426 Th-230		Source Ser. #	3972-02
Initial Source Readings		Nuclide	Th-230
Date	Result (cpm)		
5/13/2003	2,975		
5/13/2003	3,062		
5/13/2003	2,968		
5/13/2003	2,989		
5/13/2003	3,000		
5/13/2003	2,934		
5/13/2003	3,040		
5/13/2003	3,043		
5/13/2003	3,034		
5/13/2003	3,095		
[redacted]	Average		
	3014		


Inst.#162426 Th-230, Daily QC Trend Graph
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
5/9/03
5/19/03
5/29/03
6/8/03
6/18/03
6/28/03
7/8/03
7/18/03
QC Date
Value
+20 %
Average
-20%

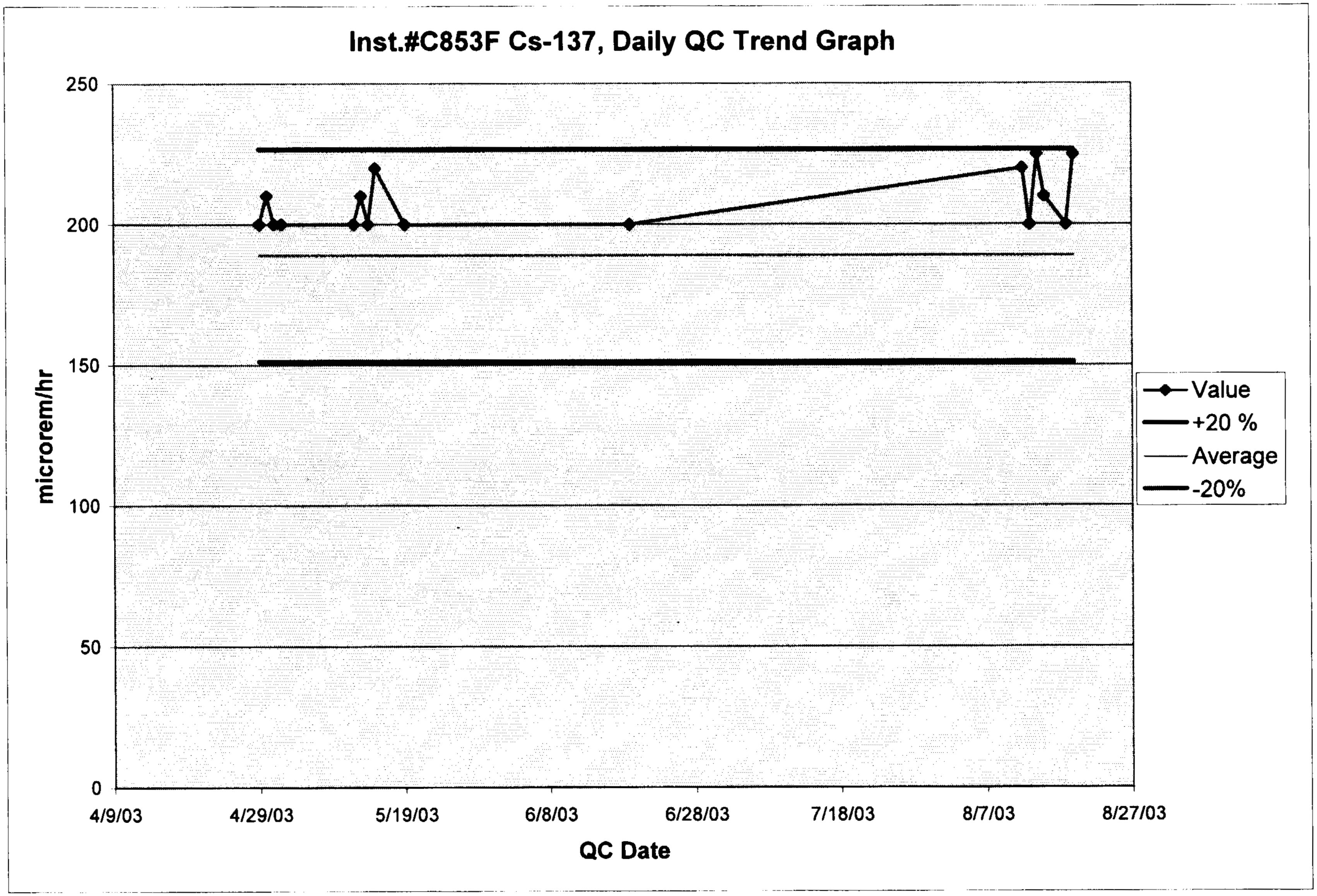
Inst.#162426 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
5/5/2003	2,013	[redacted]
5/6/2003	2,039	[redacted]

Inst.#162426 Tc-99	
Initial Source Readings	
Date	Result (cpm)
5/1/2003	1,959
5/1/2003	1,969
5/1/2003	1,934
5/1/2003	1,981
5/1/2003	1,964
5/1/2003	1,997
5/1/2003	1,987
5/1/2003	2,052
5/1/2003	2,042
5/1/2003	1,951
	Average
	1984

Source Ser. #	3974-02
Nuclide	Tc-99



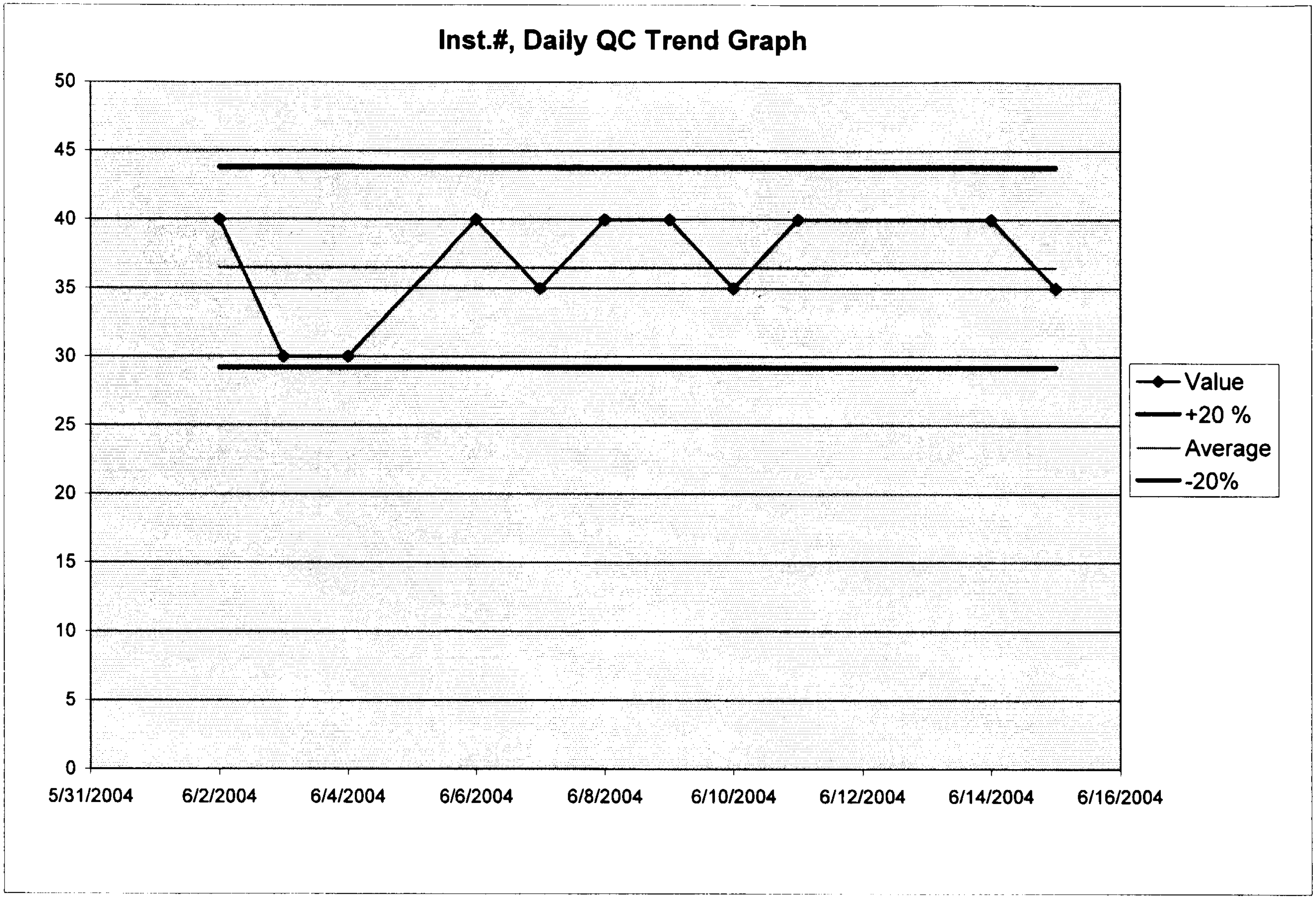
Inst.#162426 Tc-99, Daily QC Trend Graph
2,500
2,000
1,500
1,000
500
0
cpm
5/4/03
5/5/03
5/5/03
5/5/03
5/5/03
5/5/03
5/6/03
5/6/03
QC Date
Value
+20 %
Average
-20%



Inst.#C853F Cs-137, Daily QC Trend Graph
250
200
150
100
50
0
microrem/hr
4/9/03
4/29/03
5/19/03
6/8/03
6/28/03
7/18/03
8/7/03
8/27/03
QC Date
Value
+20 %
Average
-20%

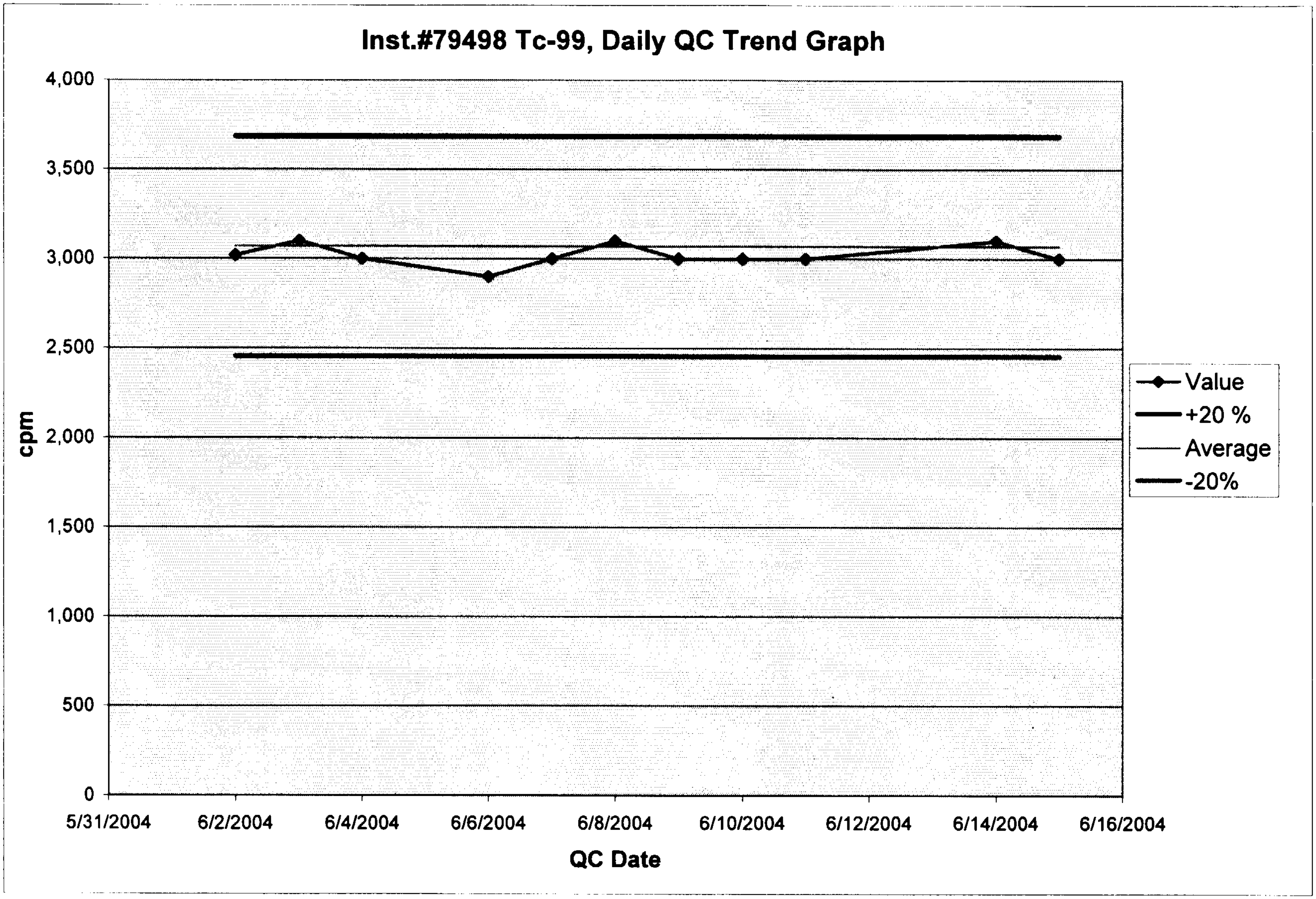
Inst.#79498 Background		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	40	
6/3/2004	30	
6/4/2004	30	
6/6/2004	40	
6/7/2004	35	
6/8/2004	40	
6/9/2004	40	
6/10/2004	35	
6/11/2004	40	
6/14/2004	40	
6/15/2004	35	

Inst.#79498 Background		Source Ser. #	BKG
Initial Source Readings		Nuclide	
Date	Result (cpm)		
6/2/2004	50		
6/2/2004	40		
6/2/2004	50		
6/2/2004	30		
6/2/2004	25		
6/2/2004	30		
6/2/2004	40		
6/2/2004	20		
6/2/2004	60		
6/2/2004	20		
	Average		
	37		


Inst.#, Daily QC Trend Graph
50
45
40
35
30
25
20
15
10
5
0
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
Value
+20 %
Average
-20%

Inst.#79498 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	3,020	[redacted]
6/3/2004	3,100	[redacted]
6/4/2004	3,000	[redacted]
6/6/2004	2,900	[redacted]
6/7/2004	3,000	[redacted]
6/8/2004	3,100	[redacted]
6/9/2004	3,000	[redacted]
6/10/2004	3,000	[redacted]
6/11/2004	3,000	[redacted]
6/14/2004	3,100	[redacted]
6/15/2004	3,000	[redacted]

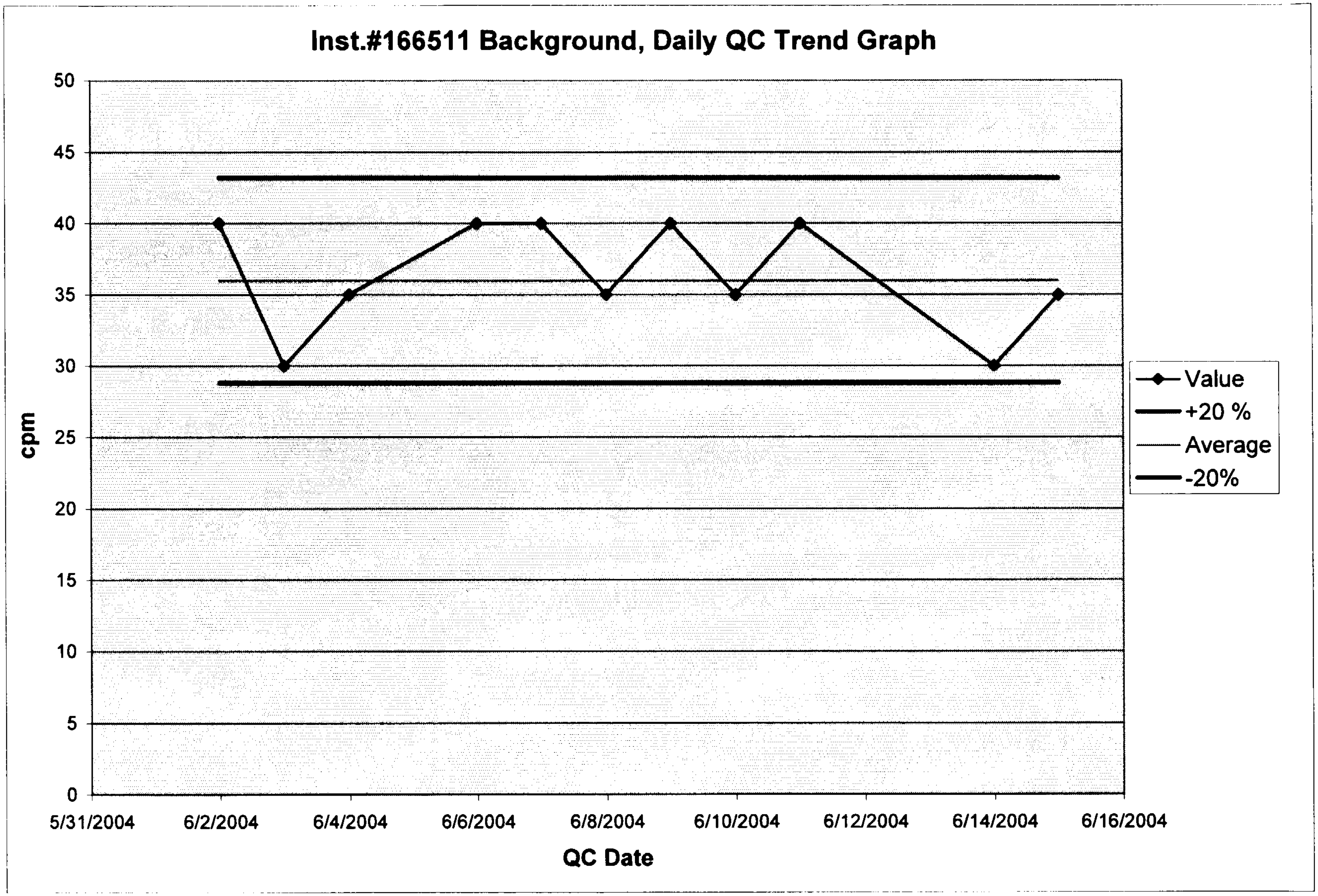
Inst.#79498 Tc-99		Source Ser. #	2889-01
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
6/2/2004	2,900		
6/2/2004	3,100		
6/2/2004	2,800		
6/2/2004	3,000		
6/2/2004	3,200		
6/2/2004	3,300		
6/2/2004	3,100		
6/2/2004	3,300		
6/2/2004	3,100		
6/2/2004	2,900		
[redacted]	Average		
[redacted]	3070		



Inst.#79498 Tc-99, Daily QC Trend Graph
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
QC Date
Value
+20 %
Average
-20%

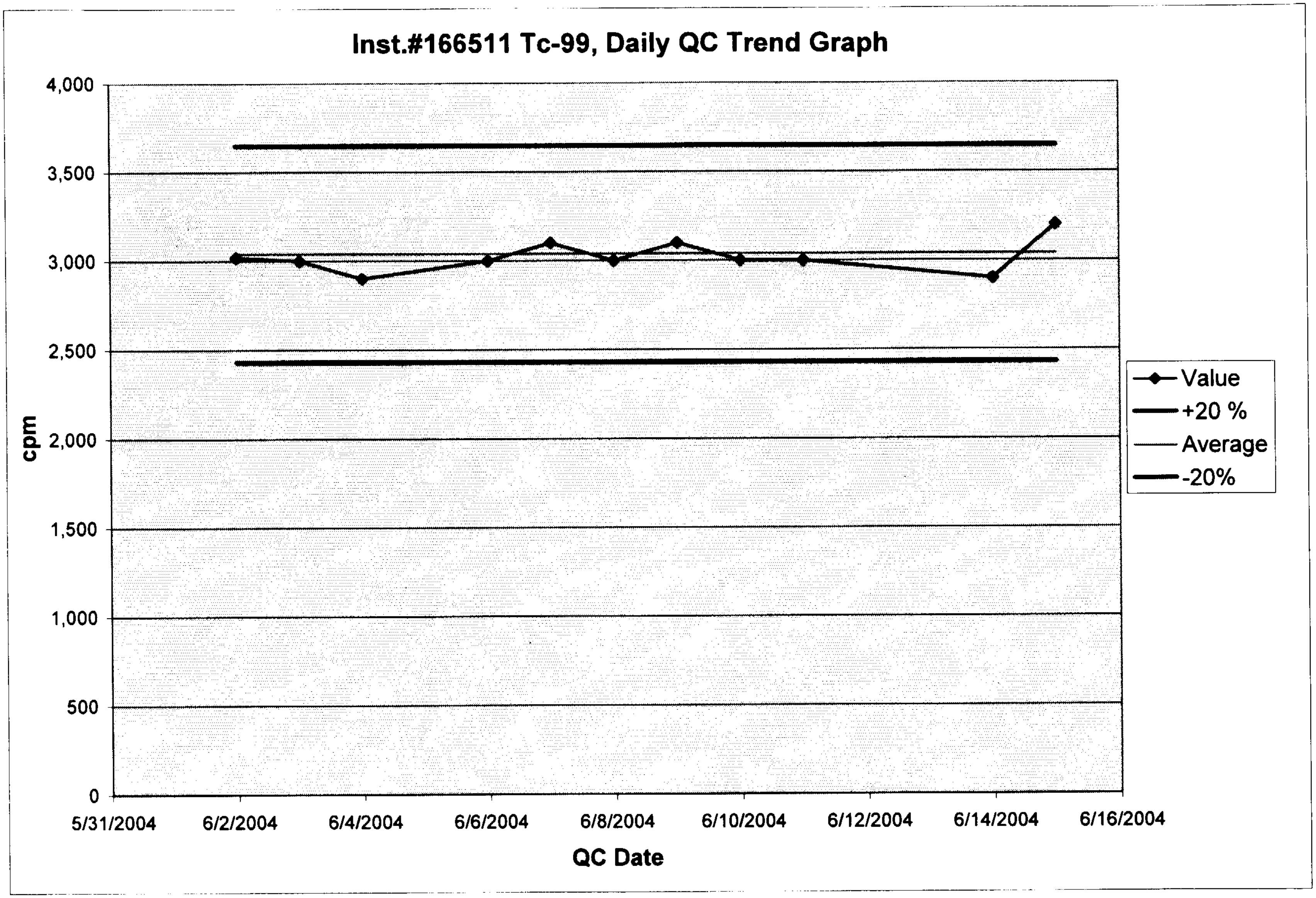
Inst.#166511 Background		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	40	[redacted]
6/3/2004	30	[redacted]
6/4/2004	35	[redacted]
6/6/2004	40	[redacted]
6/7/2004	40	[redacted]
6/8/2004	35	[redacted]
6/9/2004	40	[redacted]
6/10/2004	35	[redacted]
6/11/2004	40	[redacted]
6/14/2004	30	[redacted]
6/15/2004	35	[redacted]

Inst.#166511 Background		Source Ser. #	BKG
Initial Source Readings		Nuclide	
Date	Result (cpm)		
6/2/2004	20		
6/2/2004	50		
6/2/2004	60		
6/2/2004	30		
6/2/2004	35		
6/2/2004	25		
6/2/2004	50		
6/2/2004	40		
6/2/2004	30		
6/2/2004	20		
[redacted]	Average		
[redacted]	36		


Inst.#166511 Background, Daily QC Trend Graph
cpm
50
45
40
35
30
25
20
15
10
5
0
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
QC Date
Value
+20 %
Average
-20%

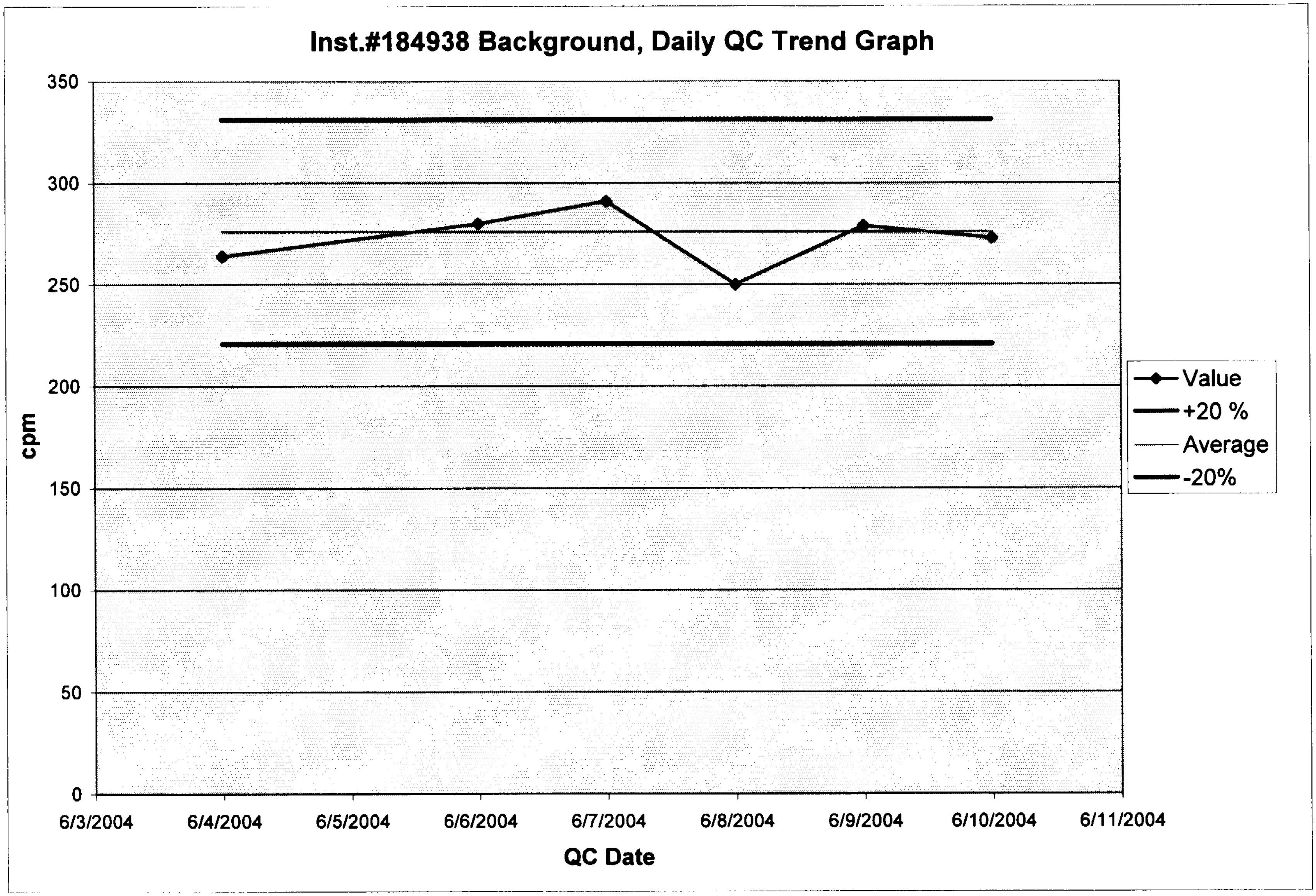
Inst.#166511 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	3,020	[redacted]
6/3/2004	3,000	[redacted]
6/4/2004	2,900	[redacted]
6/6/2004	3,000	[redacted]
6/7/2004	3,100	[redacted]
6/8/2004	3,000	[redacted]
6/9/2004	3,100	[redacted]
6/10/2004	3,000	[redacted]
6/11/2004	3,000	[redacted]
6/14/2004	2,900	[redacted]
6/15/2004	3,200	[redacted]

Inst.#166511 Tc-99		Source Ser. #	2889-01
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
6/2/2004	3,100		
6/2/2004	3,000		
6/2/2004	2,900		
6/2/2004	3,000		
6/2/2004	3,200		
6/2/2004	2,800		
6/2/2004	3,100		
6/2/2004	3,300		
6/2/2004	3,100		
6/2/2004	2,900		
[redacted]	Average		
[redacted]	3040		


Inst.#166511 Tc-99, Daily QC Trend Graph
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
QC Date
Value
+20 %
Average
-20%

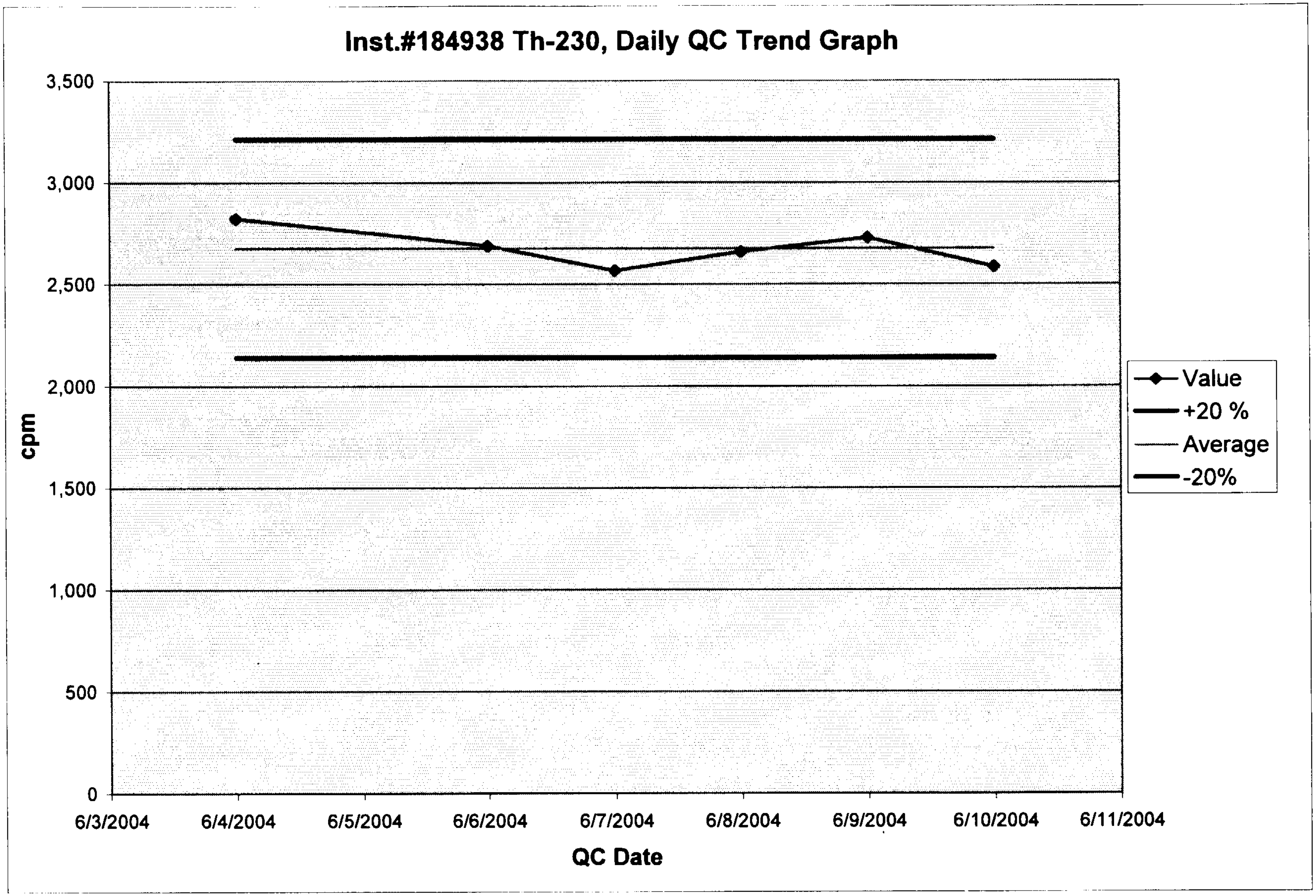
Inst.#184938 Background		
QC Daily Source		
Date	Result (cpm)	P/F
6/4/2004	264	[redacted]
6/6/2004	280	[redacted]
6/7/2004	291	[redacted]
6/8/2004	250	[redacted]
6/9/2004	279	[redacted]
6/10/2004	273	[redacted]

Inst.#184938 Background		Source Ser. #	BKG
Initial Source Readings		Nuclide	
Date	Result (cpm)		
6/4/2004	263		
6/4/2004	286		
6/4/2004	287		
6/4/2004	279		
6/4/2004	256		
6/4/2004	285		
6/4/2004	280		
6/4/2004	290		
6/4/2004	265		
6/4/2004	269		
	Average		
	276		


Inst.#184938 Background, Daily QC Trend Graph
350
300
250
200
150
100
50
0
cpm
6/3/2004
6/4/2004
6/5/2004
6/6/2004
6/7/2004
6/8/2004
6/9/2004
6/10/2004
6/11/2004
QC Date
Value
+20 %
Average
-20%

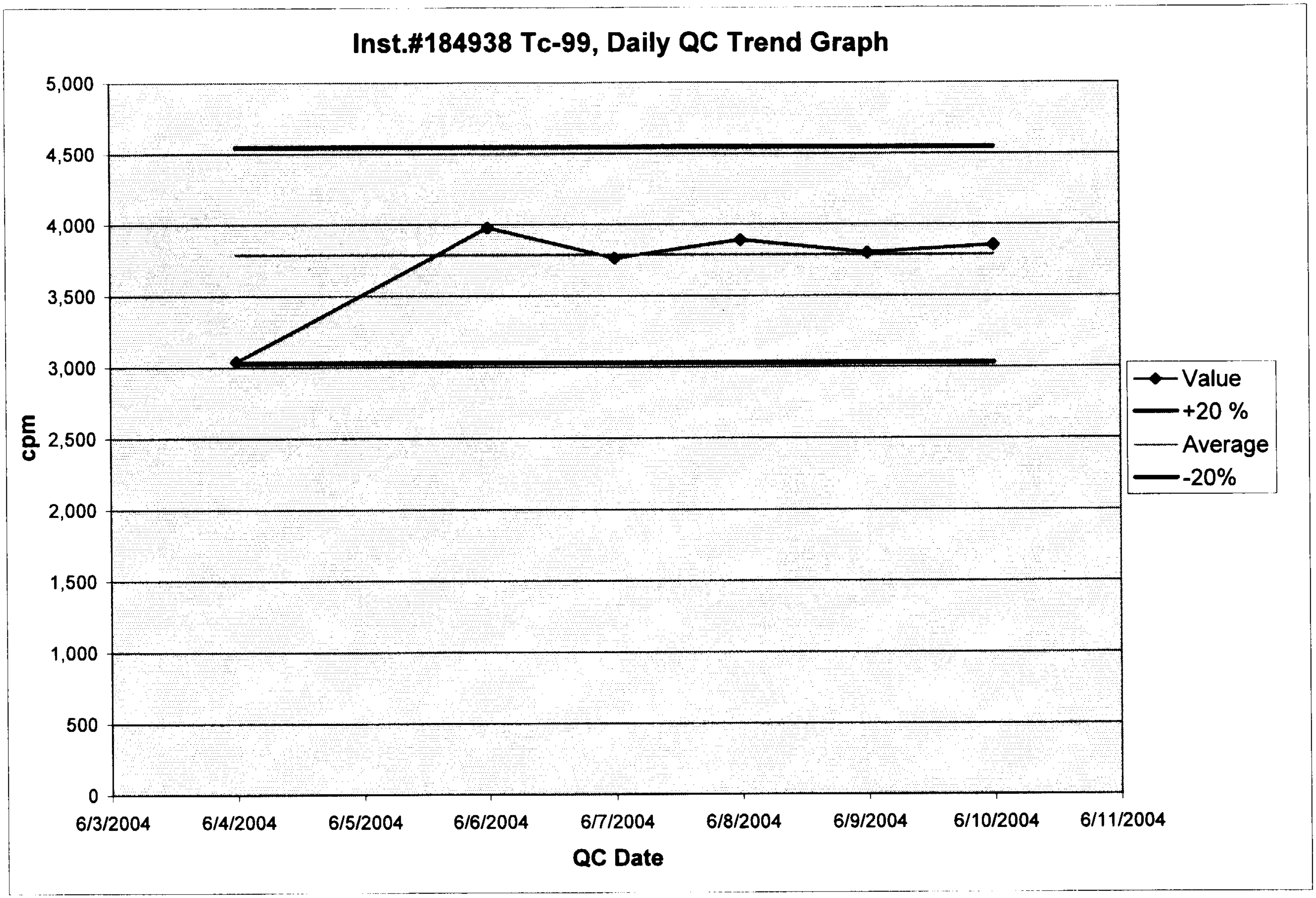
Inst.#184938 Th-230		
QC Daily Source		
Date	Result (cpm)	P/F
6/4/2004	2,822	[redacted]
6/6/2004	2,689	[redacted]
6/7/2004	2,567	[redacted]
6/8/2004	2,661	[redacted]
6/9/2004	2,730	[redacted]
6/10/2004	2,587	[redacted]

Inst.#184938 Th-230		Source Ser. #	2897-01
Initial Source Readings		Nuclide	Th-230
Date	Result (cpm)		
6/4/2004	2,811		
6/4/2004	2,709		
6/4/2004	2,722		
6/4/2004	2,730		
6/4/2004	2,556		
6/4/2004	2,649		
6/4/2004	2,585		
6/4/2004	2,657		
6/4/2004	2,638		
6/4/2004	2,722		
	Average		
	2678		


Inst.#184938 Th-230, Daily QC Trend Graph
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
6/3/2004
6/4/2004
6/5/2004
6/6/2004
6/7/2004
6/8/2004
6/9/2004
6/10/2004
6/11/2004
QC Date
Value
+20 %
Average
-20%

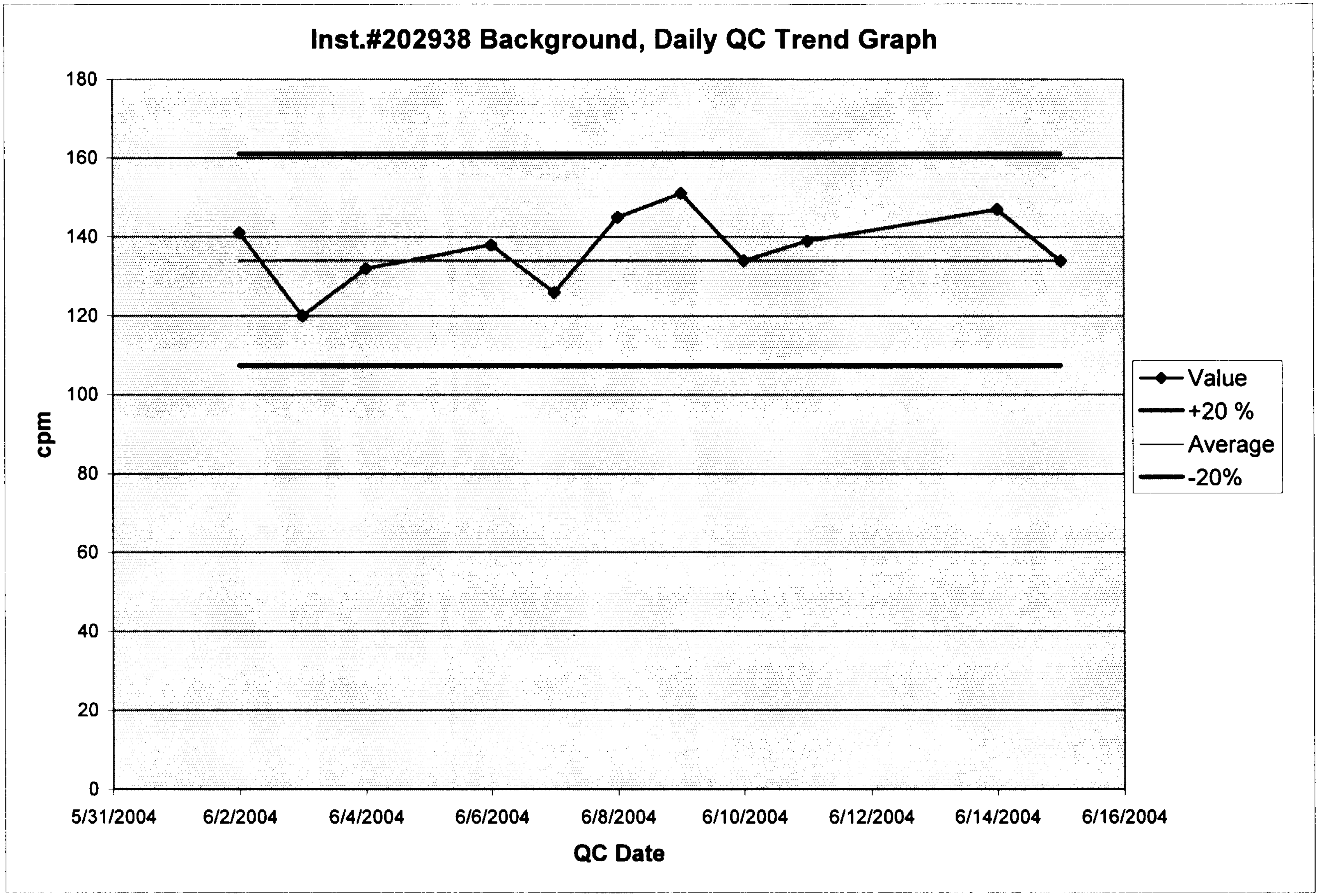
Inst.#184938 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
6/4/2004	3,039	
6/6/2004	3,980	
6/7/2004	3,765	
6/8/2004	3,891	
6/9/2004	3,802	
6/10/2004	3,856	

Inst.#184938 Tc-99		Source Ser. #	2889-01
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
6/4/2004	3,671		
6/4/2004	3,787		
6/4/2004	3,730		
6/4/2004	3,797		
6/4/2004	3,799		
6/4/2004	3,939		
6/4/2004	3,776		
6/4/2004	3,820		
6/4/2004	3,789		
6/4/2004	3,782		
	Average		
	3789		


Inst.#184938 Tc-99, Daily QC Trend Graph
cpm
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
6/3/2004
6/4/2004
6/5/2004
6/6/2004
6/7/2004
6/8/2004
6/9/2004
6/10/2004
6/11/2004
QC Date
Value
+20 %
Average
-20%

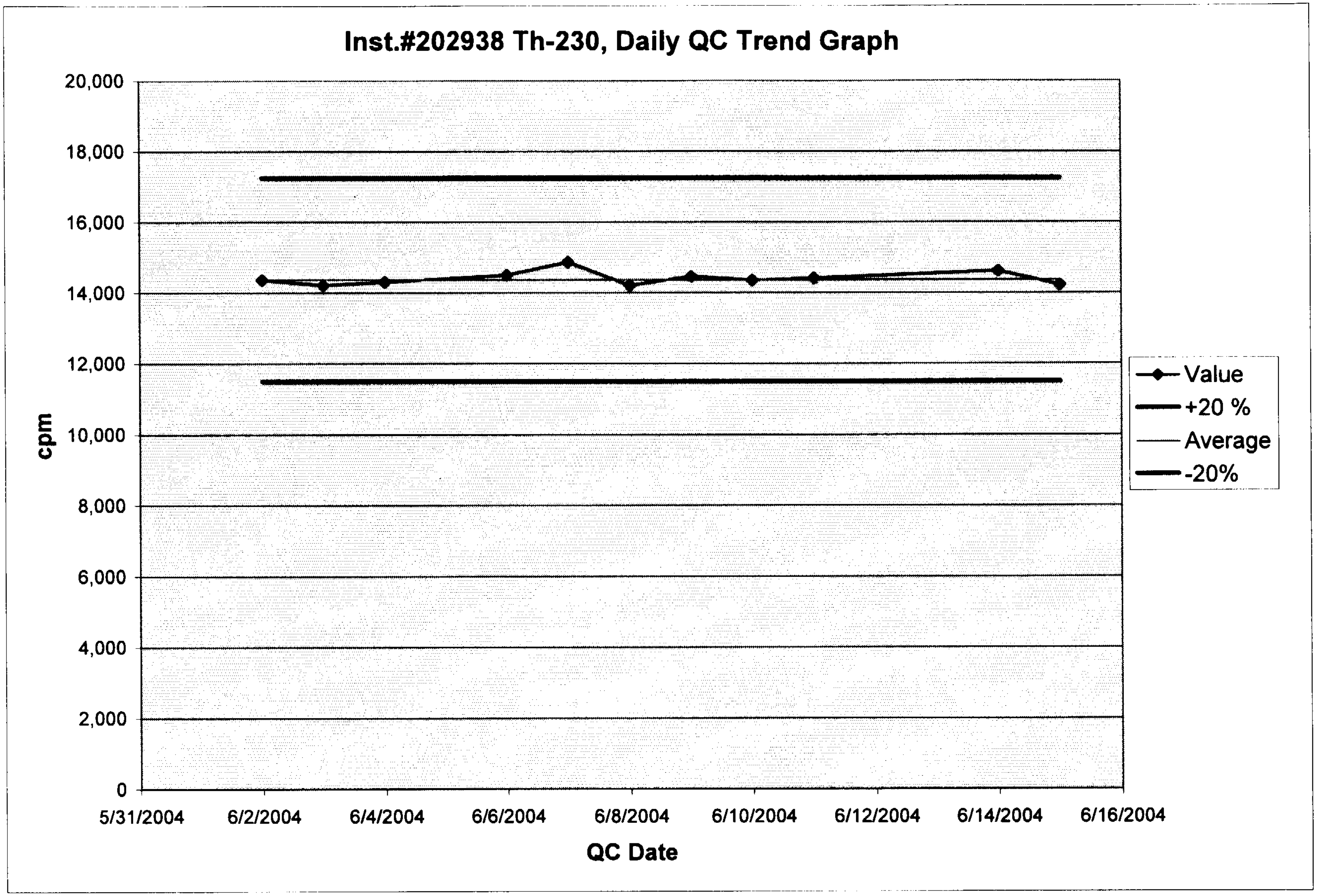
Inst.#202938 Background		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	141	
6/3/2004	120	
6/4/2004	132	
6/6/2004	138	
6/7/2004	126	
6/8/2004	145	
6/9/2004	151	
6/10/2004	134	
6/11/2004	139	
6/14/2004	147	
6/15/2004	134	

Inst.#202938 Background		Source Ser. #	BKG
Initial Source Readings		Nuclide	
Date	Result (cpm)		
6/2/2004	135		
6/2/2004	145		
6/2/2004	156		
6/2/2004	123		
6/2/2004	137		
6/2/2004	123		
6/2/2004	133		
6/2/2004	138		
6/2/2004	146		
6/2/2004	106		
	Average		
	134		


Inst.#202938 Background, Daily QC Trend Graph
180
160
140
120
100
80
60
40
20
0
cpm
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
QC Date
Value
+20 %
Average
-20%

Inst.#202938 Th-230		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	14,370	[redacted]
6/3/2004	14,218	[redacted]
6/4/2004	14,310	[redacted]
6/6/2004	14,507	[redacted]
6/7/2004	14,870	[redacted]
6/8/2004	14,213	[redacted]
6/9/2004	14,467	[redacted]
6/10/2004	14,354	[redacted]
6/11/2004	14,412	[redacted]
6/14/2004	14,621	[redacted]
6/15/2004	14,231	[redacted]

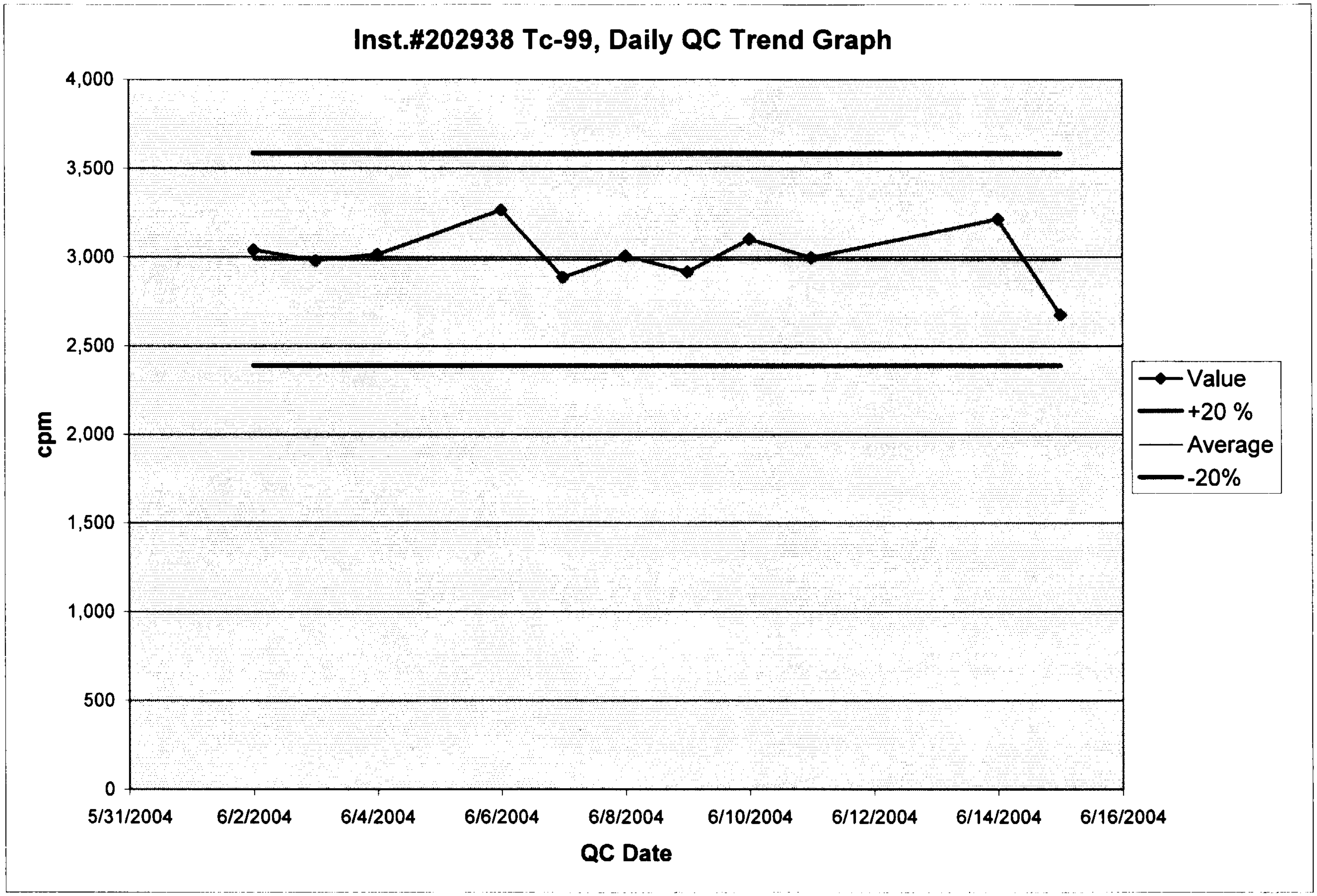
Inst.#202938 Th-230		Source Ser. #	2897-01
Initial Source Readings		Nuclide	Th-230
Date	Result (cpm)		
6/2/2004	14,463		
6/2/2004	14,390		
6/2/2004	14,504		
6/2/2004	14,211		
6/2/2004	14,433		
6/2/2004	14,315		
6/2/2004	14,183		
6/2/2004	14,452		
6/2/2004	14,421		
6/2/2004	14,356		
[redacted]	Average		
	14373		



Inst.#202938 Th-230, Daily QC Trend Graph
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
cpm
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
QC Date
Value
+20 %
Average
-20%

Inst.#202938 Tc-99		
QC Daily Source		
Date	Result (cpm)	P/F
6/2/2004	3,039	[redacted]
6/3/2004	2,980	[redacted]
6/4/2004	3,015	[redacted]
6/6/2004	3,267	[redacted]
6/7/2004	2,887	[redacted]
6/8/2004	3,008	[redacted]
6/9/2004	2,918	[redacted]
6/10/2004	3,102	[redacted]
6/11/2004	2,998	[redacted]
6/14/2004	3,214	[redacted]
6/15/2004	2,676	[redacted]

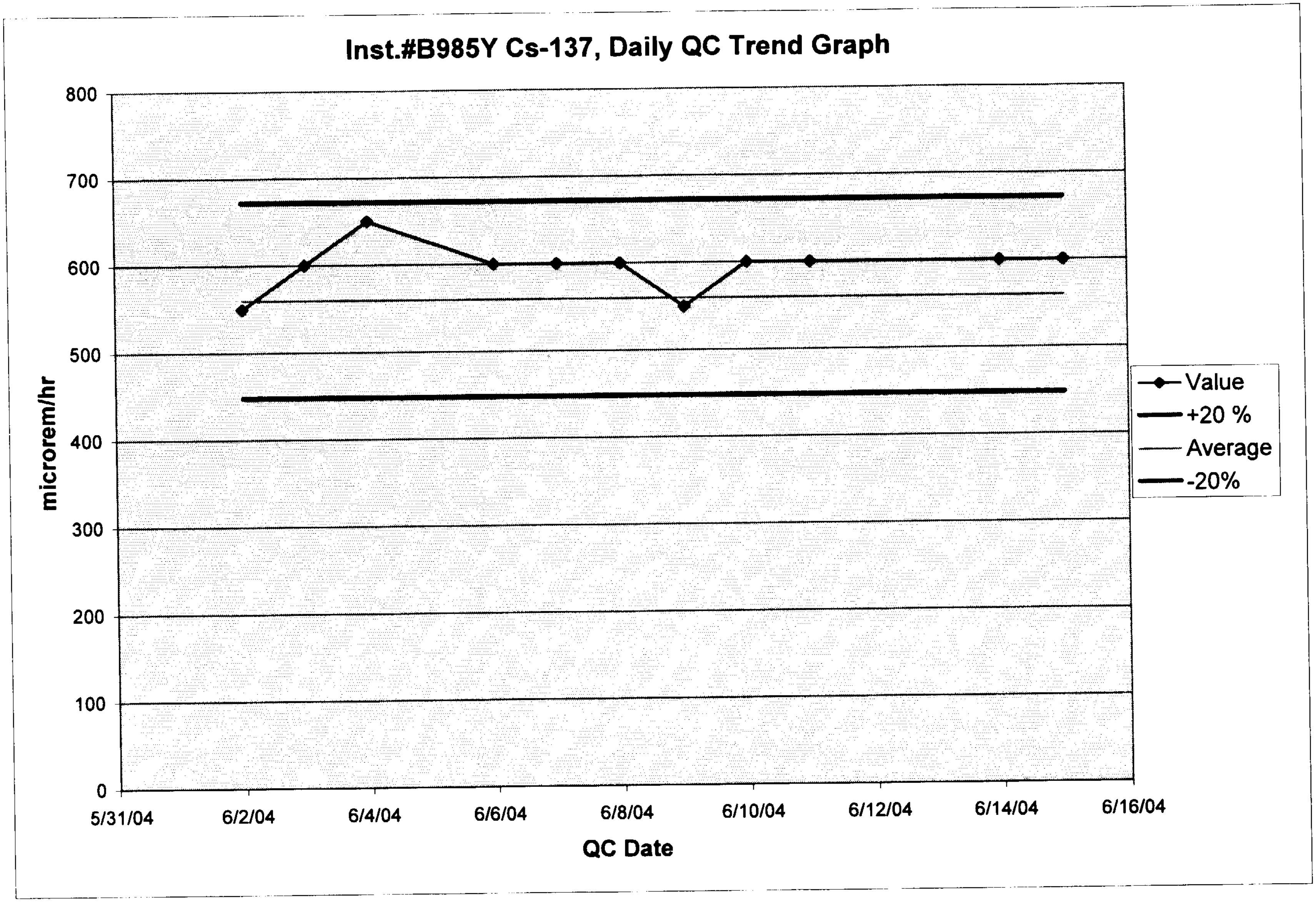
Inst.#202938 Tc-99		Source Ser. #	2889-01
Initial Source Readings		Nuclide	Tc-99
Date	Result (cpm)		
6/2/2004	3,168		
6/2/2004	3,000		
6/2/2004	2,932		
6/2/2004	3,027		
6/2/2004	3,127		
6/2/2004	2,901		
6/2/2004	3,046		
6/2/2004	2,872		
6/2/2004	2,840		
6/2/2004	2,965		
[redacted]	Average		
	2988		



Inst.#202938 Tc-99, Daily QC Trend Graph
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
cpm
5/31/2004
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/2004
6/12/2004
6/14/2004
6/16/2004
QC Date
Value
+20 %
Average
-20%

Inst.#B985Y Cs-137		
QC Daily Source		
Date	Result (μrem/hr)	P/F
6/2/2004	550	
6/3/2004	600	
6/4/2004	650	
6/6/2004	600	
6/7/2004	600	
6/8/2004	600	
6/9/2004	550	
6/10/2004	600	
6/11/2004	600	
6/14/2004	600	
6/15/2004	600	

Inst.#B985Y Cs-137		Source Ser. #	1134
Initial Source Readings		Nuclide	Cs-137
Date	Result (μrem/hr)		
6/2/2004	550		
6/2/2004	600		
6/2/2004	550		
6/2/2004	550		
6/2/2004	500		
6/2/2004	600		
6/2/2004	550		
6/2/2004	550		
6/2/2004	600		
6/2/2004	550		
	Average		
	560		



Inst.#B985Y Cs-137, Daily QC Trend Graph
800
700
600
500
400
300
200
100
0
microrem/hr
5/31/04
6/2/04
6/4/04
6/6/04
6/8/04
6/10/04
6/12/04
6/14/04
6/16/04
QC Date
Value
+20 %
Average
-20%

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
STATIC INSTRUMENT QC

Counting Instrument		Ludlum 2360		Detector	43-37		Cal. Date	4/29/2004					
Serial #		193675		Serial #	PR161687		Cal. Due Date OK?	WARNING					
Detector Active Area or Area Covered by Smear (cm^2)					582								
	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source Count Time	Control Chart bkg Average α β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α β cpm	Control Chart source 1 sigma, cpm
Alpha	0.1206	Th-230	3973-02	17,500	4/29/2002	7.70E+04	17,500	100	1	1	4.40	1.51	2107.6	49.72
Beta	0.2885	Tc-99	3975-02	17,700	4/29/2002	2.13E+05	17,700	1000	1	1	505.30	24.15	4247.1	83.68

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail				α MDA OK?	β MDA OK?	H.P. Technician	Technician Initials
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	MDA α (dpm)	MDA β (dpm)				
5/8/2003	8	797	2,419	4,229	8.0	797.0	2411.0	3432.0	QUESTION	FAIL	FAIL	FAIL	23.02	86	Yes	Yes		
5/9/2003	7	722	2,451	4,328	7.0	722.0	2444.0	3908.0	PASS	FAIL	FAIL	FAIL	21.81	82	Yes	Yes		
5/12/2003	5	457	2,156	4,760	5.0	457.0	2151.0	4203.0	PASS	PASS	PASS	PASS	19.10	66	Yes	Yes		
5/12/2003	4	478	2,162	4,645	4.0	478.0	2158.0	4167.0	PASS	PASS	PASS	PASS	17.53	67	Yes	Yes		
5/13/2003	4	492	2,086	4,675	4.0	492.0	2082.0	4183.0	PASS	PASS	PASS	PASS	17.53	68	Yes	Yes		
5/13/2003	3	560	2,100	4,846	3.0	560.0	2097.0	4286.0	PASS	QUESTION	PASS	PASS	15.76	72	Yes	Yes		
5/13/2003	3	528	2,100	4,846	3.0	528.0	2097.0	4318.0	PASS	PASS	PASS	PASS	15.76	70	Yes	Yes		
5/14/2003	4	459	2,052	4,560	4.0	459.0	2048.0	4101.0	PASS	PASS	PASS	PASS	17.53	66	Yes	Yes		
5/14/2003	4	529	2,085	4,751	4.0	529.0	2081.0	4222.0	PASS	PASS	PASS	PASS	17.53	70	Yes	Yes		
5/15/2003	6	463	2,049	4,582	6.0	463.0	2043.0	4119.0	PASS	PASS	PASS	PASS	20.51	66	Yes	Yes		
6/2/2003	5	482	2,056	4,699	5.0	482.0	2051.0	4217.0	PASS	PASS	PASS	PASS	19.10	67	Yes	Yes		
6/2/2003	4	510	2,078	4,755	4.0	510.0	2074.0	4245.0	PASS	PASS	PASS	PASS	17.53	69	Yes	Yes		

Initial Background and Source Counts for Control Chart

#	Initial bkg counts				Initial source plus bkg counts			
	Alpha	cpm	Beta	cpm	Alpha	cpm	Beta	cpm
1	5	5	511	511	2,197	2197	4,657	4657
2	2	2	519	519	2,172	2172	4,786	4786
3	4	4	560	560	2,042	2042	4,743	4743
4	5	5	479	479	2,072	2072	4,891	4891
5	6	6	492	492	2,143	2143	4,651	4651
6	5	5	508	508	2,121	2121	4,684	4684
7	3	3	520	520	2,057	2057	4,798	4798
8	7	7	518	518	2,101	2101	4,739	4739
9	4	4	490	490	2,089	2089	4,804	4804
10	3	3	486	486	2,128	2128	4,771	4771
Mean		4.40		505.3		2112.0		4752.4
$S_{(n-1)}$		1.51		24.15		49.71		74.35
-3 sigma		-0.12		432.84		1962.88		4529.34
+3 sigma		8.92		577.76		2261.12		4975.46
-2 sigma		1.39		456.99		2012.56		4603.66
+2 sigma		7.41		553.61		2211.42		4901.11
					Mean-bkg	2107.6		4247.1
					$S_{(n-1)}$	49.72		83.68
				Mean-bkg	-3 sigma	1958.43		3996.07
				Mean-bkg	+3 sigma	2256.77		4466.13
				Mean-bkg	-2 sigma	2008.16		4079.75
				Mean-bkg	+2 sigma	2207.04		4414.45
						2192		4146
						2170		4267
						2038		4183
						2067		4412
						2137		4159
						2116		4178
						2064		4278
						2094		4221
						2086		4314
						2123		4305

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
STATIC INSTRUMENT QC

Counting Instrument	Ludlum 2360	Detector	43-37	Cal. Date	4/29/2004
Serial #	193675	Serial #	PR161987	Cal. Due Date OK?	WARNING
Detector Active Area or Area Covered by Smear (cm^2)	582				

	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source Count Time	Control Chart bkg Average α/β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α β cpm	Control Chart source 1 sigma, cpm
Alpha	0.1115	Th-230	3973-02	17,500	4/29/2002	7.70E+04	17,500	100	1	1	4.50	0.53	1946.3	38.22
Beta	0.2563	Tc-99	3975-02	17,700	4/29/2002	2.13E+05	17,700	1000	1	1	822.70	37.06	3713.6	115.87

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail		MDA α (dpm)	MDA β (dpm)	α MDA OK?	β MDA OK?	H.P. Technician	Technician Initials
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta						
6/5/2003	4	842	2,020	4,588	4.0	842.0	2016.0	3746.0	PASS	PASS	PASS	PASS	18.96	93	Yes	Yes		
6/5/2003	4	855	2,004	4,576	4.0	855.0	2000.0	3721.0	PASS	PASS	PASS	PASS	18.96	93	Yes	Yes		
6/6/2003	2	740	2,008	4,581	2.0	740.0	2006.0	3841.0	FAIL	QUESTION	PASS	PASS	14.78	87	Yes	Yes		
6/6/2003	5	768	2,008	4,591	5.0	768.0	2003.0	3823.0	PASS	PASS	PASS	PASS	20.66	88	Yes	Yes		
6/6/2003	4	786	2,020	4,513	4.0	786.0	2016.0	3727.0	PASS	PASS	PASS	PASS	18.96	89	Yes	Yes		
6/9/2003	5	874	2,024	4,629	5.0	874.0	2019.0	3755.0	PASS	PASS	PASS	PASS	20.66	94	Yes	Yes		
6/9/2003	5	759	2,029	4,559	5.0	759.0	2024.0	3800.0	PASS	PASS	PASS	PASS	20.66	88	Yes	Yes		
6/11/2003	5	758	1,876	4,646	5.0	758.0	1871.0	3888.0	PASS	PASS	PASS	PASS	20.66	88	Yes	Yes		
6/11/2003	4	764	2,041	4,533	4.0	764.0	2037.0	3769.0	PASS	PASS	QUESTION	PASS	18.96	88	Yes	Yes		
6/12/2003	5	801	1,878	4,665	5.0	801.0	1873.0	3864.0	PASS	PASS	PASS	PASS	20.66	90	Yes	Yes		
6/12/2003	5	812	1,986	4,697	5.0	812.0	1981.0	3885.0	PASS	PASS	PASS	PASS	20.66	91	Yes	Yes		
6/16/2003	5	787	2,029	4,701	5.0	787.0	2024.0	3914.0	PASS	PASS	PASS	PASS	20.66	90	Yes	Yes		
6/16/2003	4	778	1,923	4,607	4.0	778.0	1919.0	3829.0	PASS	PASS	PASS	PASS	18.96	89	Yes	Yes		
6/19/2003	5	816	1,969	4,584	5.0	816.0	1964.0	3768.0	PASS	PASS	PASS	PASS	20.66	91	Yes	Yes		
6/20/2003	4	848	1,987	4,592	4.0	848.0	1983.0	3744.0	PASS	PASS	PASS	PASS	18.96	93	Yes	Yes		
6/23/2003	5	866	1,950	4,809	5.0	866.0	1945.0	3943.0	PASS	PASS	PASS	PASS	20.66	94	Yes	Yes		
6/24/2003	4	756	1,906	4,428	4.0	756.0	1902.0	3672.0	PASS	PASS	PASS	PASS	18.96	88	Yes	Yes		
6/25/2003	5	854	1,920	4,792	5.0	854.0	1915.0	3938.0	PASS	PASS	PASS	PASS	20.66	93	Yes	Yes		
6/25/2003	4	819	2,027	4,646	4.0	819.0	2023.0	3827.0	PASS	PASS	PASS	PASS	18.96	91	Yes	Yes		

Initial Background and Source Counts for Control Chart

#	Initial bkg counts				Initial source plus bkg counts			
	Alpha	cpm	Beta	cpm	Alpha	cpm	Beta	cpm
1	4	4	827	827	1,872	1872	4,650	4650
2	4	4	888	888	2,021	2021	4,583	4583
3	4	4	774	774	1,936	1936	4,676	4676
4	4	4	840	840	1,964	1964	4,402	4402
5	5	5	833	833	1,947	1947	4,507	4507
6	4	4	854	854	1,951	1951	4,436	4436
7	5	5	759	759	1,966	1966	4,442	4442
8	5	5	806	806	1,927	1927	4,677	4677
9	5	5	827	827	1,879	1879	4,549	4549
10	5	5	817	817	1,923	1923	4,481	4481
Mean		4.50		822.7		1950.8		4536.3
$s_{(n-1)}$		0.53		37.06		38.98		103.82
-3 sigma		2.92		711.51		1833.91		4225.44
+3 sigma		6.08		933.89		2067.69		4847.16
-2 sigma		3.45		748.57		1872.87		4329.06
+2 sigma		5.55		896.83		2028.73		4743.54
					Mean-bkg	1946.3		3713.6
					$s_{(n-1)}$	38.22		115.87
				Mean-bkg	-3 sigma	1828.63		3366.00
				Mean-bkg	+3 sigma	2063.97		4061.20
				Mean-bkg	-2 sigma	1867.85		3481.87
				Mean-bkg	+2 sigma	2024.75		3945.33
						1988		3823
						2017		3675
						1832		3802
						1980		3582
						1942		3874
						1947		3582
						1963		3683
						1822		3869
						1874		3722
						1918		3644

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
STATIC INSTRUMENT QC

Counting Instrument	Ludlum 2360	Detector	43-37	Cal. Date	4/29/2004
Serial #	193675	Serial #	PR161687	Cal. Due Date OK?	WARNING
Detector Active Area or Area Covered by Smear (cm^2)			582		

	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source Count Time	Control Chart bkg Average α β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α β cpm	Control Chart source 1 sigma, cpm
Alpha	0.1115	Th-230	3973-02	17,500	4/29/2002	7.70E+04	17,500	100	1	1	5.30	2.45	2468.5	47.44
Beta	0.2583	Tc-99	3975-02	17,700	4/29/2002	2.13E+05	17,700	1000	1	1	730.70	25.96	3863.1	76.52

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail		MDA α (dpm)	MDA β (dpm)	α MDA OK?	β MDA OK?	H.P. Technician	Technician Initials
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta						
3/30/2004	10	714	2,450	4,475	10.0	714.0	2440.0	3761.0	PASS	PASS	PASS	PASS	27.30	85	Yes	Yes		
3/30/2004	6	755	2,467	4,532	6.0	755.0	2461.0	3777.0	PASS	PASS	PASS	PASS	22.19	88	Yes	Yes		
3/31/2004	8	789	2,237	4,447	8.0	789.0	2229.0	3658.0	PASS	PASS	FAIL	QUESTION	24.90	89	Yes	Yes		
3/31/2004	6				6.0				PASS									

Initial Background and Source Counts for Control Chart

#	Initial bkg counts: Alpha	cpm	Beta	cpm	Initial source plus bkg counts: Alpha	cpm	Beta	cpm
1	7	7	712	712	2,481	2481	4,585	4585
2	4	4	724	724	2,486	2486	4,600	4600
3	2	2	725	725	2,548	2548	4,479	4479
4	3	3	697	697	2,460	2460	4,521	4521
5	5	5	758	758	2,409	2409	4,582	4582
6	7	7	773	773	2,428	2428	4,589	4589
7	3	3	704	704	2,501	2501	4,742	4742
8	7	7	724	724	2,508	2508	4,580	4580
9	10	10	765	765	2,521	2521	4,633	4633
10	5	5	725	725	2,415	2415	4,667	4667
Mean		5.30		730.7		2473.8		4593.6
$S_{(n-1)}$		2.45		25.96		47.20		73.14
-3 sigma		-2.06		652.83		2332.20		4374.37
+3 sigma		12.66		808.57		2615.40		4813.23
-2 sigma		0.40		678.79		2379.40		4447.51
+2 sigma		10.20		782.81		2568.20		4740.09
					Mean-bkg	2468.5		3863.1
					$S_{(n-1)}$	47.44		76.52
				Mean-bkg	-3 sigma	2326.17		3633.53
				Mean-bkg	+3 sigma	2610.83		4092.67
				Mean-bkg	-2 sigma	2373.61		3710.06
				Mean-bkg	+2 sigma	2563.39		4016.14
						2454		3853
						2482		3878
						2547		3754
						2457		3824
						2404		3824
						2421		3826
						2496		4038
						2501		3836
						2511		3868
						2410		3832

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
WASH RACK #3 SOUTH FLOOR - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
582

α eff	β eff
0.1700	0.2500

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts* α	Background Total Counts* β	Sample Total Counts α	Sample Total Counts β	Background (cpm) α	Background (cpm) β	Sample Counts (cpm) α	Sample Counts (cpm) β	Sample (dpm/100 cm^2) α	Sample (dpm/100 cm^2) β	> α flag	> β flag	Tech. Initial
1	WR3-SF-1	6/23/2003	5	866	5	808	0.3	43.3	5.00	808	4.8	526			KP
2	WR3-SF-2	6/23/2003	5	866	3	758	0.3	43.3	3.00	758	2.8	491			KP
3	WR3-SF-3	6/23/2003	5	866	6	561	0.3	43.3	6.00	561	5.8	356			KP
4	WR3-SF-4	6/23/2003	5	866	7	1005	0.3	43.3	7.00	1005	6.8	661			KP
5	WR3-SF-5	6/23/2003	5	866	2	258	0.3	43.3	2.00	258	1.8	148			KP
6	WR3-SF-6	6/23/2003	5	866	2	647	0.3	43.3	2.00	647	1.8	415			KP
7	WR3-SF-7	6/23/2003	5	866	3	665	0.3	43.3	3.00	665	2.8	427			KP
8	WR3-SF-8	6/23/2003	5	866	1	569	0.3	43.3	1.00	569	0.8	361			KP
9	WR3-SF-9	6/23/2003	5	866	6	880	0.3	43.3	6.00	880	5.8	575			KP
10	WR3-SF-10	6/23/2003	5	866	4	940	0.3	43.3	4.00	940	3.8	616			KP
11	WR3-SF-11	6/23/2003	5	866	2	558	0.3	43.3	2.00	558	1.8	354			KP
12	WR3-SF-12	6/23/2003	5	866	3	551	0.3	43.3	3.00	551	2.8	349			KP
13	WR3-SF-13	6/23/2003	5	866	2	434	0.3	43.3	2.00	434	1.8	269			KP
14	WR3-SF-14	6/23/2003	5	866	4	1283	0.3	43.3	4.00	1283	3.8	852			KP
15	WR3-SF-15	6/23/2003	5	866	7	1076	0.3	43.3	7.00	1076	6.8	710			KP
16	WR3-SF-16	6/23/2003	5	866	4	572	0.3	43.3	4.00	572	3.8	363			KP
17	WR3-SF-17	6/23/2003	5	866	4	620	0.3	43.3	4.00	620	3.8	396			KP
18	WR3-SF-18	6/23/2003	5	866	4	576	0.3	43.3	4.00	576	3.8	366			KP
19	WR3-SF-19	6/23/2003	5	866	7	683	0.3	43.3	7.00	683	6.8	440			KP
20	WR3-SF-20	6/23/2003	5	866	4	664	0.3	43.3	4.00	664	3.8	427			KP

CABRERA STATIC COU(.NG WORKSHEET (Rev 5)
WASH RACK #3 CEILING AND UPPER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)
100

α eff	β eff
0.2000	0.2000

Static Count Time (min)
1.0

Daily Background Count Time (min)
20.0

dpm/100 cm^2	
α Flag	β Flag
100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	East Wall	6/26/2003	0	0	0	108	0.0	0.0	0.00	108	0.0	540			KP
2	East Wall	6/26/2003	0	0	1	115	0.0	0.0	1.00	115	5.0	575			KP
3	East Wall	6/26/2003	0	0	2	98	0.0	0.0	2.00	98	10.0	490			KP
4	East Wall	6/26/2003	0	0	0	88	0.0	0.0	0.00	88	0.0	440			KP
5	North Wall	6/26/2003	0	0	1	92	0.0	0.0	1.00	92	5.0	460			KP
6	Ceiling	6/26/2003	0	0	0	96	0.0	0.0	0.00	96	0.0	480			KP
7	Ceiling	6/26/2003	0	0	0	79	0.0	0.0	0.00	79	0.0	395			KP
8	Ceiling	6/26/2003	0	0	2	93	0.0	0.0	2.00	93	10.0	465			KP
9	Ceiling	6/26/2003	0	0	0	87	0.0	0.0	0.00	87	0.0	435			KP
10	South Wall	6/26/2003	0	0	0	95	0.0	0.0	0.00	95	0.0	475			KP
11	North Wall	6/26/2003	0	0	1	101	0.0	0.0	1.00	101	5.0	505			KP
12	Ceiling	6/26/2003	0	0	0	103	0.0	0.0	0.00	103	0.0	515			KP
13	Ceiling	6/26/2003	0	0	2	99	0.0	0.0	2.00	99	10.0	495			KP
14	Ceiling	6/26/2003	0	0	0	86	0.0	0.0	0.00	86	0.0	430			KP
15	Ceiling	6/26/2003	0	0	0	103	0.0	0.0	0.00	103	0.0	515			KP
16	South Wall	6/26/2003	0	0	1	93	0.0	0.0	1.00	93	5.0	465			KP
17	West Wall	6/26/2003	0	0	0	84	0.0	0.0	0.00	84	0.0	420			KP
18	West Wall	6/26/2003	0	0	0	72	0.0	0.0	0.00	72	0.0	360			KP
19	West Wall	6/26/2003	0	0	0	89	0.0	0.0	0.00	89	0.0	445			KP
20	West Wall	6/26/2003	0	0	2	71	0.0	0.0	2.00	71	10.0	355			KP

CABRERA STATIC COUNTING WORKSHEET (Rev 5)
WASH RACK #3 LOWER WALLS - INTEGRATED DIRECT MEASUREMENTS

Detector Active Area (cm^2)	α eff	β eff	Static Count Time (min)	Daily Background Count Time (min)	dpm/100 cm^2 α Flag	dpm/100 cm^2 β Flag
582	0.1700	0.2500	1.0	20.0	100	5000

* Morning Daily Count

seq. #	Sample ID# and Description	Date	Background Total Counts*		Sample Total Counts		Background (cpm)		Sample Counts (cpm)		Sample (dpm/100 cm^2)		> α flag	> β flag	Tech. Initial
			α	β	α	β	α	β	α	β	α	β			
1	North Wall	6/25/2003	5	854	4	757	0.3	42.7	4.00	757	3.8	491			KP
2	North Wall	6/25/2003	5	854	5	781	0.3	42.7	5.00	781	4.8	507			KP
3	North Wall	6/25/2003	5	854	9	988	0.3	42.7	9.00	988	8.8	650			KP
4	North Wall	6/25/2003	5	854	6	794	0.3	42.7	6.00	794	5.8	516			KP
5	East Wall	6/25/2003	5	854	7	516	0.3	42.7	7.00	516	6.8	325			KP
6	East Wall	6/25/2003	5	854	5	558	0.3	42.7	5.00	558	4.8	354			KP
7	East Wall	6/25/2003	5	854	5	539	0.3	42.7	5.00	539	4.8	341			KP
8	East Wall	6/25/2003	5	854	2	617	0.3	42.7	2.00	617	1.8	395			KP
9	East Wall	6/25/2003	5	854	6	1348	0.3	42.7	6.00	1348	5.8	897			KP
10	East Wall	6/25/2003	5	854	2	582	0.3	42.7	2.00	582	1.8	371			KP
11	East Wall	6/25/2003	5	854	5	886	0.3	42.7	5.00	886	4.8	580			KP
12	East Wall	6/25/2003	5	854	5	1212	0.3	42.7	5.00	1212	4.8	804			KP
13	South Wall	6/25/2003	5	854	5	861	0.3	42.7	5.00	861	4.8	562			KP
14	South Wall	6/25/2003	5	854	9	1206	0.3	42.7	9.00	1206	8.8	800			KP
15	South Wall	6/25/2003	5	854	4	1102	0.3	42.7	4.00	1102	3.8	728			KP
16	South Wall	6/25/2003	5	854	5	974	0.3	42.7	5.00	974	4.8	640			KP
17	West Wall	6/25/2003	5	854	7	521	0.3	42.7	7.00	521	6.8	329			KP
18	West Wall	6/25/2003	5	854	5	538	0.3	42.7	5.00	538	4.8	340			KP
19	West Wall	6/25/2003	5	854	3	508	0.3	42.7	3.00	508	2.8	320			KP
20	West Wall	6/25/2003	5	854	3	448	0.3	42.7	3.00	448	2.8	279			KP
21	West Wall	6/25/2003	5	854	6	613	0.3	42.7	6.00	613	5.8	392			KP
22	West Wall	6/25/2003	5	854	5	541	0.3	42.7	5.00	541	4.8	342			KP
23	West Wall	6/25/2003	5	854	4	527	0.3	42.7	4.00	527	3.8	333			KP
24	West Wall	6/25/2003	5	854	4	542	0.3	42.7	4.00	542	3.8	343			KP

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Alpha Standard

S.O.# 3863
P.O.# 02-055

Description of Standard:

Model No. DNS-11 Serial No. 3973-02 Isotope Th-230

Electroplated on polished SS disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi alpha emission rate was measured using an internal gas flow proportional chamber. Absolute counting of alpha particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated alpha source S/N 2393/91 .

Measurement Result:

The observed alpha particles emitted from the surface of the disc per minute (cpm) on the calibration date was:

8,860 ± 265

The total disintegration rate (dpm) assuming 1.5% backscatter of alpha particles from the surface of the disc, was:

17,500 ± 523 (0.00786 μCi)

The uncertainty of the measurement is 3 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] Q.A. Representative: [signature]

Calibration Date: 4-29-2002 Reviewed Date: 4-29-02

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Beta Standard

S.O.# 3863
P.O.# 02-055

Description of Standard:

Model No. DNS-12 Serial No. 3974-02 Isotope Tc-99

Electroplated on polished SS disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source S/N 2148/90.

Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

10,400 ± 414

The total disintegration rate (dpm) assuming 25 % backscatter of beta particles from the surface of the disc, was:

16,600 ± 663 (0.00747 μCi)

The uncertainty of the measurement is 4 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] Q.A. Representative: [signature]

Calibration Date: 4-25-2002 Reviewed Date: 4-29-02

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Beta Standard

S.O.# 3863
P.O.# 02-055

Description of Standard:

Model No. DNS-12 Serial No. 3975-02 Isotope Tc-99

Electroplated on polished SS disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source S/N 2148/90.

Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

11,000 ± 441

The total disintegration rate (dpm) assuming 25 % backscatter of beta particles from the surface of the disc, was:

17,700 ± 706 (0.00796 µCi)

The uncertainty of the measurement is 4 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] Q.A. Representative: [signature]

Calibration Date: 4-25-2002 Reviewed Date: 4-29-02

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

Isotope Products Laboratories
An Eckert & Ziegler Company

24937 Avenue Tibbitts
Valencia, California 91355

Tel 661•309•1010
Fax 661•257•8303

CERTIFICATE OF CALIBRATION
GAMMA STANDARD SOURCE

Radionuclide:	Eu-152	**Customer:**	CABRERA SERVICES, INC.
Half-life:	4933 ± 11 days	**P.O. No.:**	01-414
Catalog No.:	GF-152	**Reference Date:**	15-Oct-01 12:00 PST
Source No.:	812-99-2	**Contained Radioactivity:**	0.9640 **µCi** 35.67 **kBq**

Physical description:

A. Capsule type: D
B. Nature of active deposit: Evaporated metallic salt
C. Active Diameter: 5 mm
D. Backing: Epoxy
E. Cover: Acrylic

Radioimpurities:

Gd-153 = 2.25%; Eu-154 = 1.30% on 15 Oct 01

Method of Calibration:

This source was prepared from a weighed aliquot of solution whose activity in µCi/g was determined using gamma ray spectrometry.

Peak energy used for integration: 344.3 keV
Branching ratio used: 0.266 gammas per decay

Uncertainty of Measurement:

A. Type A (random) uncertainty: ± 0.7 %
B. Type B (systematic) uncertainty: ± 3.0 %
C. Uncertainty in aliquot weighing: ± 0.6 %
D. Total uncertainty at the 99% confidence level: ± 3.1 %

Notes:

- See reverse side for leak test(s) performed on this source.
- IPL participates in a NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Nuclear data was taken from IAEA-TECDOC-619, 1991.
- This source has a working life of 5 years.

Quality Control

26-Sep-01
Date Signed

IPL Ref. No.: 812-99

FINAL Report

Remediation and Final Status Survey
Bomb Throwing Device Site - Structures

Aberdeen Proving Ground, Aberdeen, Maryland

Contract Number

DAAA09-00-G-0002/39

Prepared for:

U.S. Army Field Support Command

AMSIO-ACE-D Bldg. 350, 5th Floor

Rock Island, IL 61299-6000

Prepared by:

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

473 Silver Lane
East Hartford, Connecticut 06118
Cabrera Project No: 01-3030.39
December 2004

EXECUTIVE SUMMARY

Cabrera Services, Inc. (CABRERA), under contract to the U.S. Army Field Support Command (FSC), performed remedial activities, remedial support surveys, and Final Status Surveys (FSS) for the Bomb Throwing Device (BTD) site at the Aberdeen Proving Ground (APG), Maryland. This document provides the results of post-remediation final status surveys for the structures associated with the BTD site. These surveys were designed so that the results of the individual integrated static measurements could be compared to the release criteria (DCGLw) by survey unit. If all of the survey units associated with a structure meet the criteria for unrestricted release, then the structure as a whole is considered a viable candidate for unrestricted release.

CABRERA conducted survey activities in accordance with the U.S. Nuclear Regulatory Commission (NRC) approved FSS work plan, prepared by CABRERA. This FSS Report addresses final status surveys performed on five BTD structures. The five structures are: the BTD Armor Reclamation Facility, Wash Rack #2, Wash Rack #3, Concrete Pad #2 located behind Building 701, and Concrete Pad #1 located behind the DU Test Enclosure Building.

FSS activities were designed in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (NRC, 2000).

The project had several major activities associated with the remediation and FSS including:

- Remediation of soils, debris, and structures within the confines of the BTD site,
- Deconstruction of structures on the BTD site,
- Removal of plate steel for on-site recycling,
- Removal and shipment of remediated soils and debris to Envirocare of Utah (the disposal site),
- Designation of the BTD land areas into 25 MARSSIM Class 1 Survey Units,
- FSS of the BTD site soils and structures, and
- Determination that the dose from residual contamination at the site is not greater than the release criterion for each Survey Unit.

The radiological contaminant of concern was depleted uranium (DU). The derived concentration guideline (DCGLw) for fixed (or total) DU activity was determined to be 100 disintegrations per minute alpha per 100 square centimeters (dpm/100cm^2). The maximum measurements from all of the survey units associated with the five structures were well below the DCGLw value.

Smear samples for gross transferable alpha contamination were collected and analyzed to determine if transferable activity is less than 10% of total activity, to confirm assumptions in the release criterion. The maximum smear measurements from all of the survey units associated with the five structures were below 10% (i.e., 10 dpm/100cm^2) of total activity.

The FSS data indicates that the five structures are suitable for release for unrestricted use, without regard for former operations with licensed radioactive material.

FSSs were also performed over a land area of approximately 46,000 square meters and on access roads and several support buildings situated on the BTD site. Discussions of the surveys over land areas are addressed in a separate FSS document.

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Appendix I: Survey Instrument Quality Control and Calibration Certificates

ACRONYMS AND ABBREVIATIONS

AFSC	U.S. Army Field Support Command
ALARA	As Low As Reasonably Achievable
APG	Aberdeen Proving Ground
ARL	Army Research Laboratory
ATC	Aberdeen Test Center
BARF	BTD Armor Reclamation Facility
BTD	Bomb Throwing Device
CABRERA	Cabrera Services, Inc.
CFR	Code of Federal Regulations
cm	Centimeters
DCGL or DCGLw	Derived Concentration Guideline Level
dpm alpha/100cm^2	Disintegrations per minute alpha per 100 square centimeters
DU	Depleted Uranium
FSC	U.S. Army Field Support Command
FSS	Final Status Survey
HEPA	High Efficiency Particulate Air filter
LAB	Liquid Abrasive Blaster
LBGR	Lower Bound of the Grey Region
m	Meters
m^2	Square Meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrem/yr	Millirem per year
NAD	Normalized Absolute Difference
NIST	National Institute of Standards and Technology
NRC	U. S. Nuclear Regulatory Commission
PSA	Plate Storage Area
QA	Quality Assurance
QC	Quality Control

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 291453/269534

Mfg. Ludlum Measurements, Inc. Model 2929 Serial No. 163827

Mfg. Ludlum Measurements, Inc. Model 43-10-1 Serial No. PR171322

Cal. Date 21-Jan-03 Cal Due Date 21-Jan-04 Cal. Interval 1 Year Meterface 202-014

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 76 °F RH 20 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Window Operation

☑ Audio ck.

☑ Meter Zeroed Alpha Sensitivity 175 mV Beta Sensitivity 4 mV Beta Window 50 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 825 V = 3.28 on High Voltage dial. High Voltage set with detector connected.

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2010 / 2000 V

COMMENTS:
Th230 #2748
Current Activity: 6130dpm
Source count minus background: 2772cpm
Eff: 45 %(4pi)

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

Alpha Channel Digital Readout

REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400K cpm	39994 (0)	39994 (0)
40K cpm	4002	4002
4K cpm	400	400
400 cpm	40	40
40 cpm	4	4

Beta/Gamma Channel Digital Readout

REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400K cpm	40012 (0)	40012 (0)
40K cpm	4001	4001
4K cpm	400	400
400 cpm	40	40
40 cpm	4	4

*Uncertainty within ± 10% C.F. within ± 20%

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N Th230 #2748 ☑ Beta S/N Tc99 NI-EV, C14 GV471 ☐ Other

☑ m 500 S/N 57885 ☐ Oscilloscope S/N ☑ Multimeter S/N 71300353

Calibrated By: [signature] Date 21-Jan-03

Reviewed By: Rhonda Harris Date 22 Jan 03

FORM C25 10/31/2001

AC Inst. Only ☑ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Designer and Manufacturer of Scientific and Industrial Instruments

Bench Test Data For Detector

Detector 43-10-1 Serial No. PR171322 Order #. 291453/269534

Customer CABRERA SERVICES Alpha Input Sensitivity 175 mV

Counter 2929 Serial No. 163827 Beta Input Sensitivity 4 mV

Count Time 1 Minute Beta Window 50 mV

Other Distance Source to Detector Tray

High Voltage	Background Alpha	Background Beta	Isotope Th 230, Size 6130 dpm Alpha	Isotope Th 230, Size 6130 dpm Beta	Isotope C 14, Size 240 kdpm Alpha	Isotope C 14, Size 240 kdpm Beta	Isotope Tc 99, Size 22.6 dpm Alpha	Isotope Tc 99, Size 22.6 dpm Beta
775	0	37	2214	196	0	9278	0	5098
800	1	49	2588	187	1	13647	0	6268
→ 825	0	58	2772	232	1	19991	2	7028
850	0	69	2738	281	4	24368	2	7567

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Jeremy Irgun Date 21-Jan-03

FORM C4B 12/09/97

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 206689 / 277045

Mfg. Ludlum Measurements, Inc. Model 2929 Serial No. 171590

Mfg. Ludlum Measurements, Inc. Model 43-10-1 Serial No. PR 174813

Cal. Date 19-Nov-03 Cal Due Date 19-Nov-04 Cal. Interval 1 Year Meterface 202-014

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 33 % Alt 708.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☐ Window Operation

☑ Audio ck.

☑ Meter Zeroed Alpha Sensitivity 175 mV Beta Sensitivity 4 mV Beta Window 50 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 875 V = 359 on High Voltage dial. High Voltage set with detector connected.

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 2025 V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

Alpha Channel Digital Readout	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400K cpm	399989	399989
	40K cpm	40009	40009
	4K cpm	4008	4008
	400 cpm	400	400
	40 cpm	40	40

Beta/Gamma Channel Digital Readout	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400K cpm	399987	399987
	40K cpm	40009	40009
	4K cpm	4007	4007
	400 cpm	400	400
	40 cpm	40	40

*Uncertainty within ± 10% C.F. within ± 20%

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N Pu 239 12.6Kcpm ☑ Beta S/N Tc99 161.3Kcpm C14 91.8Kcpm ☐ Other

☑ m 500 S/N 102799 ☐ Oscilloscope S/N ☑ Multimeter S/N 68260348

Calibrated By: V. Lee Alvarado Date 19Nov03

Reviewed By: [signature] Date 19NOV03

FORM C25 04/09/2003

AC Inst. Only ☑ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-10-1 Serial No. PR 174813 Order #. 206689 / 277045

Customer CABRERA SERVICES Alpha Input Sensitivity 175 mV

Counter 2929 Serial No. 171590 Beta Input Sensitivity 4 mV

Count Time 1Minute Beta Window 50 mV

Other H.V. set with detector connected Distance Source to Detector Tray

High Voltage	Background Alpha	Background Beta	Isotope Pu239 Size 12.6Kcpm Alpha	Isotope Pu239 Size 12.6Kcpm Beta	Isotope Tc99 Size 14.3Kcpm Alpha	Isotope Tc99 Size 14.3Kcpm Beta	Isotope C14 Size 91.8Kcpm Alpha	Isotope C14 Size 91.8Kcpm Beta
825	0	44	9654	414	12	6427	1	13281
850	0	43	9890	391	14	6964	1	17268
875	0	51	9692	325	12	7633	3	22561
900	0	69	9860	280	24	7994	0	26432
925	0	61	9859	343	11	8724	1	32163

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature V. Lee Alvarez Date 19Nov03

FORM C4B 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 208017

Mfg. Ludlum Measurements, Inc. Model 2929 Serial No. 180830

Mfg. Ludlum Measurements, Inc. Model 43-10-1 Serial No. PR 207849

Cal. Date 15-Dec-03 Cal Due Date 15-Dec-04 Cal. Interval 1 Year Meterface 202-014

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 25 % Alt 694.8 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Window Operation

☑ Audio ck.

☑ Meter Zeroed Alpha Sensitivity 175 mV Beta Sensitivity 4 mV Beta Window 50 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 675 V = 2.81 on High Voltage dial. High Voltage set with detector connected.

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 1996 V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Alpha Channel Digital Readout	400K cpm		400340
	40K cpm		39992
	4K cpm		3999
	400 cpm		400
	40 cpm		40

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Beta/Gamma Channel Digital Readout	400K cpm		400063
	40K cpm		40021
	4K cpm		4004
	400 cpm		400
	40 cpm		40

*Uncertainty within ± 10% C.F. within ± 20%

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N 4337 Pu239 15.7kcpm ☑ Beta S/N 1659 C14 635/83 Tc99 ☐ Other

☑ m 500 S/N 141244 ☐ Oscilloscope S/N ☑ Multimeter S/N 68160950

Calibrated By: [signature] Date 15-Dec-03

Reviewed By: [signature] Date 16 Dec 03

FORM C25 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-10-1 Serial No. PR 207849 Order #. 208017

Customer CABRERA SERVICES Alpha Input Sensitivity 175 mV

Counter 2929 Serial No. 180830 Beta Input Sensitivity 4 mV

Count Time 1 Minute Beta Window 50 mV

Other Distance Source to Detector Tray

High Voltage	Background		Isotope C14, Size 155,824 cpm		Isotope Pu239, Size 15,700 cpm		Isotope Tc99, Size 14,300 cpm	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
625	0	54	0	20785	12380	357	7	8080
650	0	56	0	26072	12305	430	11	8841
→ 675	0	57	0	29842	12405	607	14	9261
700	0	49	0	33312	12534	1015	12	9034
725	0	66	0	36430	12377	1960	15	8389
750	0	81	0	40094	12441	8888	9	7890

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature [signature] Date 15-Dec-03

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER CABRERA SERVICES ORDER NO. 297060/272290

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 79498

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR073106

Cal. Date 9-May-03 Cal Due Date 9-May-04 Cal. Interval 1 Year Meterface 202-002

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 28 % Alt 697.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☑ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 28 mV Det. Oper. 900 V at 28 mV Threshold Dial Ratio = mV

☐ HV Readout (2 points) Ref./Inst. ______ / ______ V Ref./Inst. ______ / ______ V

COMMENTS:
Efficiency for Tc-99: Background count = 50cpm, Source count = 4800 cpm, dpm value of source = 22600 dpm, 4π efficiency = 21.02%, SN of Tc-99 source = NI-EV.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	400kcpm	4 K	4K
X 100	100kcpm	1 K	1K
X 10	40kcpm	4 K	4K
X 10	10kcpm	1 K	1K
X 1	4kcpm	4 K	4K
X 1	1kcpm	1 K	1K
X 0.1	400cpm	4 K	4K
X 0.1	100cpm	1 K	1K

*Uncertainty within ± 10% C.F. within ± 20% All Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:
Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______

☑ m 500 S/N 57881 ☐ Oscilloscope S/N ______ ☑ Multimeter S/N 82080087

Calibrated By: Josh Boston Date 9 May 03

Reviewed By: Rhonda Harris Date 14 May 03

FORM C22A 04/09/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CONVERSION CHART

Customer CABRERA SERVICES Date 9-May-03 Order #. 297060/272290

Model 3 Serial No. 79498 Detector Model 44-9 Serial No. PR073106

Source Cs-137 194.6 mCi Cs-137 20 mCi High Voltage 900 V

Input Sensitivity 28 mV

Reference Point	"As Found" Readings (CPM): Meter Reading	Range/Scale	After Adjustment Readings (CPM): Meter Reading	Range/Scale
150 mR/hr	NA	NA	2.2K	X100
50 mR/hr	↓	↓	1.15K	X100
15 mR/hr	↓	↓	4.0K	X10
5 mR/hr	↓	↓	1.45K	X10
1.5 mR/hr	↓	↓	4.5K	X1
1.0 mR/hr	↓	↓	3.1K	X1

Signature: Josh Boston Date 9 May 03

FORM C17-1A 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

USTOMER CABRERA SERVICES ORDER NO. 216307/281793

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 79498

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR073106

Cal. Date 19-May-04 Cal Due Date 19-May-05 Cal. Interval 1 Year Meterface 202-002

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 75 °F RH 45 % Alt 698.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 29 mV Det. Oper. 900 V at 29 mV Threshold Dial Ratio ____ = ____ mV

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS:
4 pi efficiency for Tc-99 as follows: source count = 5000cpm, background count = 39cpm, dpm value of source = 22600dpm, SN of source = NI-EV, 4 pi efficiency = 21.95%.

Cal'd with 6' cable.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	400kcpm	4K	4K
X 100	100kcpm	1K	1K
X 10	40kcpm	4K	4K
X 10	10kcpm	1K	1K
X 1	4kcpm	4K	4K
X 1	1kcpm	1K	1K
X 0.1	400cpm	4K	4K
X 0.1	100cpm	1K	1K

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:
Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☐ Other ____

☑ m 500 S/N 132899 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 82080087

Calibrated By: Josh Boston Date 19 May 04

Reviewed By: [signature] Date 20 may 04

FORM C22A 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ____

Designer and Manufacturer
of
Scientific and Industrial
Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CONVERSION CHART

Customer CABRERA SERVICES Date 19-May-04 Order #. 216307/281793

Model 3 Serial No. 79498 Detector Model 44-9 Serial No. PR073106

Source Cs-137 194.6 mCi Cs-137 20 mCi High Voltage 900 V

Input Sensitivity 29 mV

Reference Point	"As Found" Readings (CPM): Meter Reading	Range/Scale	After Adjustment Readings (CPM): Meter Reading	Range/Scale
150 mR/hr	2.05K	X100	2.05K	X100
50 mR/hr	1.1K	X100	1.1K	X100
15 mR/hr	4.1K	X10	4.1K	X10
5 mR/hr	1.5K	X10	1.5K	X10
1.5 mR/hr	4.6K	X1	4.6K	X1
1.0 mR/hr	3.2K	X1	3.2K	X1

Signature: Josh Boston Date 19 May 04

FORM C17-1A 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER CABRERA SERVICES ORDER NO. 289386/268534

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 79511

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. Pr 137499

Cal. Date 3-Dec-02 Cal Due Date 3-Dec-03 Cal. Interval 1 Year Meterface 202-002

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 28 % Alt 701.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 28 mV Det. Oper. 900 V at 28 mV Threshold Dial Ratio ____ = ____ mV

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS: efficiency for Tc 99 22.9 Kdpm Value is 26 % 4π.
(6000 cpm - 50 cpm BG: 5950 cpm)

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	400 Kcpm	4K	4K
X 100	100 Kcpm	1K	1K
X 10	40 Kcpm	4K	4K
X 10	10 Kcpm	1K	1K
X 1	4 Kcpm	4K	4K
X 1	1 Kcpm	1K	1K
X 0.1	400 cpm	4K	4K
X 0.1	100 cpm	1K	1K

*Uncertainty within ± 10% C.F. within ± 20% ____ **Range(s) Calibrated Electronically**

Digital Readout: REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale: REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☐ Other ____

☑ m 500 S/N 54680 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 69101832

Calibrated By: [signature] Date 3-Dec-02

Reviewed By: Rhonda Harris Date 5 Dec 02

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ____

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CONVERSION CHART

Customer CABRERA SERVICES Date 3-Dec-02 Order #. 289386/268534

Model 3 Serial No. 79511 Detector Model 44-9 Serial No. PR 137499

Source Cs-137 194.6 mCi Cs-137 20 mCi High Voltage 900 V

Input Sensitivity 28 mV

Reference Point	"As Found" Readings (CPM): Meter Reading	Range/Scale	After Adjustment Readings (CPM): Meter Reading	Range/Scale
150 mR/hr	N/A		1.7 K	X100
50 mR/hr			1.1 K	"
15 mR/hr			4.2 K	X10
5 mR/hr			1.6 K	"
1.5 mR/hr			4.5 K	X1
1.0 mR/hr			3.3 K	"

Signature: [signature] Date 3-Dec-02

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

TOMER CABRERA SERVICES ORDER NO. 294734/271134

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 89973

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR084781

Cal. Date 27-Mar-03 Cal Due Date 27-Mar-04 Cal. Interval 1 Year Meterface 202-560

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 78 °F RH 20 % Alt 690.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 27 mV Det. Oper. 900 V at 27 mV Threshold Dial Ratio ___ = ___ mV

☐ HV Readout (2 points) Ref./Inst. ___ / ___ V Ref./Inst. ___ / ___ V

COMMENTS: eff for Tc-99: 20.6% (4π) source size: 22,600 dpm source count: 4,700 cpm background: 50 cpm S/n: NI-EV

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	150 mR/hr	1.5	1.5
X 100	50 mR/hr	0.5	0.5
X 10	15 mR/hr	1.48	1.48
X 10	5 mR/hr	0.53	0.53
X 1	1.5 mR/hr = 5160 cpm	1.6	1.5
X 1	1.0 mR/hr	1.1	1.0
X 0.1	516 cpm	1.6	1.5
X 0.1	172 cpm	0.55	0.5

*Uncertainty within ± 10% C.F. within ± 20% X 0.1 Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ___ ☐ Beta S/N ___ ☐ Other ___

☑ m 500 S/N 81084 ☐ Oscilloscope S/N ___ ☑ Multimeter S/N 80040300

Calibrated By: Michael J Thomas Date 27-Mar-03

Reviewed By: Rhonda Harris Date 30 Mar 03

FORM C22A 03/07/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ___

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 298393/272921

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 135696

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR145224

Cal. Date 6-Jun-03 Cal Due Date 6-Jun-04 Cal. Interval 1 Year Meterface 202-002

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 59 % Alt 701.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 38 mV Det. Oper. 900 V at 38 mV Threshold Dial Ratio ____ = ____ mV

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS:
EFF: for TC-99#NI-EV act.22,600dpm 5000cpm - Bg 50 4950cpm 22% 4pi
Cal. with a 6 Ft. cable

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	400 K cpm	4K	4K
X 100	100 K cpm	1K	1K
X 10	40 K cpm	4K	4K
X 10	10 K cpm	1K	1K
X 1	4 K cpm	4K	4K
X 1	1 K cpm	1K	1K
X 0.1	400 cpm	4K	4K
X 0.1	100 cpm	1K	1K

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☐ Other ____

☑ m 500 S/N 54683 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 70602489

Calibrated By: Duane Jackson Date 6-Jun-03

Reviewed By: [signature] Date 6 Jun 03

FORM C22A 04/09/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ____

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CONVERSION CHART

Customer CABRERA SERVICES Date 6-Jun-03 Order #. 298393/272921

Model 3 Serial No. 135696 Detector Model 44-9 Serial No. PR145224

Source Cs-137 194.6 mCi Cs-137 20 mCi High Voltage 900 V

Input Sensitivity 38 mV

Reference Point	"As Found" Readings (CPM): Meter Reading	Range/Scale	After Adjustment Readings (CPM): Meter Reading	Range/Scale
150 mR/hr	3.5K	x100	3.5K	x100
50 mR/hr	1.65K	x100	1.65K	x 100
15 mR/hr	0.55K	x100	0.55K	x 100
5 mR/hr	1.85K	x10	1.85K	x 10
1.5 mR/hr	0.55K	x 10	0.55K	x 10
1.0 mR/hr	3.2K	x1	3.2K	x 1

Signature: Duane Jackson Date 6-Jun-03

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

USTOMER CABRERA SERVICES ORDER NO. 207741/277558

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 166511

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR073107

Cal. Date 16-Dec-03 Cal Due Date 16-Dec-04 Cal. Interval 1 Year Meterface 202-002

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 20 % Alt 710.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity

☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism

☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 35 mV Det. Oper. 900 V at 35 mV Threshold Dial Ratio = mV

☐ HV Readout (2 points) Ref./Inst. ______ / ______ V Ref./Inst. ______ / ______ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	400kcpm	4K	4K
X 100	100kcpm	1K	1K
X 10	40kcpm	4K	4K
X 10	10kcpm	1K	1K
X 1	4kcpm	4K	4K
X 1	1kcpm	1K	1K
X 0.1	400cpm	4K	4K
X 0.1	100cpm	1K	1K

*Uncertainty within ± 10% C.F. within ± 20% ALL **Range(s) Calibrated Electronically**

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______

☑ m 500 S/N 132899 ☐ Oscilloscope S/N ______ ☑ Multimeter S/N 82080087

rated By: Josh Boston Date 16 Dec 03

Reviewed By: [signature] Date 17 Dec 03

FORM C22A 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CONVERSION CHART

Customer CABRERA SERVICES Date 16-Dec-03 Order #. 207741/277558

Model 3 Serial No. 166511 Detector Model 44-9 Serial No. PR073107

Source Cs-137 194.6 mCi Cs-137 20 mCi High Voltage 900 V

Input Sensitivity 35 mV

Reference Point	"As Found" Readings (CPM): Meter Reading	Range/Scale	After Adjustment Readings (CPM): Meter Reading	Range/Scale
150 mR/hr	3.8K	X100	3.8K	X100
50 mR/hr	1.8K	X100	1.8K	X100
15 mR/hr	0.5K	X100	0.5K	X100
5 mR/hr	1.9K	X10	1.9K	X10
1.5 mR/hr	4.8K	X1	4.8K	X1
1.0 mR/hr	3.3K	X1	3.3K	X1

Signature: Josh Boston Date 16 Dec 03

FORM C17-1A 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 291453/269534

Mfg. Bicron Model MICRO REM Serial No. C853F

Mfg. ______ Model ______ Serial No. ______

Cal. Date 20-Jan-03 Cal Due Date 20-Jan-04 Cal. Interval 1 Year Meterface 0-200µrem

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 76 °F RH 20 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☐ Reset ck. ☐ Window Operation ☐ Geotropism
☐ Audio ck. ☐ Alarm Setting ck. ☐ Batt. ck. (Min. Volt) ______ VDC

☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set ______ V Input Sens. ______ mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio ______ = ______ mV

☐ HV Readout (2 points) Ref./Inst. ______ / ______ V Ref./Inst. ______ / ______ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1000	150mR/hr	155	150
X1000	50mR/hr	50	50
X100	15mR/hr	155	150
X100	5mR/hr	50	50
X10	1.5mR/hr	145	150
X10	500µR/hr	50	50
X1	150µR/hr	145	~~5H 150~~ 150
X1	100µR/hr	95	100
X0.1	15µR/hr	140	150
X0.1			

*Uncertainty within ± 10% C.F. within ± 20% ______ **Range(s) Calibrated Electronically**

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ______ ☐ Beta S/N ______ ☑ Other Cs 137 201µCi

☐ m 500 S/N ______ ☐ Oscilloscope S/N ______ ☐ Multimeter S/N ______

[Cali]brated By: [signature] Date 20-Jan-03

[Re]viewed By: [signature] Date 22 Jan 03

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER CABRERA SERVICES ORDER NO. 298393/272921

Mfg. Bicron Model MICRO REM Serial No. B837Y

Mfg. ______ Model ______ Serial No. ______

Cal. Date 6-Jun-03 Cal Due Date 6-Jun-04 Cal. Interval 1 Year Meterface 0-200µrem/

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 59 % Alt 701.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☐ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) ______VDC

☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set ______ V Input Sens. ______ mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio ______ = ______ mV

☐ HV Readout (2 points) Ref./Inst. ______ / ______ V Ref./Inst. ______ / ______ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x 1000	150 mR/hr	155	150
x 1000	50 mR/hr	55	50
x 100	15 mR/hr	150	150
x 100	5 mR/hr	51	51
x 10	1500 µR/hr	140	150
x 10	500 µR/hr	48	50
x 1	150 µR/hr	135	150
x 1	100 µR/hr	90	100
x0.1	15 µR/hr	150	150
x0.1			

*Uncertainty within ± 10% C.F. within ± 20%

Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

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Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other CS-137 20µci

☐ m 500 S/N ______ ☐ Oscilloscope S/N ______ ☐ Multimeter S/N ______

Calibrated By: Duane Jackson Date 6-Jun-03

Reviewed By: [signature] Date 6 June 03

FORM C22A 04/09/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER CABRERA SERVICES ORDER NO. 208949 / 278168

Mfg. Bicron Model MICRO REM Serial No. B9854

Mfg. ______ Model ______ Serial No. ______

Cal. Date 13-Jan-04 Cal Due Date 13-Jan-05 Cal. Interval 1 Year Meterface 0-200µrem/

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 76 °F RH 20 % Alt 711.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☐ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) ______ VDC
☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set ______ V Input Sens. ______ mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio ______ = ______ mV

☐ HV Readout (2 points) Ref./Inst. ______ / ______ V Ref./Inst. ______ / ______ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x 1000	150 mR/hr	140	150
x 1000	50 mR/hr	50	50
x 100	15 mR/hr	145	150
x 100	5 mR/hr	50	50
x 10	1500 µR/hr	150	150
x 10	500 µR/hr	50	50
x 1	150 µR/hr	150	150
x 1	100 µR/hr	100	100
x0.1	15 µR/hr	150	150
x0.1			

*Uncertainty within ± 10% C.F. within ± 20% Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☑ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______

☐ m 500 S/N ______ ☐ Oscilloscope S/N ______ ☐ Multimeter S/N ______

Calibrated By: [signature] Date 13 · JAN · 04

Reviewed By: [signature] Date 13 Jan 04

FORM C22A 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Alpha Standard

S.O.# 3740
P.O.# 01-267

Description of Standard:

Model No. DNS-11 Serial No. 2888-01 Isotope Th-230

Electroplated on polished Ni disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi alpha emission rate was measured using an internal gas flow proportional chamber. Absolute counting of alpha particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated alpha source S/N 2393/91.

Measurement Result:

The observed alpha particles emitted from the surface of the disc per minute (cpm) on the calibration date was:

10,100 ± 403

The total disintegration rate (dpm) assuming no backscatter of alpha particles from the surface of the disc, was:

20,200 ± 807 (0.00909 µCi)

The uncertainty of the measurement is 4 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] Q.A. Representative: [signature]

Calibration Date: 5-01-2001 Reviewed Date: 05/02/01

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Beta Standard

S.O.# 3740
P.O.# 01-267

Description of Standard:

Model No. DNS-12 Serial No. 2889-01 Isotope Tc-99

Electroplated on polished SS disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source S/N 2148/90.

Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

13,400 ± 402

The total disintegration rate (dpm) assuming 25 % backscatter of beta particles from the surface of the disc, was:

21,400 ± 643 (0.00966 µCi)

The uncertainty of the measurement is 3 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] Q.A. Representative: [signature]

Calibration Date: 5-01-2001 Reviewed Date: 05/02/01

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Alpha Standard

S.O.# 3759
P.O.# 01-325

Description of Standard:

Model No. DNS-11 Serial No. 2897-01 Isotope Th-230

Electroplated on polished SS disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi alpha emission rate was measured using an internal gas flow proportional chamber. Absolute counting of alpha particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated alpha source S/N 2393/91.

Measurement Result:

The observed alpha particles emitted from the surface of the disc per minute (cpm) on the calibration date was:

11,400 ± 343

The total disintegration rate (dpm) assuming no backscatter of alpha particles from the surface of the disc, was:

22,800 ± 685 (0.0103 µCi)

The uncertainty of the measurement is 3 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: Barbara M. F[illegible]

Calibration Technician: Art Reust Q.A. Representative: [illegible]

Calibration Date: 6-11-2001 Reviewed Date: 6/11/01

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Alpha Standard

S.O.# 3863
P.O.# 02-055

Description of Standard:

Model No. DNS-11 Serial No. 3972-02 Isotope Th-230

Electroplated on polished SS disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi alpha emission rate was measured using an internal gas flow proportional chamber. Absolute counting of alpha particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated alpha source S/N 2393/91.

Measurement Result:

The observed alpha particles emitted from the surface of the disc per minute (cpm) on the calibration date was:

7,970 ± 398

The total disintegration rate (dpm) assuming 1.5% backscatter of alpha particles from the surface of the disc, was:

15,700 ± 785 (0.00708 μCi)

The uncertainty of the measurement is 5 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] Q.A. Representative: [signature]

Calibration Date: 4-29-2002 Reviewed Date: 4-29-02

Analytical Services
7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 345-3461 Fax (505) 761-5416
Toll Free (866) RAD-LABS (723-5227)
www.eberlineservices.com

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
SMEAR INSTRUMENT QC

Counting Instrument:	Ludlum 2929	Detector:	43-10-1	Calibration Date:	1/21/2004
Serial #:	163827	Serial #:	PR171322	12 month calibration:	OK
Detector Active Area or Area Covered by Smear (cm^2):			100	NRC 6 Mo Cal. Due Date?	OK

	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM/100cm²)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source-Sample Count Time	Control Chart bkg Average α β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α β cpm	Control Chart source 1 sigma, cpm
Alpha	0.4060	Th-230	3972-02	15,700	4/29/2002	2.13E+05	15,700	10	20	2	0.12	0.08	5576.2	56.96
Beta	0.2400	Tc-99	3974-02	16,600	4/29/2002	7.70E+04	16,600	500	20	2	36.66	1.22	3294.2	51.92

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail				α MDA OK?	β MDA OK?	H.P. Technician	Technician Initials
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	MDA α (dpm)	MDA β (dpm)				
5/3/2003	3	732	11,184	6,477	0.2	36.6	5591.9	3201.9	PASS	PASS	PASS	PASS	6.02	68	Yes	Yes		
5/5/2003	2	738	11,280	6,709	0.1	36.9	5639.9	3317.6	PASS	PASS	PASS	PASS	5.60	68	Yes	Yes		

Initial Background and Source Counts for Control Chart

#	Initial bkg counts				Initial source plus bkg counts			
	Alpha	cpm	Beta	cpm	Alpha	cpm	Beta	cpm
1	2	0.1	714	35.7	11,083	5541.5	6,622	3311
2	2	0.1	709	35.45	11,120	5560	6,644	3322
3	3	0.15	737	36.85	10,886	5443	6,809	3404.5
4	4	0.2	713	35.65	11,179	5589.5	6,796	3398
5	1	0.05	727	36.35	11,276	5638	6,737	3368.5
6	6	0.3	727	36.35	11,175	5587.5	6,621	3310.5
7	2	0.1	714	35.7	11,135	5567.5	6,663	3331.5
8	2	0.1	740	37	11,159	5579.5	6,696	3348
9	0	0	777	38.85	11,281	5640.5	6,494	3247
10	2	0.1	773	38.65	11,233	5616.5	6,535	3267.5
Mean		0.12		36.7		5576.4		3330.9
$S_{(n-1)}$		0.08		1.22		56.94		51.18
-3 sigma		-0.13		32.99		5405.54		3177.31
+3 sigma		0.37		40.32		5747.16		3484.39
-2 sigma		-0.04		34.21		5462.47		3228.49
+2 sigma		0.28		39.10		5690.23		3433.21
					Mean-bkg	5576.2		3294.2
					$S_{(n-1)}$	56.96		51.92
				Mean-bkg	-3 sigma	5405.34		3138.45
				Mean-bkg	+3 sigma	5747.12		3449.94
				Mean-bkg	-2 sigma	5462.30		3190.36
				Mean-bkg	+2 sigma	5690.16		3398.03
						5541.4		3275.3
						5559.9		3286.55
						5442.85		3367.65
						5589.3		3362.35
						5637.95		3332.15
						5587.2		3274.15
						5567.4		3295.8
						5579.4		3311
						5640.5		3208.15
						5616.4		3226.85

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
SMEAR INSTRUMENT QC

Counting Instrument:			Ludlum 2929		Detector:	43-10-1		Calibration Date:		1/21/2004				
Serial #:			163827		Serial #:	PR171322		12 month calibration:		OK				
Detector Active Area or Area Covered by Smear (cm^2):						100		NRC 6 Mo Cal. Due Date?		OK				
	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM/100cm²)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source-Sample Count Time	Control Chart bkg Average α.β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α/β cpm	Control Chart source 1 sigma, cpm
Alpha	0.4060	Th-230	3972-02	15,700	4/29/2002	7.70E+04	15,700	10	20	2	0.38	0.14	5576.0	56.97
Beta	0.2400	Tc-99	3974-02	16,600	4/29/2002	2.13E+05	16,600	500	20	2	39.96	1.30	3290.9	51.05

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail				α MDA	β MDA	H.P.	Technician
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	MDA α (dpm)	MDA β (dpm)	OK?	OK?	Technician	Initials
5/8/2003	3	850	11,147	6,590	0.2	42.5	5573.4	3252.5	PASS	PASS	PASS	PASS	6.02	73	Yes	Yes		
5/9/2003	8	812	11,153	6,682	0.4	40.6	5576.1	3300.4	PASS	PASS	PASS	PASS	7.50	71	Yes	Yes		
5/12/2003	7	828	11,336	6,724	0.4	41.4	5667.7	3320.8	PASS	PASS	PASS	PASS	7.25	72	Yes	Yes		
5/12/2003	7	828	11,108	6,730	0.4	41.4	5552.7	3323.6	PASS	PASS	PASS	PASS	7.25	72	Yes	Yes		
5/13/2003	6	844	11,184	6,694	0.3	42.2	5591.7	3304.8	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
5/13/2003	6	844	11,294	6,485	0.3	42.2	5646.7	3200.3	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
5/14/2003	8	819	11,118	6,584	0.4	41.0	5558.6	3251.1	PASS	PASS	PASS	PASS	7.50	71	Yes	Yes		
5/14/2003	8	819	11,015	6,604	0.4	41.0	5507.1	3261.1	PASS	PASS	PASS	PASS	7.50	71	Yes	Yes		
5/15/2003	6	796	11,094	6,632	0.3	39.8	5546.7	3276.2	PASS	PASS	PASS	PASS	6.99	70	Yes	Yes		
5/19/2003	7	845	11,162	6,635	0.4	42.3	5580.7	3275.3	PASS	PASS	PASS	PASS	7.25	72	Yes	Yes		
5/21/2003	6	892	11,050	6,690	0.3	44.6	5524.7	3300.4	PASS	FAIL	PASS	PASS	6.99	74	Yes	Yes		
5/21/2003	6	847	11,050	6,690	0.3	42.4	5524.7	3302.7	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
5/22/2003	10	850	11,080	6,547	0.5	42.5	5539.5	3231.0	PASS	PASS	PASS	PASS	7.94	73	Yes	Yes		
5/29/2003	6	818	11,097	6,717	0.3	40.9	5548.2	3317.6	PASS	PASS	PASS	PASS	6.99	71	Yes	Yes		
5/29/2003	5	875	11,167	6,739	0.3	43.8	5583.3	3325.8	PASS	QUESTION	PASS	PASS	6.70	73	Yes	Yes		
5/29/2003	3	918	11,167	6,739	0.2	45.9	5583.4	3323.6	PASS	FAIL	PASS	PASS	6.02	75	Yes	Yes		
5/30/2003	7	898	11,177	6,671	0.4	44.9	5588.2	3290.6	PASS	FAIL	PASS	PASS	7.25	74	Yes	Yes		
5/30/2003	6	840	11,177	6,671	0.3	42.0	5588.2	3293.5	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
6/2/2003	3	829	11,014	6,637	0.2	41.5	5506.9	3277.1	PASS	PASS	PASS	PASS	6.02	72	Yes	Yes		
6/2/2003	6	860	11,243	6,597	0.3	43.0	5621.2	3255.5	PASS	QUESTION	PASS	PASS	6.99	73	Yes	Yes		
6/2/2003	4	850	11,243	6,597	0.2	42.5	5621.3	3256.0	PASS	PASS	PASS	PASS	6.38	73	Yes	Yes		
6/3/2003	9	868	11,163	6,458	0.5	43.4	5581.1	3185.6	PASS	QUESTION	PASS	QUESTION	7.73	73	Yes	Yes		
6/3/2003	7	848	11,163	6,593	0.4	42.4	5581.2	3254.1	PASS	PASS	PASS	PASS	7.25	72	Yes	Yes		
6/3/2003	8	848	11,056	6,578	0.4	42.4	5527.6	3246.6	PASS	PASS	PASS	PASS	7.50	72	Yes	Yes		
6/4/2003	6	834	11,274	6,690	0.3	41.7	5636.7	3303.3	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
6/6/2003	2	863	10,898	6,748	0.1	43.2	5448.9	3330.9	PASS	QUESTION	QUESTION	PASS	5.60	73	Yes	Yes		
6/9/2003	5	799	11,344	6,594	0.3	40.0	5671.8	3257.1	PASS	PASS	PASS	PASS	6.70	71	Yes	Yes		
6/10/2003	4	834	11,292	6,704	0.2	41.7	5645.8	3310.3	PASS	PASS	PASS	PASS	6.38	72	Yes	Yes		
6/11/2003	6	843	11,234	6,651	0.3	42.2	5616.7	3283.4	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
6/12/2003	13	836	11,120	6,729	0.7	41.8	5559.4	3322.7	PASS	PASS	PASS	PASS	8.54	72	Yes	Yes		
6/16/2003	6	847	11,321	6,614	0.3	42.4	5660.2	3264.7	PASS	PASS	PASS	PASS	6.99	72	Yes	Yes		
6/26/2003	12	847	11,228	6,673	0.6	42.4	5613.4	3294.2	PASS	PASS	PASS	PASS	8.35	72	Yes	Yes		
6/26/2003	2	851	11,336	6,585	0.1	42.8	5667.9	3250.0	PASS	QUESTION	PASS	PASS	5.60	73	Yes	Yes		
6/27/2003	2	849	11,233	6,733	0.1	42.5	5616.4	3324.1	PASS	PASS	PASS	PASS	5.60	72	Yes	Yes		
6/27/2003	6	771	11,271	6,575	0.3	38.6	5635.2	3249.0	PASS	PASS	PASS	PASS	6.99	69	Yes	Yes		
6/30/2003	9	752	11,290	6,581	0.5	37.6	5644.6	3252.9	PASS	PASS	PASS	PASS	7.73	69	Yes	Yes		
6/30/2003	4	753	10,981	6,623	0.2	37.7	5490.3	3273.9	PASS	PASS	PASS	PASS	6.38	69	Yes	Yes		
7/1/2003	7	765	11,133	6,641	0.4	38.3	5566.2	3282.3	PASS	PASS	PASS	PASS	7.25	69	Yes	Yes		
7/1/2003	7	801	11,114	6,537	0.4	40.1	5556.7	3226.5	PASS	PASS	PASS	PASS	7.25	71	Yes	Yes		
7/2/2003	6	748	11,046	6,477	0.3	37.4	5522.7	3201.1	PASS	PASS	PASS	PASS	6.99	68	Yes	Yes		
7/2/2003	3	791	10,942	6,518	0.2	39.6	5470.9	3219.5	PASS	PASS	PASS	PASS	6.02	70	Yes	Yes		
7/8/2003	8	766	11,105	6,507	0.4	38.3	5552.1	3215.2	PASS	PASS	PASS	PASS	7.50	69	Yes	Yes		
7/8/2003	3	786	11,255	6,581	0.2	39.3	5627.4	3251.2	PASS	PASS	PASS	PASS	6.02	70	Yes	Yes		
7/9/2003	2	764	11,039	6,492	0.1	38.2	5519.4	3207.8	PASS	PASS	PASS	PASS	5.60	69	Yes	Yes		
7/10/2003	4	756	11,110	6,467	0.2	37.8	5554.8	3195.7	PASS	PASS	PASS	PASS	6.38	69	Yes	Yes		
8/26/2003	4	786	11,107	6,572	0.2	39.3	5553.3	3246.7	PASS	PASS	PASS	PASS	6.38	70	Yes	Yes		
8/26/2003	5	797	10,946	6,631	0.3	39.9	5472.8	3275.7	PASS	PASS	PASS	PASS	6.70	70	Yes	Yes		

Initial Background and Source Counts for Control Chart

#	Initial bkg counts				Initial source plus bkg counts			
	Alpha	cpm	Beta	cpm	Alpha	cpm	Beta	cpm
1	8	0.4	797	39.85	11,083	5541.5	6,622	3311
2	7	0.35	812	40.6	11,120	5560	6,644	3322
3	11	0.55	795	39.75	10,886	5443	6,809	3404.5
4	8	0.4	784	39.2	11,179	5589.5	6,796	3398
5	8	0.4	791	39.55	11,276	5638	6,737	3368.5
6	4	0.2	768	38.4	11,175	5587.5	6,621	3310.5
7	9	0.45	798	39.9	11,135	5567.5	6,663	3331.5
8	3	0.15	861	43.05	11,159	5579.5	6,696	3348
9	12	0.6	774	38.7	11,281	5640.5	6,494	3247
10	5	0.25	811	40.55	11,233	5616.5	6,535	3267.5
Mean		0.38		40.0		5576.4		3330.9
$S_{(n-1)}$		0.14		1.30		56.94		51.18
-3 sigma		-0.06		36.06		5405.54		3177.31
+3 sigma		0.81		43.85		5747.16		3484.39
-2 sigma		0.09		37.36		5462.47		3228.49
+2 sigma		0.66		42.55		5690.23		3433.21
					Mean-bkg	5576.0		3290.9
					$S_{(n-1)}$	56.97		51.05
				Mean-bkg	-3 sigma	5405.07		3137.74
				Mean-bkg	+3 sigma	5746.88		3444.05
				Mean-bkg	-2 sigma	5462.04		3188.79
				Mean-bkg	+2 sigma	5689.91		3393.00
						5541.1		3271.15
						5559.65		3281.4
						5442.45		3364.75
						5589.1		3358.8
						5637.6		3328.95
						5587.3		3272.1
						5567.05		3291.6
						5579.35		3304.95
						5639.9		3208.3
						5616.25		3226.95

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
SMEAR INSTRUMENT QC

Counting Instrument:			Ludlum 2929	Detector:	43-10-1		Calibration Date:		12/15/2004					
Serial #:			180830	Serial #:	PR 207649		12 month calibration:		OK					
Detector Active Area or Area Covered by Smear (cm^2):					100		NRC 6 Mo Cal. Due Date?		OK					
	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM/100cm²)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source-Sample Count Time	Control Chart bkg Average α β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α β cpm	Control Chart source 1 sigma, cpm
Alpha	0.3328	Th 230	2888-01	20,200	5/1/2001	7.70E+04	20,199	10	20	2	0.11	0.08	7113.1	41.91
Beta	0.2789	Tc 99	2889-01	21,400	5/1/2001	2.13E+05	21,400	500	20	2	50.99	1.48	5634.7	61.44

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail		MDA α (dpm)	MDA β (dpm)	α MDA OK?	β MDA OK?	H.P. Technician	Technician Initials
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta						
2/11/2004	2	1,012	14,215	11,313	0.1	50.6	7107.4	5605.9	PASS	PASS	PASS	PASS	6.83	68	Yes	Yes		
2/16/2004	3	1,063	14,109	11,428	0.2	53.2	7054.4	5680.9	PASS	PASS	PASS	PASS	7.35	69	Yes	Yes		
2/17/2004	2	1,020	14,174	11,490	0.1	51.0	7086.9	5694.0	PASS	PASS	PASS	PASS	6.83	68	Yes	Yes		
2/18/2004	3	1,048	14,275	11,525	0.2	52.4	7137.4	5710.1	PASS	PASS	PASS	PASS	7.35	69	Yes	Yes		
2/19/2004	4	1,068	14,239	11,463	0.2	53.4	7119.3	5678.1	PASS	PASS	PASS	PASS	7.79	69	Yes	Yes		
2/20/2004	5	1,045	14,187	11,405	0.3	52.3	7093.3	5650.3	PASS	PASS	PASS	PASS	8.17	69	Yes	Yes		
2/23/2004	2	1,050	14,334	11,311	0.1	52.5	7166.9	5603.0	PASS	PASS	PASS	PASS	6.83	69	Yes	Yes		
2/24/2004	5	1,017	14,240	11,400	0.3	50.9	7119.8	5649.2	PASS	PASS	PASS	PASS	8.17	68	Yes	Yes		
2/25/2004	3	1,063	14,368	11,314	0.2	53.2	7183.9	5603.9	PASS	PASS	PASS	PASS	7.35	69	Yes	Yes		
2/26/2004	5	1,004	14,357	11,281	0.3	50.2	7178.3	5590.3	PASS	PASS	PASS	PASS	8.17	67	Yes	Yes		
2/27/2004	5	997	14,322	11,447	0.3	49.9	7160.8	5673.7	PASS	PASS	PASS	PASS	8.17	67	Yes	Yes		
3/1/2004	5	1,038	14,114	11,246	0.3	51.9	7056.8	5571.1	PASS	PASS	PASS	PASS	8.17	68	Yes	Yes		
3/2/2004	4	1,033	14,181	11,234	0.2	51.7	7090.3	5585.4	PASS	PASS	PASS	PASS	7.79	68	Yes	Yes		
3/3/2004	5	1,068	14,359	11,527	0.3	53.4	7179.3	5710.1	PASS	PASS	PASS	PASS	8.17	69	Yes	Yes		
3/4/2004	2	1,059	14,136	11,444	0.1	53.0	7067.9	5669.1	PASS	PASS	PASS	PASS	6.83	69	Yes	Yes		
3/30/2004	4	965	14,190	11,287	0.2	48.3	7094.8	5595.3	PASS	PASS	PASS	PASS	7.79	68	Yes	Yes		
3/30/2004	5	987	14,099	11,130	0.3	49.4	7049.3	5515.7	PASS	PASS	PASS	PASS	8.17	67	Yes	Yes		
3/31/2004	2	994	14,150	11,137	0.1	49.7	7074.9	5518.8	PASS	PASS	PASS	PASS	6.83	67	Yes	Yes		

Initial Background and Source Counts for Control Chart

#	Initial bkg counts				Initial source plus bkg counts			
	Alpha	cpm	Beta	cpm	Alpha	cpm	Beta	cpm
1	2	0.1	1,033	51.65	14,166	7083	11,208	5604
2	5	0.25	1,048	52.4	14,105	7052.5	11,558	5779
3	0	0	1,036	51.8	14,198	7099	11,281	5640.5
4	4	0.2	1,001	50.05	14,164	7082	11,391	5695.5
5	3	0.15	1,016	50.8	14,235	7117.5	11,319	5659.5
6	1	0.05	984	49.2	14,191	7095.5	11,452	5726
7	1	0.05	1,055	52.75	14,263	7131.5	11,571	5785.5
8	2	0.1	974	48.7	14,255	7127.5	11,326	5663
9	1	0.05	997	49.85	14,411	7205.5	11,360	5680
10	2	0.1	1,054	52.7	14,276	7138	11,248	5624
Mean		0.11		51.0		7113.2		5685.7
$S_{(n-1)}$		0.08		1.48		41.87		61.59
-3 sigma		-0.12		46.54		6987.59		5500.92
+3 sigma		0.33		55.44		7238.81		5870.48
-2 sigma		-0.05		48.03		7029.46		5562.51
+2 sigma		0.26		53.95		7196.94		5808.89
					Mean-bkg	7113.1		5634.7
					$S_{(n-1)}$	41.91		61.44
				Mean-bkg	-3 sigma	6987.37		5450.38
				Mean-bkg	+3 sigma	7238.82		5819.04
				Mean-bkg	-2 sigma	7029.28		5511.82
				Mean-bkg	+2 sigma	7196.91		5757.60
						7082.9		5552.35
						7052.25		5726.6
						7099		5588.7
						7081.8		5645.45
						7117.35		5608.7
						7095.45		5676.8
						7131.45		5732.75
						7127.4		5614.3
						7205.45		5630.15
						7137.9		5571.3

CABRERA SMEAR COUNTING WORKSHEET (Rev 4)
SMEAR INSTRUMENT QC

Counting Instrument:	Ludlum 2929	Detector:	43-10-1	Calibration Date:	11/19/2003
Serial #:	171590	Serial #:	PR 174813	12 month calibration:	OK
Detector Active Area or Area Covered by Smear (cm^2):			100	NRC 6 Mo Cal. Due Date?	WARNING

	Efficiency (fraction)	Source Nuclide	Source Number	Original Source Activity (DPM)	Source Creation Date	$T_{1/2}$ (yr)	Source Decayed Activity	Required MDA (DPM/100cm^2)	Control Chart & Daily Bkg Count Time	Control Chart & Daily Source-Sample Count Time	Control Chart bkg Average α β cpm	Control Chart bkg 1 sigma, cpm	Control Chart Source-bkg Average α β cpm	Control Chart source 1 sigma, cpm
Alpha	0.3850	Th-230	2897-01	22,800	6/11/2001	7.70E+04	22,799	10	20	2	0.33	0.12	7983.1	81.27
Beta	0.2650	Tc-99	2889-01	21,400	5/1/2001	2.13E+05	21,400	500	20	2	70.26	2.26	5007.0	39.53

Date	Daily Bkg Counts		Daily Check Source Counts		Daily Bkg Rate (cpm)		Net Daily Source Rate (cpm)		Bkg QC Pass/Fail		Source QC Pass/Fail		MDA α (dpm)	MDA β (dpm)	α MDA OK?	β MDA OK?	H.P. Technician	Technician Initials
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta						
6/10/2004	8	1,456	15,704	10,123	0.4	72.8	7851.6	4988.7	PASS	PASS	PASS	PASS	7.90	84	Yes	Yes	Cote	JAC

Initial Background and Source Counts for Control Chart

#	Initial bkg counts				Initial source plus bkg counts			
	Alpha	cpm	Beta	cpm	Alpha	cpm	Beta	cpm
1	11	0.55	1,412	70.6	16,251	8125.5	10,241	5120.5
2	8	0.4	1,345	67.25	15,875	7937.5	10,112	5056
3	9	0.45	1,441	72.05	15,946	7973	10,113	5056.5
4	3	0.15	1,425	71.25	15,894	7947	10,268	5134
5	4	0.2	1,352	67.6	15,933	7966.5	10,058	5029
6	7	0.35	1,410	70.5	15,865	7932.5	10,094	5047
7	7	0.35	1,466	73.3	16,035	8017.5	10,153	5076.5
8	5	0.25	1,438	71.9	15,710	7855	10,235	5117.5
9	7	0.35	1,335	66.75	15,947	7973.5	10,216	5108
10	5	0.25	1,427	71.35	16,213	8106.5	10,055	5027.5
Mean		0.33		70.3		7983.5		5077.3
$S_{(n-1)}$		0.12		2.26		61.32		39.80
-3 sigma		-0.03		63.48		7739.50		4957.84
+3 sigma		0.89		77.03		8227.40		5196.86
-2 sigma		0.09		65.74		7820.82		4997.65
+2 sigma		0.57		74.77		8146.08		5156.85
					Mean-bkg	7983.1		5007.0
					$S_{(n-1)}$	81.27		39.53
				Mean-bkg	-3 sigma	7739.32		4888.41
				Mean-bkg	+3 sigma	8226.92		5125.58
				Mean-bkg	-2 sigma	7820.59		4927.94
				Mean-bkg	+2 sigma	8145.65		5086.05
						8124.95		5049.9
						7937.1		4988.75
						7972.55		4984.45
						7946.85		5062.75
						7966.3		4961.4
						7932.15		4976.5
						8017.15		5003.2
						7854.75		5045.6
						7973.15		5041.25
						8106.25		4956.15

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 295451 / 271487

Mfg. Ludlum Measurements, Inc. Model 2224-1 Serial No. 162425

Mfg. Ludlum Measurements, Inc. Model 43-93 Serial No. PR 182403

Cal. Date 15-Apr-03 Cal Due Date 15-Apr-04 Cal. Interval 1 Year Meterface 202-848

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 78 °F RH 38 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. Comment mV Det. Oper. 900 V at Comment mV Threshold Dial Ratio ___ = ___ mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. ~~700~~ 1500 / 1490 V

COMMENTS:
AT: 120mv
BT: 3.5mv
BW: 30mv
OL set to simulated light leak
Firmware: 390094
Calibrated with 60' cable

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1000	800kcpm	800	800
X1000	200kcpm	200	200
X100	80kcpm	800	800
X100	20kcpm	200	200
X10	8kcpm	800	800
X10	2kcpm	200	200
X1	800cpm	800	800
X1	200cpm	200	200

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	800kcpm	798621	798621				
	80kcpm	79863	79863				
	8kcpm	7987	7987				
	800cpm	799	799				
	80cpm	80	80				

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N Pu-239 2928-01 ☑ Beta S/N S-90Y-90 vole, Tc-99 NI-EV ☐ Other

☑ m 500 S/N 134709 ☐ Oscilloscope S/N ☑ Multimeter S/N 57390613

Calibrated By: Conrad Galindo Date 15 Apr 03

Reviewed By: Rhonda Harris Date 16 Apr 03

FORM C22A 04/09/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer
of
Scientific and Industrial
Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-93 Serial No. 22182403

Order #. 295451 / 271487

Customer CABRERA SERVICES

Alpha Input Sensitivity 120 mV

Counter 2224-1 Serial No. 162425

Beta Input Sensitivity 35 mV

Count Time 1 Minute

Beta Window 30 mV

Other

Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Pu-239, Size 12600 cpm Alpha	Isotope Pu-239, Size 12600 cpm Beta	Isotope Sr-90 Y-90, Size 44710 Alpha	Isotope Sr-90 Y-90, Size 44710 Beta	Isotope Tc-99, Size 14100 cpm Alpha	Isotope Tc-99, Size 14100 cpm Beta
850	0	110	5802	385	2	13110	1	4062
875	0	161	6006	421	0	16757	0	4786
900	0	214	6152	604	3	20357	0	5339
925	0	260	6082	849	5	22934	3	6078
950	3	290	6313	1255	3	23062	1	6520

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Conrad Galindo

Date 15Apr03

FORM C4B 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER CABRERA SERVICES ORDER NO. 289386/268534

Mfg. Ludlum Measurements, Inc. Model 2224-1 Serial No. 162426

Mfg. Ludlum Measurements, Inc. Model 43-93 Serial No. PR 193921

Cal. Date 15-Jan-03 Cal Due Date 15-Jan-04 Cal. Interval 1 Year Meterface 202-848

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 20 % Alt 709.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 800 V Input Sens. Comm. mV Det. Oper. 800 V at Comm. mV Threshold Dial Ratio ______ = ______ mV

☑ HV Readout (2 points) Ref./Inst. 505 / 500 V Ref./Inst. 1513 / 1500 V

COMMENTS:

Alpha Thshld: 120 mv
Beta Thshld: 3.6 mv
Beta Win: 30 mv

Cal'd using 5' c/c Cable.
DL Set to Simulate light leak.
efficiency for Th^{230} 5390 dpm is 19% 4π.
(1024 cpm) Th^{230} S/N 1619

Firmware No. 390096

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X1000	800kcpm	800	800
X1000	200kcpm	200	200
X100	80kcpm	800	800
X100	20kcpm	200	200
X10	8kcpm	800	800
X10	2kcpm	200	200
X1	800cpm	800	800
X1	200cpm	200	200

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	800kcpm	801320 kcpm	801320 kcpm
	80kcpm	80129 "	80129 "
	8kcpm	8013 "	8013 "
	800cpm	801 cpm	801 cpm
	80cpm	80 "	80 "

Log Scale	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______

☑ m 500 S/N 54680 ☐ Oscilloscope S/N ______ ☑ Multimeter S/N 69101832

Calibrated By: [signature] Date 15-Jan-03

Reviewed By: Rhonda Harris Date 16 Jan 03

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-93 Serial No. PR 193921
Customer CABRERA SERVICES
Counter 2224-1 Serial No. 162426
Count Time 1 Minute
Other

Order #. 289386/268534
Alpha Input Sensitivity 120 mV
Beta Input Sensitivity 3.6 mV
Beta Window 30 mV
Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Pu 239, Size 12,600 cpm Alpha	Pu 239 Beta	Isotope Tc 99, Size 14,300 cpm Alpha	Tc 99 Beta	Isotope SrY90, Size 44979 cpm Alpha	SrY90 Beta
750	0	97	4720	347	7	2532	0	11770
775	0	141	5110	370	6	3590	0	15651
– 800	1	197	5472	425	10	4408	3	19451
825	0	269	5673	469	11	5058	2	21624
850	1	322	5744	652	11	5698	2	22583

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature [signature]

Date 15-Jan-03

FORM C4B 12/09/97

• *Serving The Nuclear Industry Since 1962* •

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 212582/279960

Mfg. Ludlum Measurements, Inc. Model 2224-1 Serial No. 162426

Mfg. Ludlum Measurements, Inc. Model 43-93 Serial No. PR193921

Cal. Date 11-Mar-04 Cal Due Date 11-Mar-05 Cal. Interval 1 Year Meterface 202-848

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 75 °F RH 20 % Alt 706.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 825 V Input Sens. Comments mV Det. Oper. 825 V at comments mV Threshold Dial Ratio = mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1500 V

COMMENTS:
Alpha threshold = 120 mV
Beta threshold = 3.5 mV
Beta window = 30 mV
Firmware: 390096
OL set to simulated light leak.
Cal'd with 6' cable.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	800kcpm	800	800
x1000	200kcpm	200	200
x100	80kcpm	800	800
x100	20kcpm	200	200
x10	8kcpm	800	800
x10	2kcpm	200	200
x1	800cpm	800	800
x1	200cpm	200	200

*Uncertainty within ± 10% C.F. within ± 20%

ALL Range(s) Calibrated Electronically

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
800kcpm	801124	801124			
80kcpm	80112	80112			
8kcpm	8011	8011			
800cpm	801	801			
80cpm	80	80			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:
Cs-137 Gamma S/N ☐ 1162 ☐ 6112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N Th-230-5020-03 ☑ Beta S/N Tc-99-NI-EV, Sr-Y-90-4016 ☐ Other

☑ m 500 S/N 132899 ☐ Oscilloscope S/N ☑ Multimeter S/N 82080087

Calibrated By: Josh Boston Date 11 Mar 04

Reviewed By: [signature] Date 15 Mar 04

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed

FORM C22A 10/31/2001

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-93 Serial No. PR193921 Order #. 212582/279960

Customer CABRERA SERVICES Alpha Input Sensitivity 120 mV

Counter 2224-1 Serial No. 162426 Beta Input Sensitivity 3.5 mV

Count Time 1Minute Beta Window 30 mV

Other Distance Source to Detector Surface

High Voltage	Background		Isotope Th-230, Size 2910 cpm		Isotope Tc-99, Size 1400 cpm		Isotope SrY-90, Size 43732 cpm	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
800	1	101	1110	235	2	3547	4	16680
825	0	196	1196	244	7	4656	2	19525
850	0	458	1197	361	2	5473	2	20755

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Josh Boston Date 11 Mar 04

FORM C48 12/09/97

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 282597

Mfg. Ludlum Measurements, Inc. Model 2224 Serial No. 183048

Mfg. Ludlum Measurements, Inc. Model 43-68 Serial No. PR 161781

Cal. Date 15-Jul-02 Cal Due Date 15-Jul-03 Cal. Interval 1 Year Meterface 202-783

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 36 % Alt 702.8 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 1575 V Input Sens. Comment mV Det. Oper. 1575 V at Comment mV Threshold Dial Ratio ____ = ____ mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1512 / 1500 V

COMMENTS:

```
Alpha sensitivity=120mV            Pu 239 s/n 4337       ; 30,900 dpm is ≈   21.2% 4pi
 Beta sensitivity=3.5mV            Tc 99  s/n 635/83     ; 22,900 dpm is ≈  29.59% 4pi
     Beta window= 35mV             Ni 63  s/n 91N13100909; 258,890dpm is ≈   6.33% 4pi
Overload not set.                  C 14   s/n I-659      ; 311,649dpm is ≈  7.69% 4pi
Count time set to 60 sec.            All efficiencies are NET efficiencies.(without background)
High Voltage set with detector connected.  All readings for efficiencies were taken with
Firmware #390063                     source placed at the surface and centered against the
Plateau'd using 5 ft. cable.         protective screen of the 43-68 probe.
```

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	400kcpm		400
x1000	100kcpm		100
x100	40kcpm		400
x100	10kcpm		100
x10	4kcpm		400
x10	1kcpm		100
x1	400cpm		400
x1	100cpm		100

*Uncertainty within ± 10% C.F. within ± 20% ALL **Range(s) Calibrated Electronically**

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm		40030 (0)	Log Scale			
	40kcpm		4006 (0)				
	4kcpm		400 (0)				
	400cpm		40 (0)				
	40cpm		4 (0)				

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N 4337,Pu239 ☑ Beta S/N 635/83,Tc99*5030,Sr90y90 ☐ Other

☑ m 500 S/N 94940 ☐ Oscilloscope S/N ☑ Multimeter S/N 50100581

Calibrated By: Cresencia Alvarado Date 15 Jul 02

Reviewed By: [signature] Date 17 Jul 02

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-68 Serial No. PR161781 Order #. 282597

Customer CABRERA SERVICES

Alpha Input Sensitivity 120 mV

Counter 2224 Serial No. 183048

Beta Input Sensitivity 3.5 mV

Count Time 1Minute

Beta Window 35 mV

Other Plateau'd using 5ft. cable.

Distance Source to Detector surface

High Voltage	Background		Isotope Pu 239 Size 15,700cpm		Isotope Tc 99 Size 14,300cpm		Isotope Sr90 Y90 Size 6850 cpm	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
1525	0	133	5813	715	7	7291	1	3127
1550	0	146	6205	762	4	7184	0	3859
1575	2	205	6555	782	6	6982	2	3949
1600	3	274	6777	782	31	6263	17	4125
1625	0	255	7017	709	209	5270	51	3821

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Crescencia Alvarado

Date 15 Jul 02

FORM C48 12/09/97

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

JSTOMER CSTE-DTC-AT-CS-SO ORDER NO. 295475

Mfg. Ludlum Measurements, Inc. Model 2360 Serial No. 193675

Mfg. Ludlum Measurements, Inc. Model 43-37 Serial No. PR161687

Cal. Date 29-Apr-03 Cal Due Date 29-Apr-04 Cal. Interval 1 Year Meterface 202-855

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 75 °F RH 37 % Alt 699.8 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☑ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 1700 V

☑ HV Readout (2 points) Ref./Inst. 500 / 503 V Ref./Inst. 2000 / 2008 V

Firmware Version: 39Ø10N25
Alpha Threshold: 100 mv.
Beta Threshold: 4 mv.
Beta Window: 40 mv
Overload checked but not set.
Instrument calibrated with a 6 ft. cable.
High voltage set with detector connected

(EEPROM Settings)
User Time: 1.0 min
Alpha Alarm: 050000
Beta Alarm: 050000
A/B Alarm: 050000
Model 2360 Date: 04/29/2003
Calibration Date Due: 04/29/2004

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	400kcpm		400
x1000	100kcpm		100
x100	40kcpm		400
x100	10kcpm		100
x10	4kcpm		400
x10	1kcpm		100
x1	400cpm		400
x1	100cpm		100

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm		399989	Log Scale			
	40kcpm		40001				
	4kcpm		4001				
	400cpm		400				
	40cpm		40				

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N 4337 Pu 239 ☑ Beta S/N 635/83,Tc99*#918,Sr90y90 ☐ Other

☑ m 500 S/N 94940 ☐ Oscilloscope S/N ☑ Multimeter S/N 65240152

Calibrated By: [signature] Date 29-APR-03

Reviewed By: [signature] Date 29 Apr 03

FORM C22S 04/09/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-37 Serial No. PR161687 Order #. 295475

Customer CSTE-DTC-AT-CS-SO Alpha Input Sensitivity 100 mV

Counter 2360 Serial No. 193375 Beta Input Sensitivity 4 mV

Count Time 1Minute Beta Window 40 mV

Other Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Pu239, Size 15,700cpm Alpha	Beta	Isotope Sr90Y90, Size 79,881cpm Alpha	Beta	Isotope Tc99, Size 14,300cpm Alpha	Beta
1625	5	434	6322	931	3	21733	13	6515
1650	4	574	6522	1068	4	26826	9	7230
1675	3	740	6802	1211	7	30741	11	8085
– 1700	5	860	7035	1421	29	34888	18	8246
1725	11	929	7311	1550	203	37371	52	7949

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☑ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Elvis Chavez

Date 29APR03

FORM C4B 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 213520/280435

Mfg. Ludlum Measurements, Inc. Model 2360 Serial No. 184938

Mfg. Ludlum Measurements, Inc. Model 43-37 Serial No. PR178371

Cal. Date 1-Apr-04 Cal Due Date 1-Apr-05 Cal. Interval 1 Year Meterface 202-855

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 20 % Alt 710.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 1675 V

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 2000 V

Firmware Version: 39010-010-25
Alpha Threshold: 100mV
Beta Threshold: 4mV
Beta Window: 40 mV
Overload checked but not set.
Instrument calibrated with a 39" cable.
High voltage set with detector not connected.

(EEPROM Settings)
User Time: 1.0
Alpha Alarm: 50000
Beta Alarm: 50000
A/B Alarm: 50000
Model 2360 Date: 04/01/2004
Calibration Date Due: 04/01/2005

COMMENTS:

Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	400 kcpm	400	400
x1000	100 kcpm	100	100
x100	40 kcpm	400	400
x100	10 kcpm	100	100
x10	4 kcpm	400	400
x10	1 kcpm	100	100
x1	400 cpm	400	400
x1	100 cpm	100	100

*Uncertainty within ± 10% C.F. within ± 20% All Range(s) Calibrated Electronically

Digital Readout

REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 kcpm	400536(0)	400536(0)
40 kcpm	4009	4009
4 kcpm	401	401
400 cpm	40	40
40 cpm	4	4

Log Scale

REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N Pu-239-2928-01 ☑ Beta S/N Tc-99 NI-EV,SrY90-4016 ☐ Other

☑ m 500 S/N 132899 ☐ Oscilloscope S/N ☑ Multimeter S/N 82080087

Calibrated By: Josh Boston Date 1 Apr 04

Reviewed By: [signature] Date 1 APR 04

FORM C22S 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 43-37 Serial No. PR178371
Customer CABRERA SERVICES
Counter 2360 Serial No. 184938
Count Time 1 Minute
Other

Order #. 213520/280435
Alpha Input Sensitivity 100 mV
Beta Input Sensitivity 4 mV
Beta Window 40 mV
Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Pu-239, Size 12600 cpm Alpha	Pu-239 Beta	Isotope Tc-99, Size 14100 cpm Alpha	Tc-99 Beta	Isotope Sr/Y-90, Size 43670 cpm Alpha	Sr/Y-90 Beta
1625	4	382	4904	705	1	7092	7	14641
1650	2	515	5022	934	2	7478	6	17734
> 1675	2	672	5243	962	6	7698	16	18478
1700	5	895	5361	1145	34	7459	73	19837
1725	12	947	5455	1244	194	6452	431	19941

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.
☑ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Josh Boston Date 1 Apr 04

FORM C4B 04/09/2003

● *Serving The Nuclear Industry Since 1962* ●

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A. 216674

CUSTOMER CABRERA SERVICES ORDER NO. 216718/281992

Mfg. Ludlum Measurements, Inc. Model 2360 Serial No. 202398

Mfg. Ludlum Measurements, Inc. Model 43-93 Serial No. PR211706

Cal. Date 26-May-04 Cal Due Date 26-May-05 Cal. Interval 1 Year Meterface 202-855

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 56 % Alt 696.0 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☑ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 725 V

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1500 V

Firmware Version: 39010-010-25
Alpha Threshold: 120 mV
Beta Threshold: 3.5 mV
Beta Window: 30 mV
Overload set to simulated light leak.
Instrument calibrated with a 5' cable.
High voltage set with detector not connected.

(EEPROM Settings)
User Time: 1.0
Alpha Alarm: 50000
Beta Alarm: 50000
A/B Alarm: 50000
Model 2360 Date: 05/26/2004
Calibration Date Due: 05/26/2005

COMMENTS:

4 pi efficiencies (Refer to plateau sheet at set voltage for details):
Th-230 = 19.48%, Tc-99 = 20.82%, SrY-90 = 30.97%, Ni-63 = 0.13%.

Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
x1000	400kcpm		400
x1000	100kcpm		100
x100	40kcpm		400
x100	10kcpm		100
x10	4kcpm		400
x10	1kcpm		100
x1	400cpm		400
x1	100cpm		100

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400kcpm	38 (0)	40151 (0)	Log Scale			
	40kcpm		4015				
	4kcpm		400				
	400cpm		40				
	40cpm		4				

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N Th-230-5020-03 ☑ Beta S/N Tc-99-NI-EV, SrY-90-9016, Ni-63-4017 ☐ Other

☑ m 500 S/N 132899 ☐ Oscilloscope S/N ☑ Multimeter S/N 82080087

Calibrated By: Josh Boston Date 26 May 04

Reviewed By: [signature] Date 27 May 04

FORM C22S 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

216674

Detector 43-93 Serial No. PR211706 Order #. 216718/281992

Customer CABRERA SERVICES Alpha Input Sensitivity 120 mV

Counter 2360 Serial No. 202398 Beta Input Sensitivity 3.5 mV

Count Time 1Minute Beta Window 30 mV

Other Distance Source to Detector Surface

High Voltage	Background		Isotope Th-230 Size 5730dpm		Isotope Tc-99 Size 22600dpm		Isotope SrY-90 Size 62157dpm	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
675	0	70	1009	140	1	2560	2	13265
700	1	119	1129	191	2	3849	2	16078
→ 725	0	170	1116	255	2	4876	3	19422
750	1	204	1155	397	0	5773	5	20319

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.

☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Josh Boston Date 26 May 04

FORM C48 04/09/2003

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

216674

Detector 43-93 Serial No. PR211706 Order #. 216718/281992

Customer CABRERA SERVICES Alpha Input Sensitivity 120 mV

Counter 2360 Serial No. 202398 Beta Input Sensitivity 3.5 mV

Count Time 1Minute Beta Window 30 mV

Other Distance Source to Detector Surface

High Voltage	Background Alpha	Background Beta	Isotope Ni-63, Size 294126dpm Alpha	Isotope Ni-63, Size 294126dpm Beta	Isotope, Size Alpha	Isotope, Size Beta	Isotope, Size Alpha	Isotope, Size Beta
675	0	70	1	75				
700	1	119	0	193				
→ 725	0	170	0	551				
750	1	204	0	1581				

☐ Gas Proportional detector count rate decreased ≤ 10% after 15 hour static test using 39" cable.
☐ Gas proportional detector count rate decreased ≤ 10% after 5 hour static test using 39" cable and alpha/beta counter.

Signature Josh Boston Date 26 May 04

FORM C48 04/09/2003

Inst.#C853F Cs-137		
QC Daily Source		
Date	Result (µrem/hr)	P/F
4/29/2003	200	[redacted]
4/30/2003	210	[redacted]
5/1/2003	200	[redacted]
5/2/2003	200	[redacted]
5/12/2003	200	[redacted]
5/13/2003	210	[redacted]
5/14/2003	200	[redacted]
5/15/2003	220	[redacted]
5/19/2003	200	[redacted]
6/19/2003	200	[redacted]
8/12/2003	220	[redacted]
8/13/2003	200	[redacted]
8/14/2003	225	[redacted]
8/15/2003	210	[redacted]
8/18/2003	200	[redacted]
8/19/2003	225	[redacted]

Inst.#C853F Cs-137		Source Ser. #	1127
Initial Source Readings		Nuclide	Cs-137
Date	Result (µrem/hr)		
4/28/2003	190		
4/28/2003	210		
4/28/2003	190		
4/28/2003	180		
4/28/2003	190		
4/28/2003	180		
4/28/2003	190		
4/28/2003	180		
4/28/2003	190		
4/28/2003	190		
	Average		
	189		

ROPC	Radionuclides of Potential Concern
σ	Sigma
S/N	Serial Number
SU	Survey Unit
^{234}U	Uranium-234
^{235}U	Uranium-235
^{238}U	Uranium-238

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the United States Army Field Support Command (AFSC) to provide support to the Aberdeen Test Center (ATC) at the Aberdeen Proving Ground (APG) in Aberdeen, Maryland. CABRERA performed facility demolition, remediation, and site wide radiological surveys of the Bomb Throwing Device (BTD) site to support consideration for unrestricted release. The BTD site consists of approximately 46,000 square meters (m^2) of land on the APG used for the testing of Depleted Uranium (DU) munitions. The BTD site also contains a number of structures used to support operations.

For consistency with other decommissioning activities at APG, radiologically impacted soils and structures are addressed separately. This document presents the Final Status Survey (FSS) activities for five structures on site – the BTD Armor Reclamation Facility (BARF), Wash Rack #2, Wash Rack #3, Concrete Pad #2 located behind Building 701, and Concrete Pad #1 located behind the DU Test Enclosure Building. The Final Status Survey conducted on soils is addressed in a separate document titled, "*Remediation and Final Status Survey, Bomb Throwing Device Site – Soils*," (CABRERA, 2004). These final status surveys are designed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (U.S. Nuclear Regulatory Commission [NRC], 2000).

1.1 Site History

APG, located in Aberdeen, Maryland, is an active U.S. Army testing and research facility. The APG lies along the western shore of the Chesapeake Bay in Harford and Baltimore Counties, Maryland, approximately 15 miles northeast of Baltimore. The APG covers a total of 72,516 acres (land and water) and consists of two distinct areas: the northern portion of APG, referred to as the Aberdeen Area; and the southern portion of APG, referred to as the Edgewood Area. The Aberdeen Area became a formal military post, designated as the APG, in 1917.

The BTD site was used between 1982 and 1993 for the testing of DU munitions. In 1993, the site consisted of the BTD ARMOR RECLAMATION FACILITY, the DU Test Enclosure Building, the Enclosure Building High Efficiency Particulate Air (HEPA) system, the Plate Storage Area (PSA), Wash Racks #2 and #3, access roads, and several support buildings situated on approximately 46,000 square meters (m^2) (11.4 acres) of land. During operations, DU munitions were fired at steel plate and other targets placed inside the DU Test Enclosure Building. The High Efficiency Particulate Air (HEPA) ventilation system equipment was located outside the DU Test Enclosure Building on a concrete pad (Concrete Pad #1). Its function was to collect and filter potentially contaminated air exiting the DU Test Enclosure Building after the firing of DU munitions.

Prior to site remediation, approximately 40 tons of DU-contaminated armor plate was located within the DU Test Enclosure Building and surrounding grounds. Heavy equipment was used to transport the armor plates between the DU Test Enclosure Building and the PSA. As part of the remedial activities and subsequent to the removal of the armor plates, the DU Test Enclosure Building, the HEPA ventilation system, the footings for the DU Test Enclosure Building, the "White" Building, the "Rust" Building, and the Sabot Stripper were removed in their entirety from the site and processed separately from this report.

The BTD site decommissioning consisted of structure demolition, soil excavation, and removal of contaminated soil and demolition debris. As physical decommissioning actions were completed, FSSs were performed on both structures and land areas (this report addresses only five structures previously mentioned). Much of the plate steel that was generated during site cleanup and demolition (primarily the DU Test Enclosure Building) was transferred to the Army Research Laboratory (ARL) facility, at APG Spesutie Island, for decontamination and recycling. A cost analysis performed by the Army indicated that recycling was a less expensive option than offsite disposal of the material and that there was a beneficial reuse for the plate steel in support of APG's mission. Other demolition debris and excavated soil was considered unwanted radioactive material and was shipped via rail to Envirocare of Utah, an NRC licensed disposal facility, for shallow land burial.

During initial mobilization in February 2003, the CABRERA field crew entered the BARF and dismantled, surveyed, and removed the DU armor plate reclamation machine (the LAB) housed within the BTD Armor Reclamation Facility.

In May 2003 CABRERA re-mobilized to perform a FSS on the inside of the BTD Armor Reclamation Facility, and demolish the DU Test Enclosure building. Most of the steel plate removed from the DU Test Enclosure Building was shipped across APG to the ARL Spesutie Island Facility for decontamination and beneficial reuse. Other steel/debris was containerized in intermodals for future rail shipment to Envirocare of Utah.

During June 2003, the CABRERA team performed remediation/FSS of Wash Racks 2 and 3, which included dismantling and ship out of the floor grids and left the scrap steel piled for transfer to ARL or other use, as instructed by ATC personnel. Concurrent to the dismantling operations and through the month of August 2003, the CABRERA team completed the majority of the gamma walkover survey, excavated contaminated soils, and stockpiled the remediated soil (approximately 1,200 cubic yards) into a lay down area within Survey Units 16 and 25. CABRERA demobilized at the end of August 2003.

In February and March 2004, the CABRERA team returned to the BTD site, performed data collection for survey gaps, and accomplished 95% of the remediated soil load out. The soil was packed into intermodal containers, and the intermodals were shipped via rail to Envirocare of Utah.

In June 2004, the remainder of the soil was loaded/shipped to Envirocare for disposal and both Concrete Pad #1 and Concrete Pad #2 surfaces were remediated with a steel ball blast/HEPA vacuum system. Following cleaning, the surfaces were surveyed and the FSSs were performed.

As of the time of this writing, all soil/debris shipped via rail to Envirocare of Utah has been transferred to Envirocare of Utah and final disposition documentation is forthcoming.

In the Figures section of this report, Figure 1 shows the location of the BTD Site relative to APG and surrounding towns. Figure 2 shows the relative locations of the five structures specifically addressed in this FSS Report. Appendix A contains site photos of the structures discussed below.

1.1.1 BTD Armor Reclamation Facility

The BARF is a steel beam and sheet metal constructed building with insulated walls and roof. The insulation is covered with a flexible protective plastic cover. The floor is a concrete pad. The interior of the BARF is approximately 12 meters (m) long by 14.8 m wide with a ceiling height of 6 m. The building is bisected by a sheetrock wall with doors leading from one side to the other. There are no drains, sumps, or ventilation system penetrations other than the liquid abrasive blaster (LAB) HEPA ventilation system. A small heating system with insulated ductwork, rollup doors for equipment entry, smaller doorways for personnel entry, and electrical circuit boxes are other general features found in the building.

The northern portion of the BARF contained the LAB decontamination equipment and a small capacity crane used to help lift and load steel plates into the LAB. The southern part of the building was used to store clean unused HEPA filters and small amounts of containerized contaminated trash. Routine radiation contamination surveys were executed on all floor areas within the BTD Armor Reclamation Facility, on stored boxes and containers, and occasionally on wall surfaces.

The ATC utilized the BARF to house the LAB. The LAB was an enclosed system used to decontaminate pieces of steel plate and other small objects with water jets and abrasive. A ventilation system with a pre-filter demister and a HEPA filter removed airborne particulates prior to ventilation release to the environment. A hopper attached to the LAB retained spent abrasive and removed contamination.

No contamination was found on either the LAB HEPA filter or areas downstream in the ventilation system ducts during removal of the LAB. Minor contamination was found within the LAB enclosure, the hopper which contained water and abrasive, the HEPA pre-filter, and small areas on the outside of the LAB enclosure near loading points. The lack of activity downstream of the HEPA filter indicates a well-designed system that did not release airborne radioactivity to the environs. Other general surveys do not show contamination on the walls of the BARF. Scan surveys showed only occasional activity on the floor areas surrounding the LAB. Surveys of selected areas overhead and on the crane are also negative with respect to contamination.

1.1.2 Wash Rack #2

Wash Rack #2 consists of a steel beam frame and sheet metal walls with no interior insulation or wallboard. The interior is approximately 17 m long by 8 m wide with a ceiling height of 6 m. The floor consists of steel plate with a recessed trough running the length of the facility. The trough area is approximately 6 m wide by 10 centimeters (cm) deep. The trough area contains multiple raised (approximately 3 inches) steel beams, which were used to support steel floor grating. The grating, which was removed prior to this FFS, was flush with the surrounding floor plate. There are no drains, sumps, heating, cooling, or ventilation systems present. Steel rollup doors for equipment entry are located at both ends of the structure. Previously documented routine surveys identified minor levels of DU contamination on the floor area of Wash Rack #2.

Since the construction of Wash Rack #2 in 1992, the ATC has utilized this facility as a warehouse. Wash Rack #2 has never been used as a wash rack. Instead, it was used to store items and equipment, some of which were contaminated with DU. Wash Rack #2 housed DU in

the form of penetrators, floor sweepings, liquid abrasive residue from previous decontamination activities, and range debris (e.g., paper, plastic, wood).

Since the wash rack was used as a storage facility for contaminated materials, the primary area of investigation is the floor, trough area, and lower wall surfaces (2 m and below).

1.1.3 Wash Rack #3

Wash Rack #3 is identical to Wash Rack #2, was also built in 1992, and was used for the storage of uncontaminated Navy accelerator parts and the temporary housing of a cutting table contaminated with DU. Contamination left by the cutting table was identified in the southwest corner of the facility. This contamination was removed though decontamination activities prior to the initiation of the FSS. Past routine surveys of this structure have identified minor levels of DU contamination on the floor.

Since the wash rack was used as a storage facility for contaminated materials, the primary area of investigation is the floor, trough area, and lower wall surfaces (2 m and below).

1.1.4 Concrete Pad #2 (Located Behind Building 701)

This concrete pad is located behind Building 701. Pad dimensions are approximately 22 m by 15 m. The pad was confirmed to have alpha contamination and therefore would not pass release criteria. Its purpose was to stage or store heavy armored vehicles.

1.1.5 Concrete Pad #1 (Located Behind the DU Test Enclosure Building)

Concrete Pad #1 is located adjacent to the DU Test Enclosure Building. It is somewhat smaller than Concrete Pad #2 and is approximately 10 m by 12 m. Its purpose was to provide a foundation for the HEPA system associated with the DU Test Enclosure Building.

1.2 Radionuclides of Potential Concern

The following three Final Status Survey Plans were utilized in producing this consolidated FSS report:

- *Final Status Survey Plan For BTD Armor Reclamation Facility, Aberdeen Proving Ground, Aberdeen, MD* (provided in Appendix B)
- *Final Status Survey Plan For Wash Rack Facilities #2 and #3, Aberdeen Proving Ground, Aberdeen, MD* (provided in Appendix C)
- *Final Status Survey Plan Bomb Throwing Device (BTD) Site, Aberdeen Proving Ground, Aberdeen, MD* (provided in Appendix D)

Section 2.2 of each FSS Plan identifies the site Radionuclides of Potential Concern (ROPC) as being limited to DU and its short-lived uranium progeny (decay products). The uranium ratios are based on isotopic uranium weight ratios used for shipments of routine DU waste from APG

(BARG, 1995). The activity fractions are calculated from the isotopic weight ratios and the specific activity of each uranium isotope. The result of the activity fraction calculation is a Uranium-234 (^{234}U):Uranium-235 (^{235}U):Uranium-238 (^{238}U) ratio of 0.084:0.012:0.904.

1.3 Derived Concentration Guideline Levels

As described by MARSSIM, a Derived Concentration Guideline Level (DCGL) is a calculated radionuclide activity concentration within a designated survey unit that corresponds to a defined release criterion in radiation dose or risk units. Per the license requirement of 10 Code of Federal Regulations (CFR) 20 Subpart E, a release criterion of 25 millirem per year (mrem/yr) will be used for the buildings and structures included in this FSS Report. Doses from residual radioactivity will be kept as low as reasonably achievable (ALARA) whenever possible. Using MARSSIM Section 4.3.4 (equation below) and knowing that there is one alpha decay per decay of each uranium isotope, a single total uranium $DCGL_W$ of 100 disintegrations per minute alpha per 100 square centimeters (dpm alpha/100cm^2) was calculated for DU. This $DCGL_W$ was calculated using the values provided by the NRC screening guidelines of 90.6 dpm/100cm^2, 97.6 dpm/100cm^2, and 101 dpm/100cm^2 for U^{234}, U^{235}, and U^{238}, respectively, as presented in Table 5.19 of NUREG/CR-5512 (volume 3, October 1999), NUREG 1757, and the DU activity fractions discussed in Section 1.2. The $DCGL_W$ is calculated as follows:

$$DCGL_W = \frac{1}{\left(\frac{f_1}{DCGL_1}\right) + \left(\frac{f_2}{DCGL_2}\right) + \left(\frac{f_3}{DCGL_3}\right)} = \frac{1}{\left(\frac{0.084}{90.6}\right) + \left(\frac{0.012}{97.6}\right) + \left(\frac{0.904}{101}\right)} = 100 \text{ dpm alpha/100cm}^2$$

Where: $DCGL_w$ = Combined gross activity DCGL (i.e., release limit).

f_n = Activity fraction of radionuclide *n*

$DCGL_n$ = DCGL of radionuclide *n*

The total uranium $DCGL_W$ of 100 dpm alpha/100cm^2 was used as the action level for both static and scanning measurements in the buildings and on the structures.

2.0 FINAL STATUS SURVEY DESIGN

The FSS performed at the BTD site was designed in accordance with Final Status Survey guidance from MARSSIM (NRC, 2000). FSS activities consisted of scanning surveys over 100% of the accessible structure surfaces. Integrated direct surface measurements were performed at frequencies based on MARSSIM guidance. Survey activities also included direct and biased smear sample collection. The FSSs were designed conservatively in that the radiological background present in the structure materials is neglected and the measured total activity is used for direct comparisons to the $DCGL_W$.

2.1 General Structure Classification Based on Contamination Potential and Survey Unit Identification

Using MARSSIM Section 5.3 as guidance, the five structures were subdivided into survey units and designated as Class 1, Class 2, or Class 3 survey units. The following subsections describe how each structure was subdivided and classified. Appendix E presents individual SU schematic diagrams along with direct (integrated) measurement/smear locations.

2.1.1 BTD Armor Reclamation Facility

The BARF was subdivided into four Class 1 SUs and one Class 3 SU as listed in Table 2-1. The floor and lower walls of the northern room of the BARF share similar contamination potential because this area housed the LAB decontamination equipment and was where the decontamination process was performed. Although the lab system was self-contained and surveys did not routinely identify transferable contamination on the floor or walls, contaminated materials were moved through this room via the south rollup door to be loaded in and out of the LAB system. In accordance with MARSSIM guidance, the south room floor and lower walls were considered Class 1 SUs as well because this area was once used to store containerized contaminated trash.

Since the upper wall and ceiling surfaces of the north and south rooms share similar potential for contamination, these areas were combined into one Class 3 SU. The potential for contamination on the upper walls and ceiling surface in the north room is small because no contamination was identified on the LAB HEPA filter or at downstream areas in the ventilation system. The lack of activity downstream of the HEPA filter indicates a well-designed system that did not release airborne radioactivity to the environs. In addition, transferable contamination was not identified during routine surveys in the BTD Armor Reclamation Facility, and the primary mechanism for transport (i.e., ventilation system) was not contaminated.

Maps presenting the BARF SU delineations and the reference coordinate system are presented in Appendix E.

Table 2-1: BTD Armor Reclamation Facility Survey Units

Description	Area (m^2)	Material	MARSSIM Survey Class
North Room Floor	88.8	Concrete	1
South Room Floor	88.8	Concrete	1
North Room Lower Walls	76.6	Foam / Sheet Metal	1
South Room Lower Walls	76.6	Foam / Sheet Metal	1
Ceilings and Upper Walls	488	Foam / Sheet Metal	3

2.1.2 Wash Rack #2

Wash Rack #2 was divided into three Class 1 SUs and one Class 2 SU as listed in Table 2-2. The floor and lower walls of Wash Rack #2 has a history of contamination and contamination potential because this structure was used to store DU waste. DU contamination has been identified previously on the floor of this facility during past routine surveys. The floor area in Wash Rack #2 was remediated for DU contamination prior to the initiation of the FFS.

The ceiling and upper walls of Wash Rack #2 are classified as Class 2 due to remediation activities being performed previously on the floor of this facility.

Maps presenting the Wash Rack #2 SU delineations and the reference coordinate system are presented in Appendix E.

Table 2-2: Wash Rack #2 Survey Units

Description	Area (m^2)	Material	MARSSIM Survey Class
Floor South Side	68	Metal	1
Floor North Side	68	Metal	1
Lower Walls	90	Metal	1
Ceiling and Upper Walls	346	Metal	2

2.1.3 Wash Rack #3

Wash Rack #3 was divided into three Class 1 SUs and one Class 2 SU as listed in Table 2-3. The floor and lower walls of Wash Rack #3 has a history of contamination and contamination potential because this structure was used to store DU waste. DU contamination has been identified previously on the floor of this facility during past routine surveys. The floor area in Wash Rack #3 was remediated for DU contamination prior to the initiation of the FFS.

The ceiling and upper walls of Wash Rack #3 are classified as Class 2 due to prior remediation activities performed on the floor of this facility.

Maps presenting the Wash Rack #3 SU delineations and the reference coordinate system are presented in Appendix E.

Table 2-3: Wash Rack #3 Survey Units

Description	Area (m^2)	Material	MARSSIM Survey Class
Floor South Side	68	Metal	1
Floor North Side	68	Metal	1
Lower Walls	90	Metal	1
Ceiling and Upper Walls	346	Metal	2

2.1.4 Concrete Pad #2

Concrete Pad #2 was designated a Class 1 survey unit. Due to its size, the pad was divided into two survey units – North and South. Each survey unit is approximately 107 m^2.

2.1.5 Concrete Pad #1

Concrete Pad #1 was designated a Class 1 survey unit. Due to its size, the pad was divided into two survey units – North and South. Each survey unit is approximately 60 m^2.

2.2 Survey Instrumentation and Survey Techniques

Instrumentation used in the survey consisted of direct alpha scan and integrated surface detectors, and alpha/beta smear counters. A number of both types of instruments were used due to the extended duration of the surveys. All instruments were properly calibrated (appendix I), QC checked (appendix F), and operated in accordance with standard operating procedures (section 4.0).

2.2.1 Direct Surface Alpha Radioactivity Scan Surveys and Integrated Direct Surface Alpha Radioactivity Measurements

Direct alpha scanning was performed to identify surface locations on structures where contaminant concentrations may exceed the criterion for unrestricted release. Integrated direct measurements (i.e., static measurements) of surface alpha radioactivity were performed during the FSS to compare contaminant levels at discrete sampling locations on building interior surfaces to the release criterion and to facilitate statistical testing, if necessary. Scanning and integrated direct surface measurements were performed using the instruments listed in Table 2-4.

Table 2-4: Instruments Used for Scanning and Integrated Direct Surface Measurements

Instrument Used (Meter and Probe)	Dates Used	Building or Structure Where Used
Ludlum Model 2224-1 portable alpha/beta scaler/ratemeter (serial number [S/N] 162425) with the Ludlum model 43-93 100 cm^2 alpha/beta detector (S/N 182403)	5/28/03, 5/29/03, 6/4/03 6/11/03, 6/12/03, 6/13/03, 6/19/03, 6/20/03 6/27/03 7/9/03, 7/10/03 8/12/03	Wash Rack #2 Wash Rack #3 Wash Racks #2 and #3 Wash Rack #3 DU Test Enclosure Building
Ludlum Model 2224-1 portable alpha/beta scaler/ratemeter (S/N 162426) with the Ludlum model 43-89 126 cm^2 alpha/beta detector (S/N 193921)	5/5/03, 5/14/03, 5/15/03 5/19/03, 5/20/03, 5/22/03, 5/28/03, 5/29/03. 6/6/03 6/9/03 6/10/03 6/11/03, 6/12/03, 6/13/03 6/19/03 6/20/03 6/26/03, 6/27/03, 7/9/03, 7/10/03 3/30/04 3/31/04	BTD Armor Reclamation Facility Wash Rack #2 Wash Racks #2 and #3 DU Test Enclosure Building DU Test Enclosure Building and Wash Rack #3 Wash Rack #3 DU Test Enclosure Building and Wash Rack #3 Wash Racks #2 and #3 Wash Rack #3 Wash Rack #2
Ludlum Model 2224 portable alpha/beta scaler/ratemeter (S/N 183048) with the Ludlum Model 43-68 large area (126 cm^2) gas proportional detector (S/N 161781)	5/8/03	BTD Armor Reclamation Facility
Ludlum Model 2360 alpha/beta data logger (S/N 193675) with the Ludlum Model 43-37 area floor monitor (S/N 161687)	5/7/03, 5/8/03, 5/9/03, 5/12/03, 5/13/03, 5/14/03, 5/15/03, 6/2/03 6/4/03, 6/5/03, 6/6/03 6/9/03 6/11/03, 6/12/03, 6/16/03, 6/19/03 6/20/03, 6/23/03, 6/24/03 6/25/03	BTD Armor Reclamation Facility Wash Rack #2 Wash Racks #2 and #3 Wash Rack #3 Wash Racks #2 and #3
Ludlum Model 2360 alpha/beta data logger (S/N 184938) with the Ludlum Model 43-37 area floor monitor (S/N 178371)	6/8/04, 6/9/04, 6/10/04	Concrete Pads #1 and #2
Ludlum Model 2360 alpha/beta data logger (S/N 202398) with the Ludlum model 43-93 100 cm^2 alpha/beta detector (S/N 211706)	6/8/04, 6/9/04, 6/10/04	Concrete Pads #1 and #2

2.2.2 Smear Sample Collection and Analysis

Gross transferable alpha contamination was collected and analyzed to determine if transferable activity is less than or equal to 10% of total activity as assumed in the NUREG/CR-5512 and NUREG 1757 documents for screening level guidelines.

Smear samples were collected over approximately 100 cm^2 areas at systematic and biased locations identified during scanning activities. Smear samples were analyzed for alpha and beta radioactivity using a Ludlum Model 2929 alpha/beta scintillation counter. Three different units were used during the field activities, as summarized in Table 2-5.

Table 2-5: Alpha/Beta Scintillation Counter Used for Transferable Activity Measurements

Instrument Used (Meter and Probe)	Dates Used	Building or Structure Where Used
Ludlum Model 2929 alpha/beta scintillation counter (S/N 163827) with attached 43-10-1 probe (S/N 171322)	5/5/03, 5/8/03, 5/9/03, 5/12/03, 5/13/03, 5/14/03	BTD Armor Reclamation Facility
	5/15/03	BTD Armor Reclamation Facility, Wash Rack #2
	5/19/03, 5/20/03, 5/21/03, 5/22/03, 5/28/03, 5/29/03, 5/30/03	Wash Rack #2
	6/2/03, 6/3/03, 6/4/03, 6/6/03, 6/9/03	DU Test Enclosure Building and Wash Rack #2
	6/10/03	DU Test Enclosure Building
	6/11/03, 6/12/03, 6/16/03	Wash Rack #3
	6/26/03, 6/27/03	Wash Racks #2 and #3
	7/8/03	Wash Rack #2
	7/9/03, 7/10/03	Wash Rack #3
Ludlum Model 2929 alpha/beta scintillation counter (S/N 180830) with attached 43-10-1 probe (S/N 207849)	3/30/04	Wash Rack #3
	3/31/04	Wash Rack #2
Ludlum Model 2929 alpha/beta scintillation counter (S/N 171590) with attached 43-10-1 probe (S/N 174813)	6/8/04, 6/9/04, 6/10/04	Concrete Pads #1 and #2

2.3 Number of Static Measurements

MARSSIM provides a method to determine the number of measurement locations required in a given survey unit. A minimum number of measurement locations are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The following subsections describe the bases for and derivation of the minimum required measurement locations per survey unit.

2.3.1 Estimation of Relative Shift

The minimum number of measurement locations required is dependent on the distribution of site residual radionuclide concentrations relative to the $DCGL_w$ and acceptable decision error limits (α and β).

The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated using the guidance found in Section 5.5.2.3 of MARSSIM. The relative shift is calculated as follows:

$$\Delta/\sigma = \frac{DCGL_w - LBGR}{\sigma}$$

Where: $DCGL_w$= Derived Concentration Guideline Level

LBGR = concentration at the lower bound of the gray region. The Lower Bound of the Grey Region (LBGR) is the concentration at which the survey unit has an acceptable probability of passing the statistical tests.

σ = an estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system).

As previously stated, the $DCGL_w$ for surface alpha radioactivity is 100 dpm/100cm^2. The LBGR was conservatively estimated at 70 dpm alpha/100 cm^2 based on previous studies with similar instruments on concrete. Without prior survey, it is reasonable to assume a coefficient of variation on the order of 30 percent (MARSSIM Section 5.5.2.2). Using a coefficient of variation of 30 percent and the LBGR as an estimate of the sample mean, a sigma value of 21 dpm/100cm^2 is estimated. Using the parameters discussed above, the relative shift is calculated as 1.4.

2.3.2 Determination of N (Number of Required Measurement Locations)

The final number of required measurement locations per survey unit is 20 as per MARSSIM (Table 5.5) given a relative shift of 1.4 and an error rate for both Type I and Type II errors of five percent (i.e., $\alpha = \beta = 0.05$). The actual number of measurements taken in each survey unit ranges from 20 to 24 samples based on the size of the survey area.

2.4 Elevated Measurement Criterion ($DCGL_{EMC}$)

MARSSIM states that, for Class 1 survey units, a dose area factor should be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion. For the purpose of ALARA, the $DCGL_W$ will be used as the $DCGL_{EMC}$, which corresponds to an area factor of one. Since the

scan minimum detectable concentration of the instrumentation is sensitive enough to identify the $DCGL_W$ with a 90% confidence limit (refer to Appendices B, C, and D), it is unlikely that small areas of elevated activity exceeding the $DCGL_W$ would be missed during surface scans.

2.5 Static Measurement Locations

Measurement locations in Class 1 and Class 2 survey units were established using a random start point in a systematic rectangular grid. The Class 3 survey unit measurement locations were randomly selected. The grid spacing for Class 1 and Class 2 survey units was determined, based on the measured area of the survey unit, using the following equation (Equation 5-7 from MARSSIM).

$$L = \sqrt{\frac{A}{0.866N}}$$

Where: L = rectangular grid spacing for survey unit

A = area of survey unit

N = number measurement locations

Measurement spacing results (L) using the equation above are presented in Table 2-6. Maps presenting the SU delineations are presented in Appendix E.

Table 2-6: Summary of Area, Number of Data Points, and Grid Spacing by SU

Survey Unit Description	Survey Unit Class	Area, A (m^2)	Number of Data Points, N	Grid Spacing, L (m)
BARF – North Room Floor	1	88.8	24	2.058
BARF – South Room Floor	1	88.8	24	2.058
BARF – North Room Lower Walls	1	76.6	24	1.920
BARF – South Room Lower Walls	1	76.6	24	1.920
BARF – Ceilings and Upper Walls	3	488	21	5.180
Wash Rack #2 – Floor South Side	1	68	20	1.859
Wash Rack #2 – Floor North Side	1	68	20	1.859
Wash Rack #2 – Lower Walls	1	90	24	2.134
Wash Rack #2 – Ceiling and	2	346	20	4.176

Survey Unit Description	Survey Unit Class	Area, A (m^2)	Number of Data Points, N	Grid Spacing, L (m)
Upper Walls				
Wash Rack #3 – Floor South Side	1	68	20	1.859
Wash Rack #3 – Floor North Side	1	68	20	1.859
Wash Rack #3 – Lower Walls	1	90	24	2.134
Wash Rack #3 – Ceiling and Upper Walls	2	346	20	4.176
Concrete Pad #2 – North	1	107	20	2.486
Concrete Pad #2 -- South	1	107	20	2.486
Concrete Pad #1 -- North	1	60	20	1.861
Concrete Pad #1 -- South	1	60	20	1.861

3.0 RESULTS

Field activities took place during three separate mobilizations. The first mobilization began May 3, 2003 and ended August 27, 2003. The second mobilization began February 10, 2004 and ended March 31, 2004. The third mobilization began June 8, 2004 and ended June 15, 2004. Appendix F contains a table that documents every day that CABRERA personnel were on-site, the instruments used, and the activities performed.

All raw data collected on Radiological Survey Maps for each SU (survey unit) are provided in Appendix G. Scan survey results are provided graphically in the Figures section of this FSS Report and are referenced in the following sub-sections. Additional data for each SU include worksheets that convert the raw data (recorded in counts per minute) to dpm/100cm^2 for integrated direct measurements (integrated one minute counts) from each one meter square grid with cross-reference to grid numbers) and 100 cm^2 smear results from each one meter square grid with cross-reference to grid numbers. These worksheets are provided in Appendix H.

3.1 BTD Armor Reclamation Facility

3.1.1 Surface Alpha Radioactivity Scan Surveys

The floors and the lower walls were surveyed for surface alpha radioactivity in the BTD Armor Reclamation Facility. All of these areas are designated MARSSIM Class 1. The ceiling and upper walls are designated MARSSIM Class 3. In the Figures section, Figures 3 through 11 graphically depict the results of the scan surveys. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.1.2 Integrated Direct Surface Alpha Radioactivity Measurements

The BARF was divided into five SUs – the North Floor Room, the South Floor Room, the North Room Lower Walls, and the South Room Lower Walls were Classified MARSSIM Class 1 SUs. The Ceiling and Upper Walls were classified MARSSIM Class 3 SUs. Twenty-four integrated direct surface alpha measurements were taken on the North Floor Room and the maximum reading was 30.1 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the South Floor Room, and the maximum reading was 20.0 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the North Room Lower Walls and the maximum reading was 12.0 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the South Room Lower Walls and the maximum reading was 10.0 dpm/100cm^2. Twenty-one integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 14.3 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.1.3 Smear Sample Collection and Analysis

All smear samples taken from the BARF resulted in alpha measurements of less than 10 dpm/100cm^2. Twenty-four smear samples were taken on the North Floor Room and the maximum alpha reading was 6.5 dpm/100cm^2. Twenty-four smear samples were taken on the

South Floor Room and the maximum alpha reading was 6.5 dpm/100cm². Twenty-two smear samples were taken on the North Room Lower Walls and the maximum alpha reading was 5.8 dpm/100cm². Twenty-five smear samples were taken on the South Room Lower Walls and the maximum reading was 4.1 dpm/100cm². Twenty-three smear samples were taken on the Ceiling and Upper Walls and the maximum reading was 4.2 dpm/100cm².

3.1.4 Recommendation

In accordance with the BARF FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm² and all smear measurements are less than the DCGL of 10 dpm/100cm². Therefore, the North Room Floor, the South Room Floor, the North Room Lower Wall, the South Room Lower Wall, and the Ceiling and Upper Walls SUs are recommended for unrestricted release.

3.2 Wash Rack #2

3.2.1 Surface Alpha Radioactivity Scan Surveys

The floor and the lower walls were surveyed for surface alpha radioactivity in Wash Rack #2. All of these areas are designated MARSSIM Class 1. The ceiling and upper walls are designated MARSSIM Class 2 and approximately 10% of the total area was scanned for alpha activity. All scans of ceiling and upper walls resulted in alpha counts that were equal to or below background, so results of these scans were not recorded on official CABRERA forms. In the Figures section of this FSS, Figures 12 through 16 graphically depict the results of the scan surveys on the floor and lower walls. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm².

3.2.2 Integrated Direct Surface Alpha Radioactivity Measurements

Wash Rack #2 was divided into four SUs – the North Floor, the South Floor, and the Lower Walls were classified Class 1 and the Ceiling and Upper Walls were classified Class 2. Twenty integrated direct surface alpha measurements were taken on the North Floor and the maximum reading was 15.0 dpm/100cm². Twenty integrated direct surface alpha measurements were taken on the South Floor and the maximum reading was 11.9 dpm/100cm². Twenty-four integrated direct surface alpha measurements were taken on the Lower Walls and the maximum reading was 13.9 dpm/100cm². Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 10.0 dpm/100cm². Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.2.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on the North Floor and the maximum reading was 2.7 dpm/100cm². Twenty smear samples were taken on the South Floor and the maximum reading was 2.7 dpm/100cm². Twenty-four smear samples were taken on the Lower Walls and the

maximum reading was 2.7 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 2.7 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.2.4 Recommendation

In accordance with the Wash Rack FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, the North Floor SU, the South Floor SU, the Lower Walls SU, and the Ceiling and Upper Walls SU of Wash Rack #2 are recommended for unrestricted release.

3.3 Wash Rack #3

3.3.1 Surface Alpha Radioactivity Scan Surveys

The floor and the lower walls were surveyed for surface alpha radioactivity in Wash Rack #3. All of these areas are designated MARSSIM Class 1. The ceiling and upper walls are designated MARSSIM Class 2 approximately 10% of the total area was scanned for alpha activity. All scans of ceiling and upper walls resulted in alpha counts that were equal to or below background, so results of these scans were not recorded on official CABRERA forms. In the Figures section of this FSS, Figures 17 through 21 graphically depict the results of the scan surveys on the floor and lower walls. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.3.2 Integrated Direct Surface Alpha Radioactivity Measurements

Wash Rack #3 was divided into four SUs – the North Floor, the South Floor, and the Lower Walls were classified Class 1 and the Ceiling and Upper Walls were classified Class 2. Twenty integrated direct surface alpha measurements were taken on the North Floor and the maximum reading was 14.9 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the South Floor and the maximum reading was 6.8 dpm/100cm^2. Twenty-four integrated direct surface alpha measurements were taken on the Lower Walls and the maximum reading was 8.8 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 10.0 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.3.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on the North Floor and the maximum reading was 0.9 dpm/100cm^2. Twenty smear samples were taken on the South Floor and the maximum reading was -0.6 dpm/100cm^2. Twenty-four smear samples were taken on the Lower Walls and the maximum reading was 2.4 dpm/100cm^2. Twenty integrated direct surface alpha measurements were taken on the Ceiling and Upper Walls and the maximum reading was 0.9 dpm/100cm^2.

Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.3.4 Recommendation

In accordance with the Wash Rack FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, the North Floor SU, the South Floor SU, the Lower Walls SU, and the Ceiling and Upper Walls SU of Wash Rack #3 are recommended for unrestricted release.

3.4 Concrete Pad #2

This 22- by 15-m pad was cleaned by shot blasting it with a Blastrac^{tm}. Then the pad was surveyed with a floor monitor and Total Station. The pad was divided into two survey units (under MARSSIM requirements, this Class 1 structure was treated similar to a building interior). Systematic fixed count surveys with alpha/beta meter were completed along with smears at those locations.

3.4.1 Surface Alpha Radioactivity Scan Surveys

One hundred percent of the surface of Concrete Pad #2 was surveyed for surface alpha radioactivity. Concrete Pad #2 is designated MARSSIM Class 1. In the Figures section of this FSS, Figures 22 and 23 graphically depict the results of the scan survey. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.4.2 Integrated Direct Surface Alpha Radioactivity Measurements

Concrete Pad #2 was divided into two Class 1 SUs and they were designated North and South. Twenty integrated direct surface alpha measurements were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 27.1 dpm/100cm^2 and the maximum measurement taken on the South SU was 18.0 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.4.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 2.9 dpm/100cm^2 and the maximum measurement taken on the South SU was 1.6 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.4.4 Recommendation

In accordance with the BTD FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2.

Therefore, both the North SU and the South SU of Concrete Pad #2 are recommended for unrestricted release.

3.5 Concrete Pad #1

This pad is somewhat smaller than the pad behind Building 701. As with Concrete Pad #2, the pad was divided into two survey units. Systematic fixed count surveys with alpha/beta meter were completed along with smears at those locations.

3.5.1 Surface Alpha Radioactivity Scan Surveys

Concrete Pad #1 is designated MARSSIM Class 1. In the Figures section of this FSS, Figures 24 and 25 graphically depict the results of the scan survey. As can be observed in the figures, no alpha scanning measurements exceeded the DCGL of 100 dpm/100cm^2.

3.5.2 Integrated Direct Surface Alpha Radioactivity Measurements

Concrete Pad #1 was divided into two Class 1 SUs and they were designated North and South. Twenty integrated direct surface alpha measurements were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 33.2 dpm/100cm^2 and the maximum measurement taken on the South SU was 16.3 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.5.3 Smear Sample Collection and Analysis

Twenty smear samples were taken on both the North SU and the South SU. The maximum measurement taken on the North SU was 4.2 dpm/100cm^2 and the maximum measurement taken on the South SU was 1.6 dpm/100cm^2. Since all measurements were below the DCGL, no further statistical analysis of the data was performed.

3.5.4 Recommendation

In accordance with the BTD FSS Work Plan and consistent with MARSSIM guidance, a SU can be cleared for release where all scans and integrated direct measurements are below the DCGL of 100 dpm/100cm^2 and all smear measurements are less than the DCGL of 10 dpm/100cm^2. Therefore, both the North SU and the South SU of Concrete Pad #1 are recommended for unrestricted release.

4.0 FINAL STATUS SURVEY INSTRUMENT QUALITY ASSURANCE AND QUALITY CONTROL

The purpose of this section is to document the calibration of the radiological survey instruments used during the FSS, and the quality control tracking of each instrument as specified in the Work Plans (as documented in Appendices B, C, and D). Data collection activities were performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. The Project Engineer ensured that individuals were appropriately trained to use project instrumentation and other equipment, and that instrumentation met the required detection sensitivities.

Scanning and integrated direct measurements were performed to measure surface radioactivity levels for total uranium. These measurements were based solely on alpha emissions due to high specificity and sensitivity, and low background interference. For smear measurements, beta measurements were collected in tandem with alpha measurements as a qualitative assessment to confirm survey assumptions. Prior to the initiation of alpha survey activities, surfaces of interest were cleaned to remove dirt and grime that could shield alpha emissions from detection.

Current calibration/maintenance records were kept on site for review and inspection (included in Appendix I). The records include, at a minimum, the following:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

Instrumentation was maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments were maintained. Instruments were calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using National Institute of Standards and Technology (NIST) traceable sources. Copies of the calibration certificates for the sources are also provided in Appendix I. A chronological summary of field activities at each structure/SU and instrumentation is presented in Appendix F.

QC measurements were performed on all deployed field instruments each day, before and after each use at a minimum. A controlled area was used to perform these checks. The QC investigation levels for count rate instruments used during the FSS were ±2-sigma (2σ) (warning) and $\pm 3\sigma$ (fail). Exposure rate and other radiation detection instruments were evaluated using a qualitative ±20% against the indicated check source response on the meter. If any single measurement was found to be outside of its investigation level, the measurement was repeated. If the second count was also found to be outside of this criterion, the instrument was investigated to assess whether any external biases or instrument physical damage was present. If response checks were found to be outside of $\pm 3\sigma$, the instrument was taken out of service unless evaluated and approved by the Field Radiological Engineer or the Project Manager. Control charts for check source response, background count rates (where applicable), and copies of the daily check source logs for all instruments are provided in Appendix I.

Gross transferable alpha contamination was collected and analyzed to determine if transferable activity is less than or equal to 10% of total activity as assumed in the NUREG/CR-5512 and NUREG 1757 documents for screening level guidelines.

Smear samples were collected over approximately 100 cm^2 areas at systematic and biased locations identified during scanning activities. Smear samples were analyzed for alpha and beta radioactivity using a Ludlum Model 2929 alpha/beta scintillation counter.

Control charts for check source response, background count rates (where applicable), and copies of the daily check source logs for all instruments are provided in Appendix I.

5.0 REFERENCES

(BARG, 1995) Specific Manufacturing Capability Program, Depleted Uranium Constituents and Decay Heating, Lockheed, Idaho presentation, dated October 3, 1995.

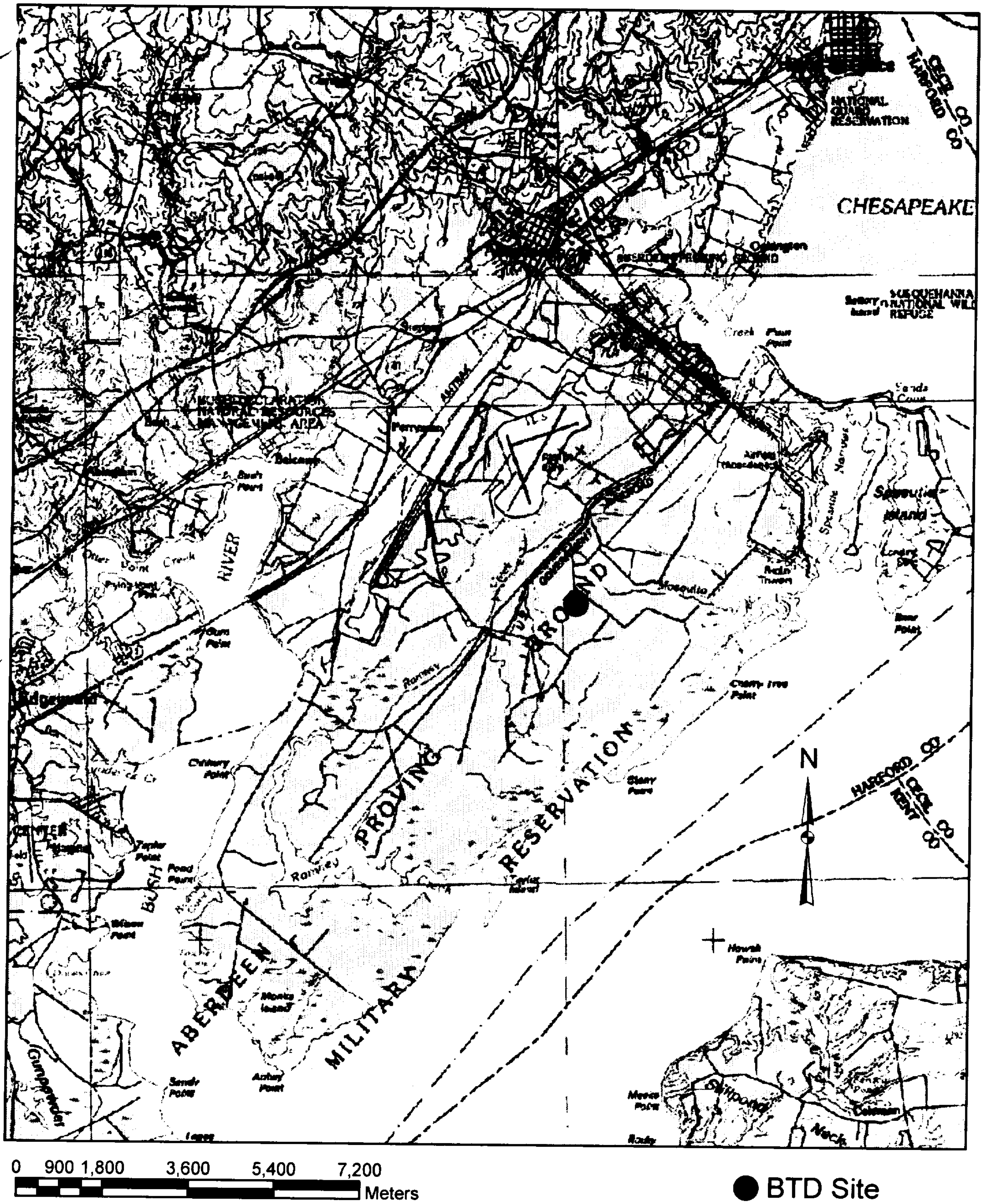
(CABRERA, 2003) CABRERA Work Plan, "Final Status Survey Plan for the Bomb Throwing Device (BTD) Site, Aberdeen Proving Ground, Aberdeen, MD", Contract DAAA09-00-G-0002/0039.

(CABRERA, 2004) CABRERA Report, "Remediation and Final Status Survey, Bomb Throwing Device Site – Soils," Contract DAAA09-00-G-0002/0039.

(NRC, 2000) NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), U.S. Nuclear Regulatory Commission, dated August, 2000.

(NRC, 2003) NUREG-1757, Consolidated NMSS Decommissioning Guidance, Rev. 1, U.S. Nuclear Regulatory Commission, September 2003.

FIGURES



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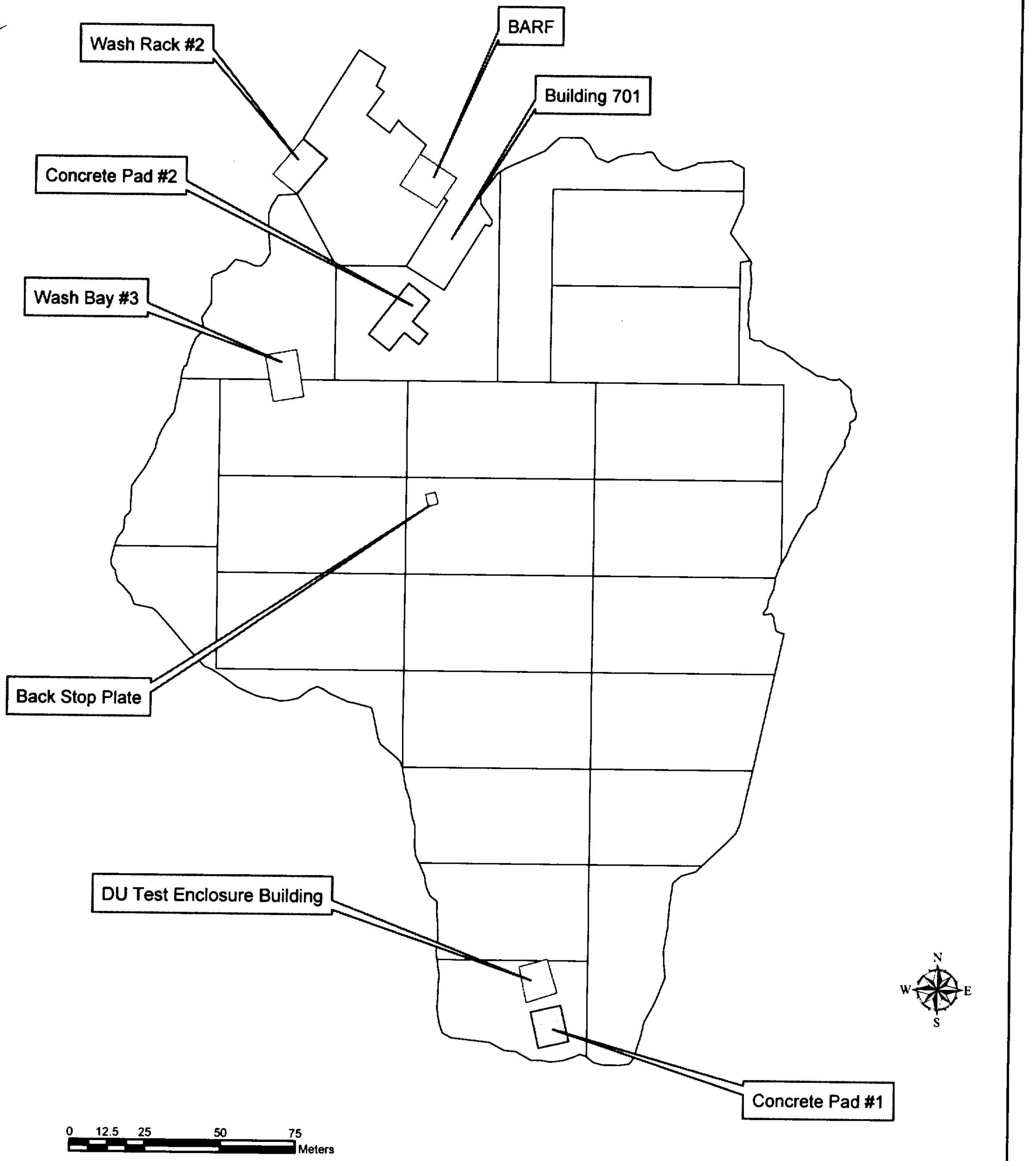
Site Location of APG	Date: 10-29-04	Project #: 01-3030.39	**Figure 1**
Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	File Name:	Prepared By: JTM	



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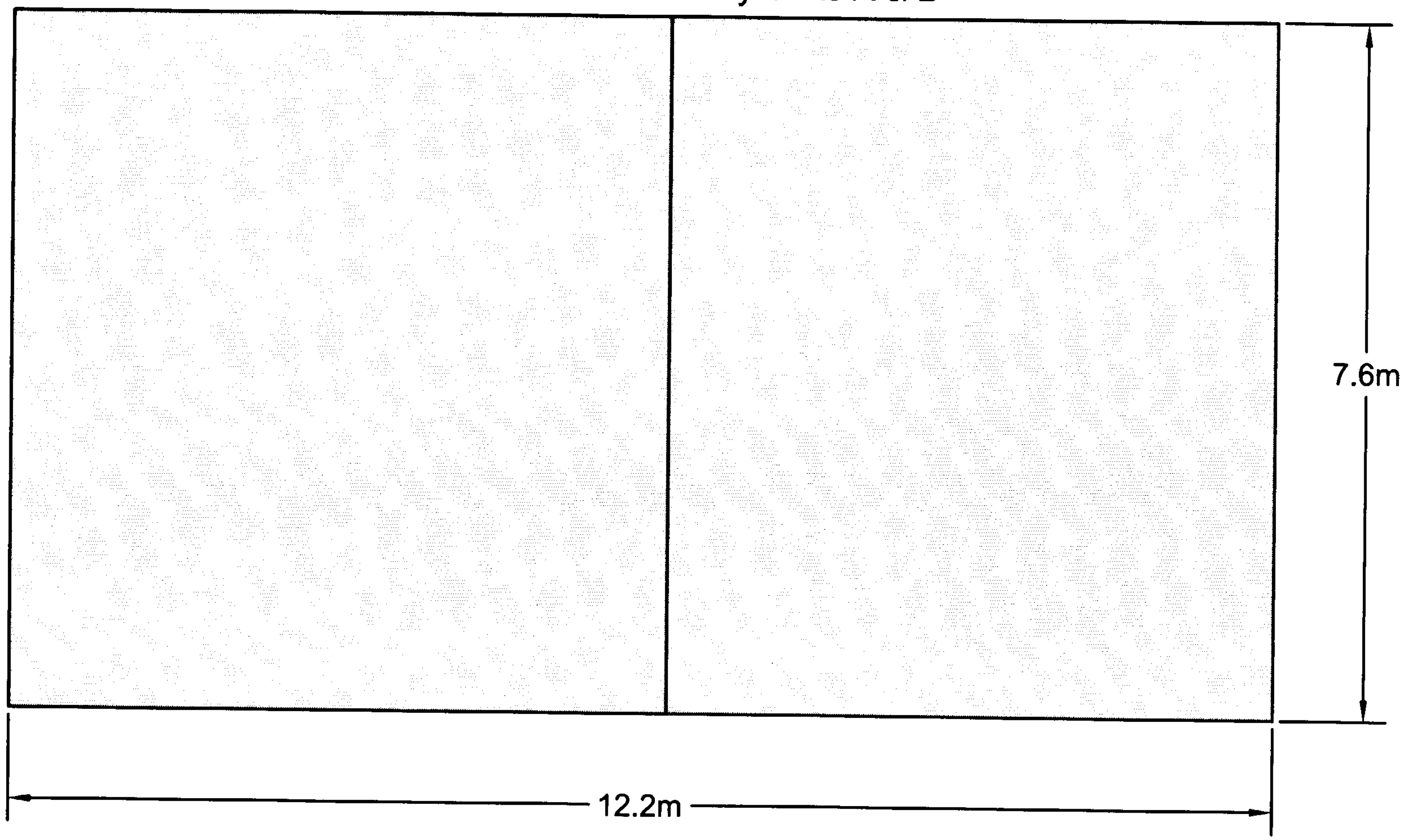
Site Survey Units

Remediation and FSS Report
BTD - Buildings
Aberdeen Proving Ground, MD

Date: 11-1-04
Project #: 01-3030-39
File Name:
Prepared By: JTM

Figure 2

BARF Building - Alpha Scan
North Room - Floor Survey Units A & B



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

10/29/2004

Scale: N.T.S.

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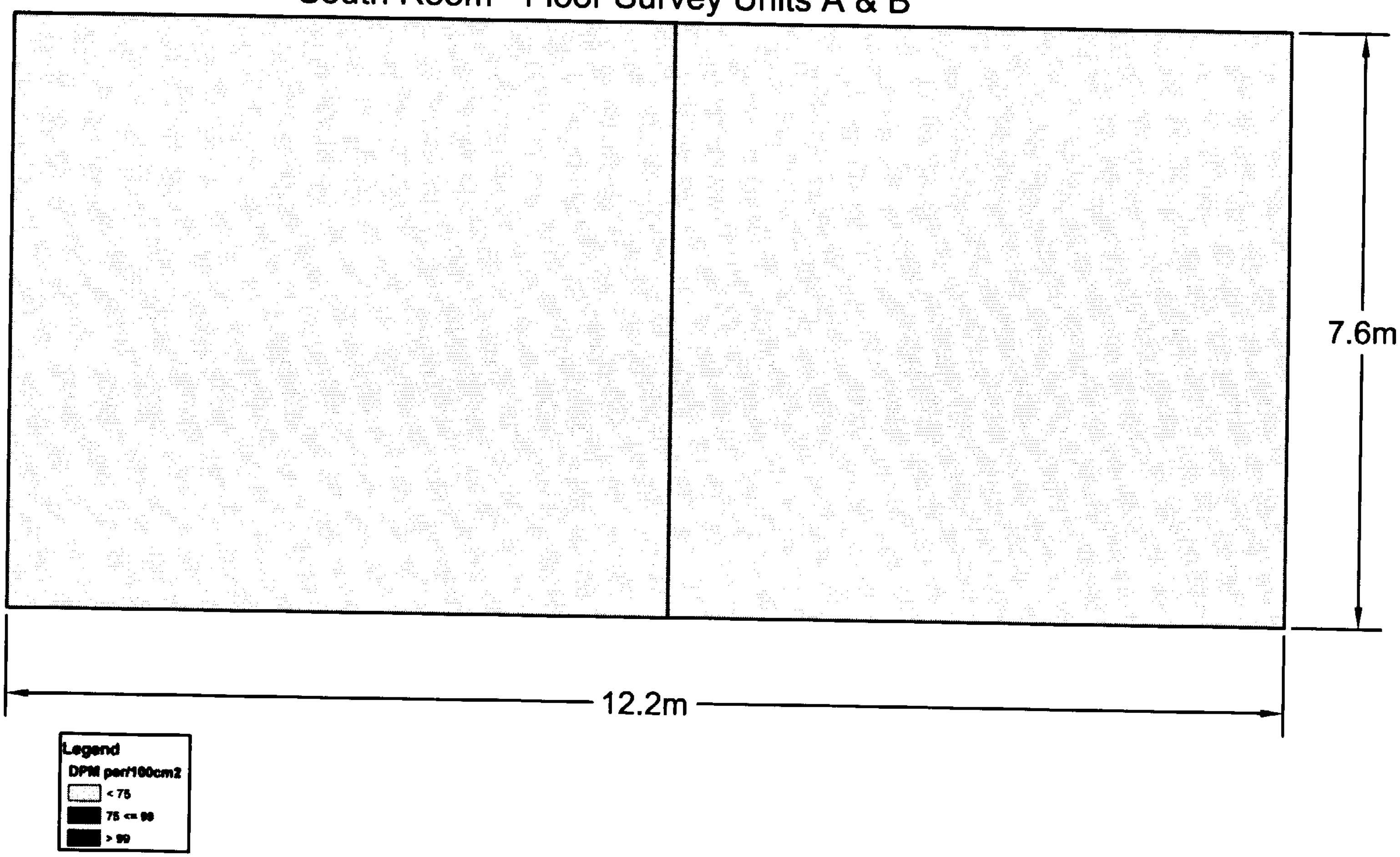
Figure: 3

BARF Building - Alpha Scan
South Room - Floor Survey Units A & B



10/29/2004
Scale: N.T.S.

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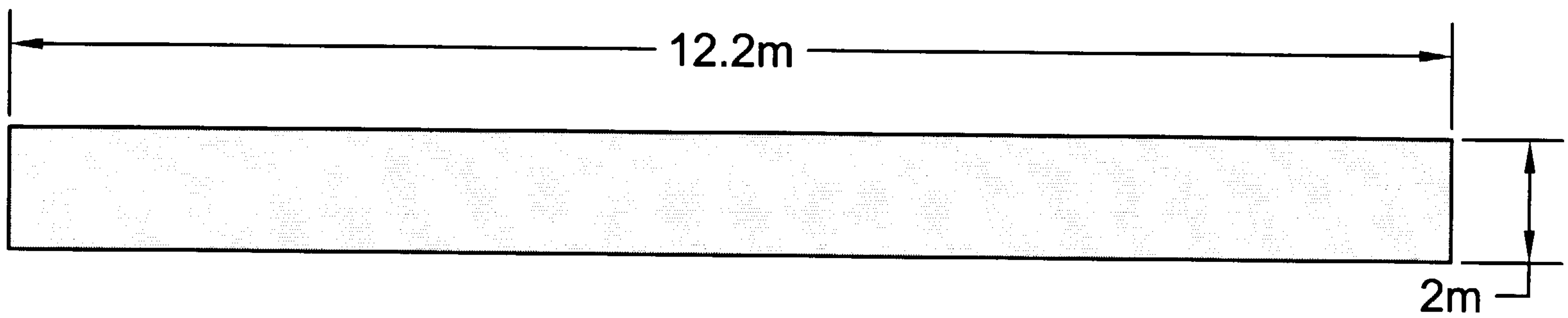
Figure: 4

BARF Building - Alpha Scan
North Room - South Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

Created by: JTM

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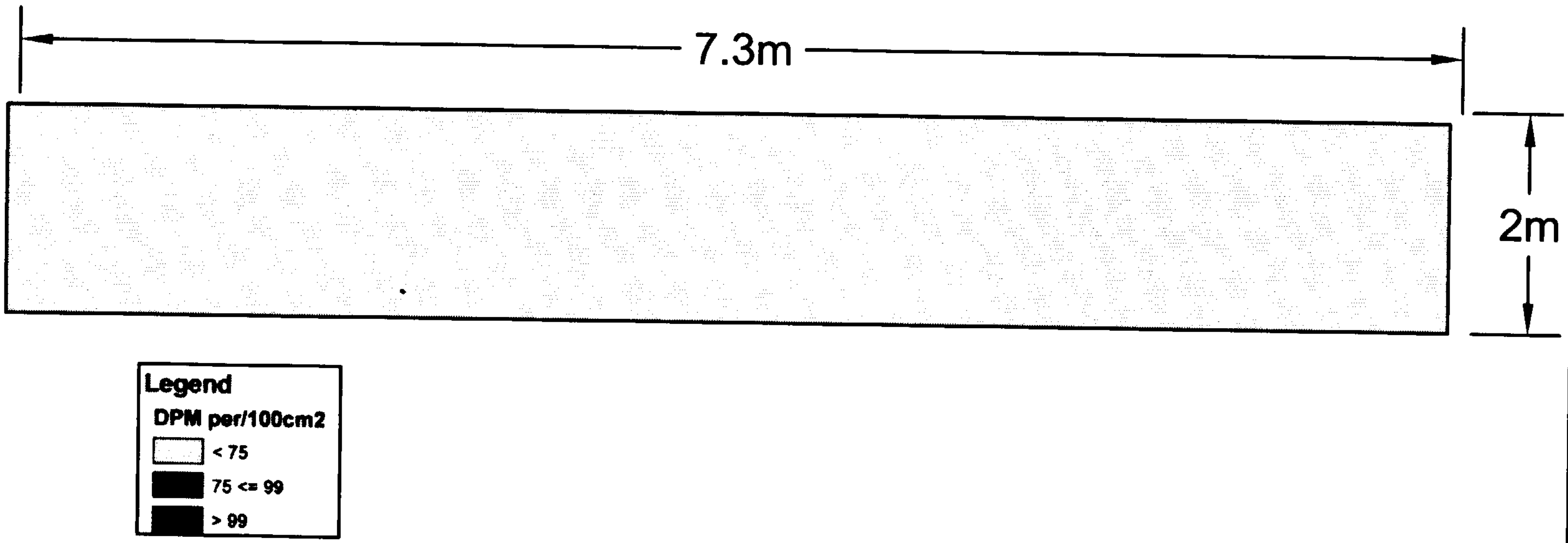
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 5

BARF Building - Alpha Scan
North Room -East Wall



Date: 11/2/2004
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Figure: 6

BARF Building - Alpha Scan
North Room - West Wall

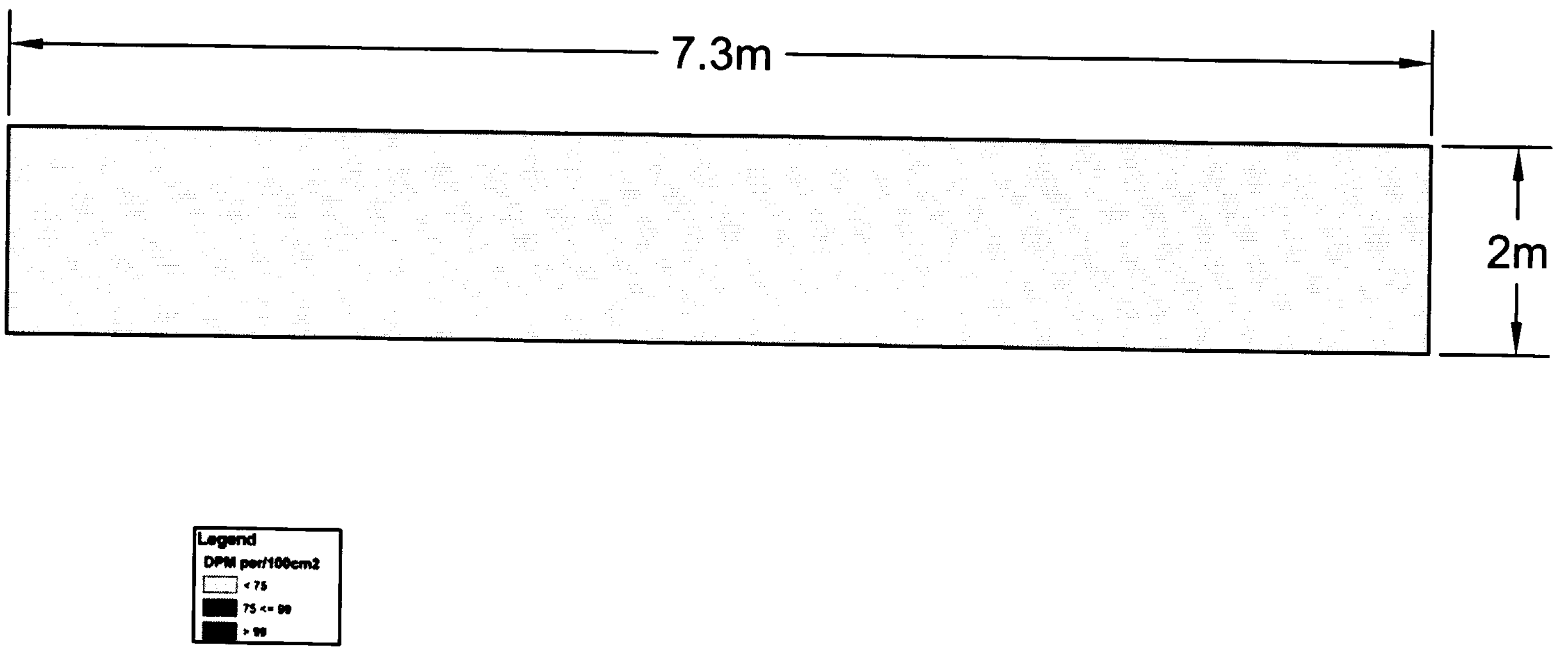

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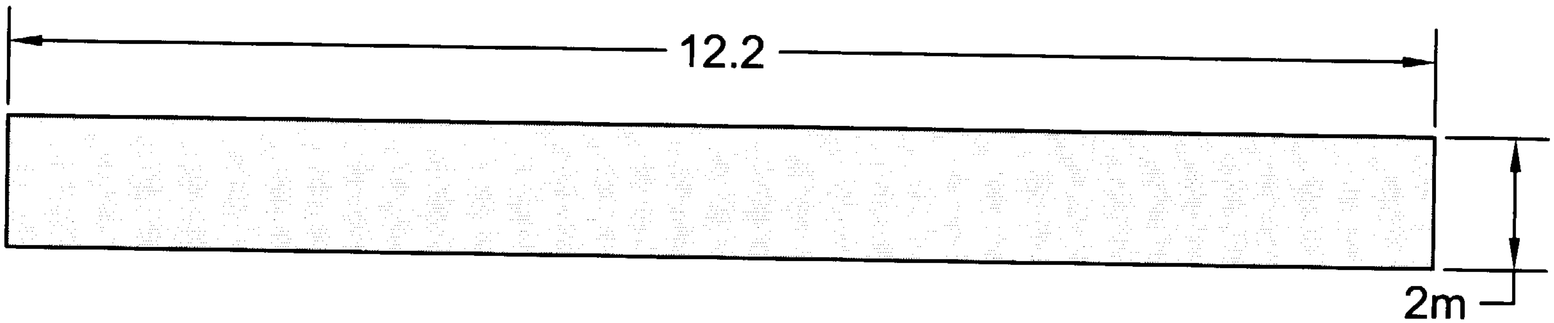
Figure: 7

BARF Building - Alpha Scan
South Room - North Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

Created by: JTM

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BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 8

BARF Building - Alpha Scan
South Room - South Wall

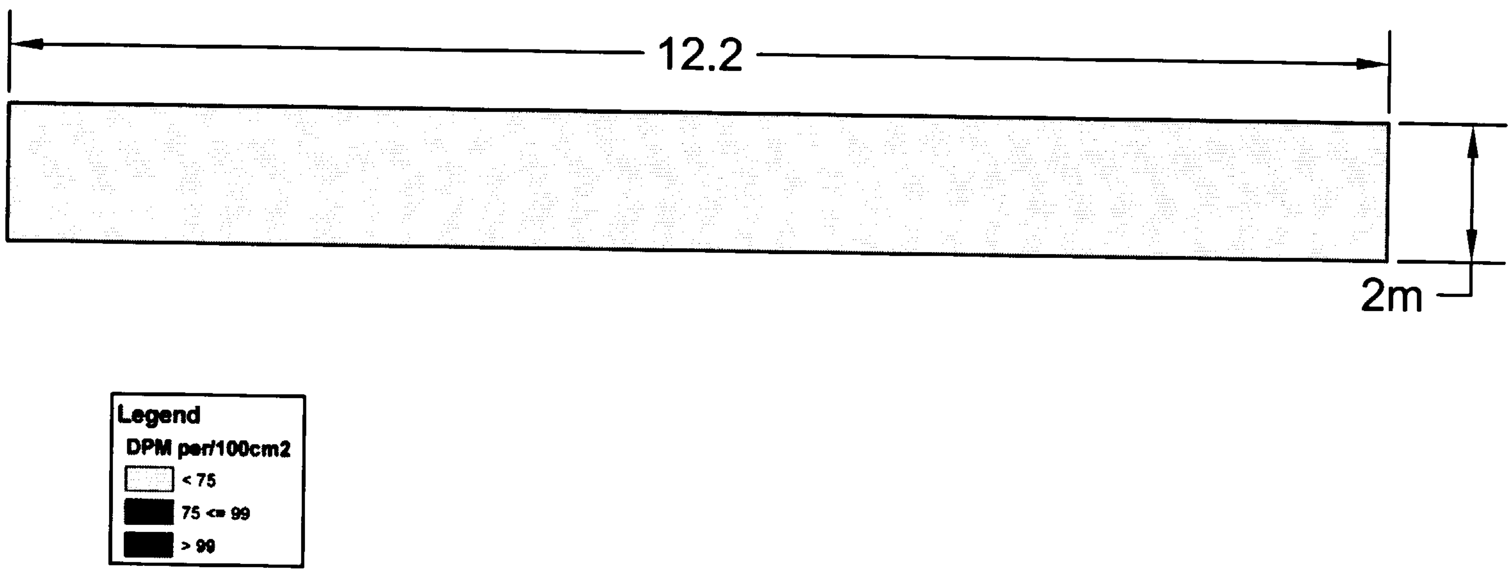

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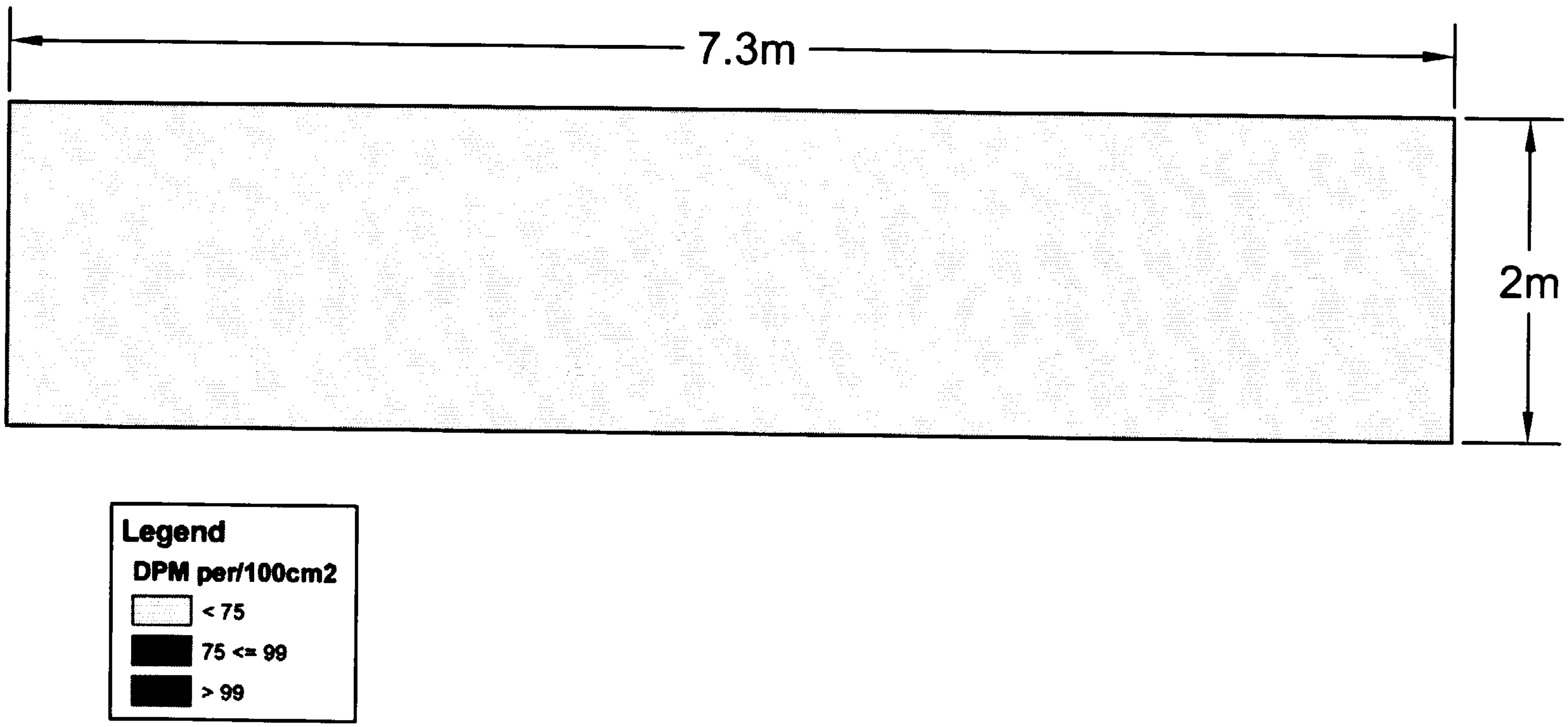
Figure: 9

BARF Building - Alpha Scan
South Room - East Wall



Date: 11/2/2004

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BTD - Buildings
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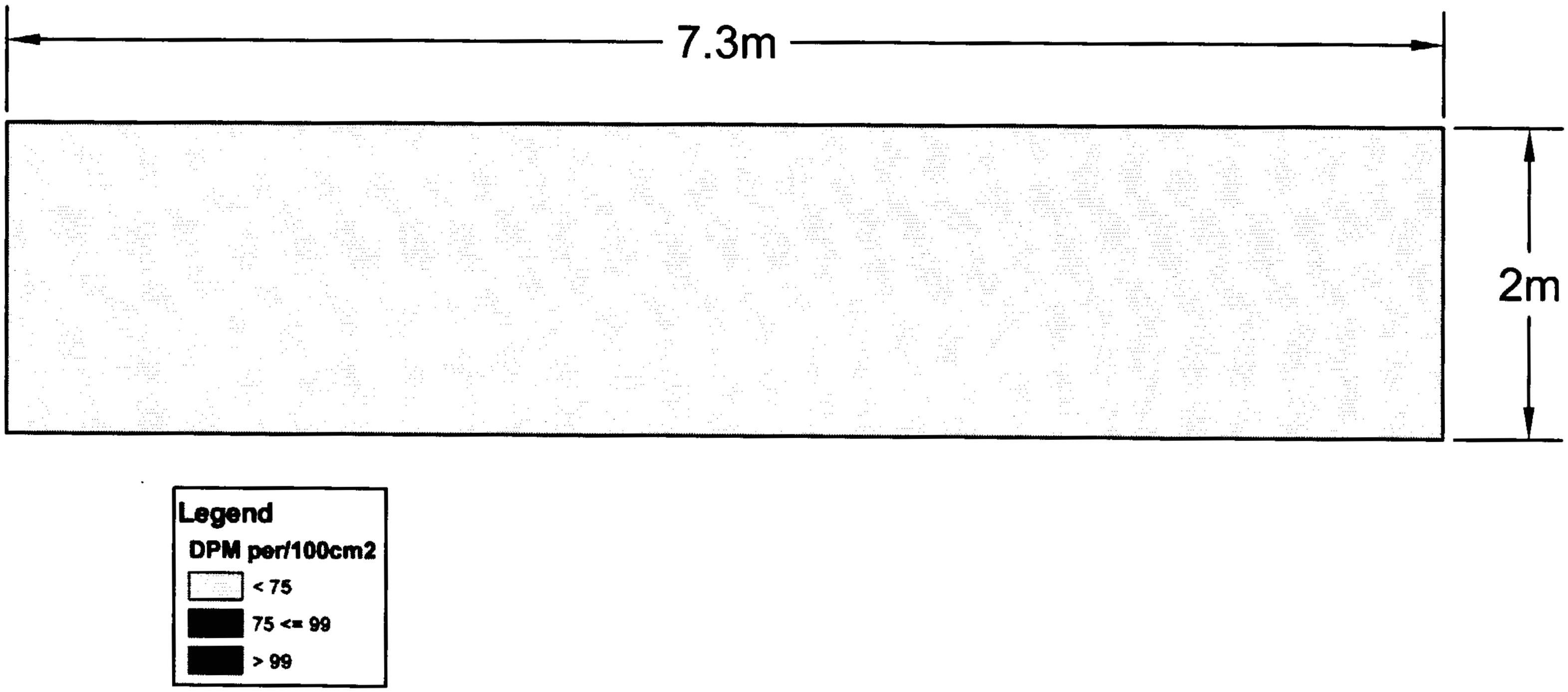
Figure: 10

BARF Building - Alpha Scan
South Room - West Wall



Date: 11/2/2004
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Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 11

Wash Rack 2 - Alpha Scan
Interior Floor

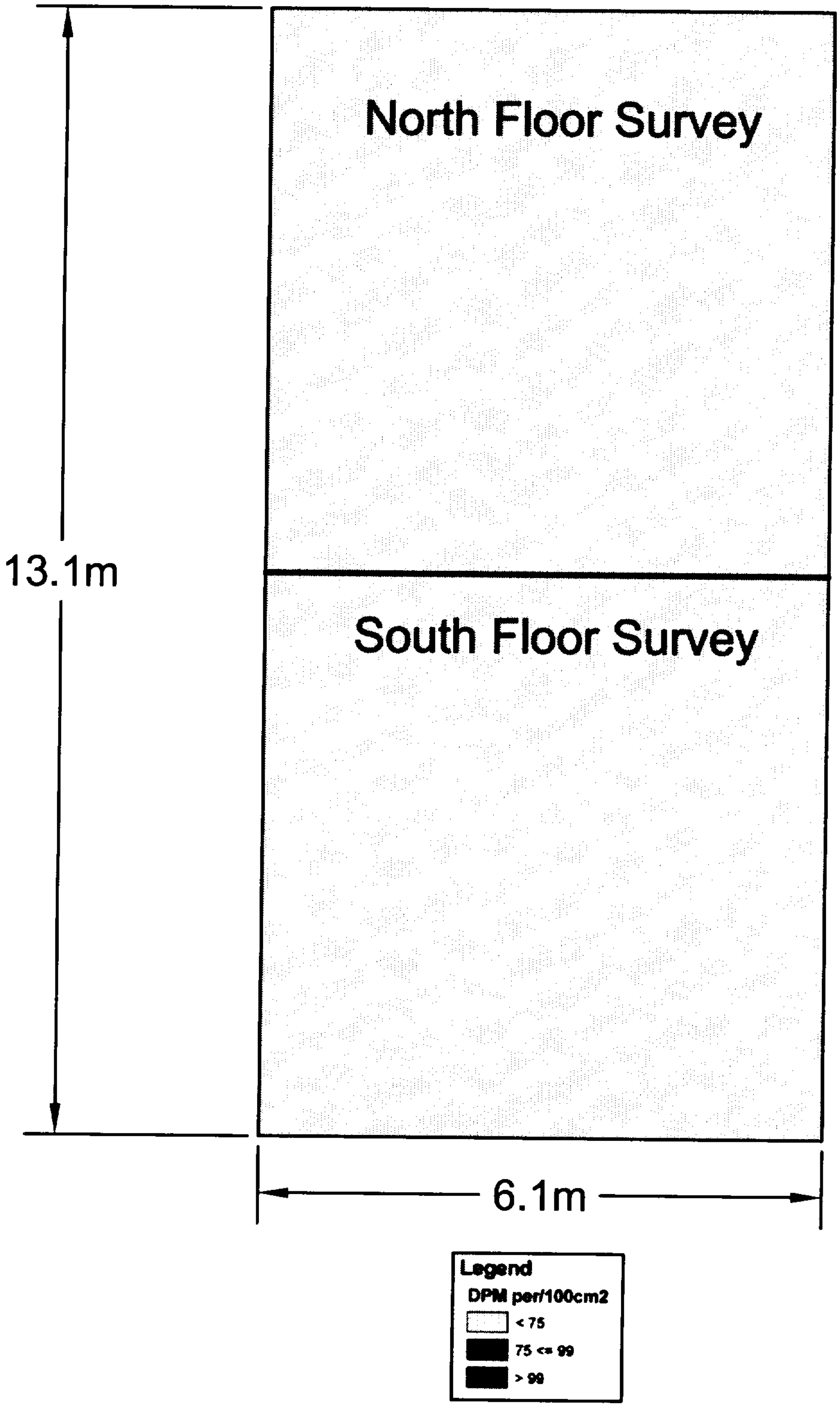
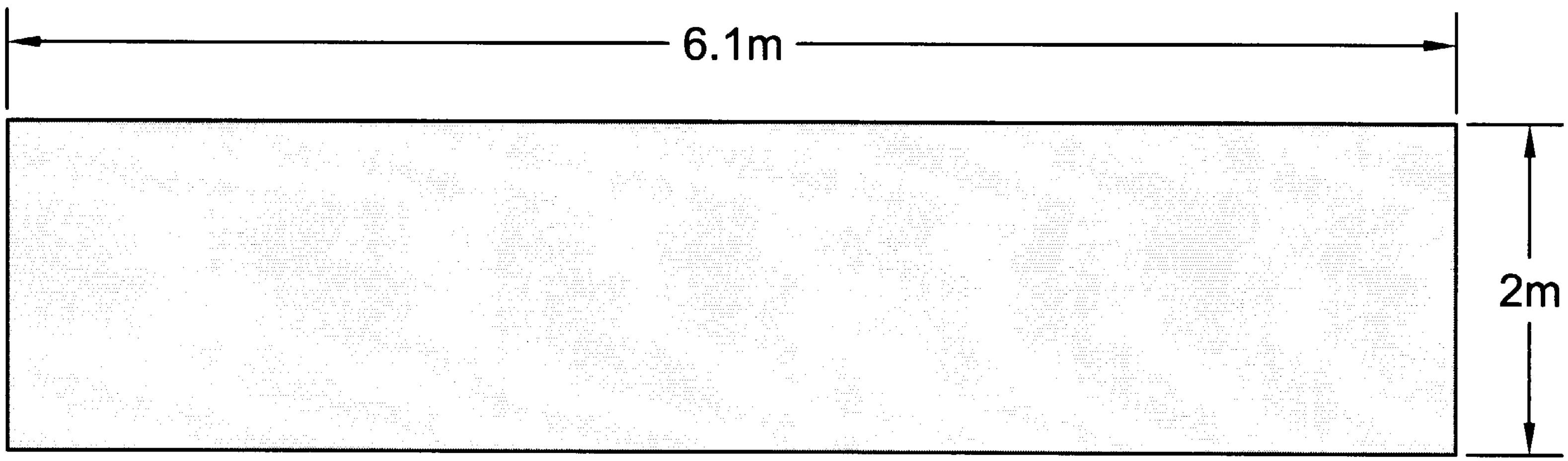


Figure: 12	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Wash Rack 2 - Alpha Scan
North Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004
Created by: JTM

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BTD - Buildings
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Figure: 13

Wash Rack 2 - Alpha Scan
South Wall

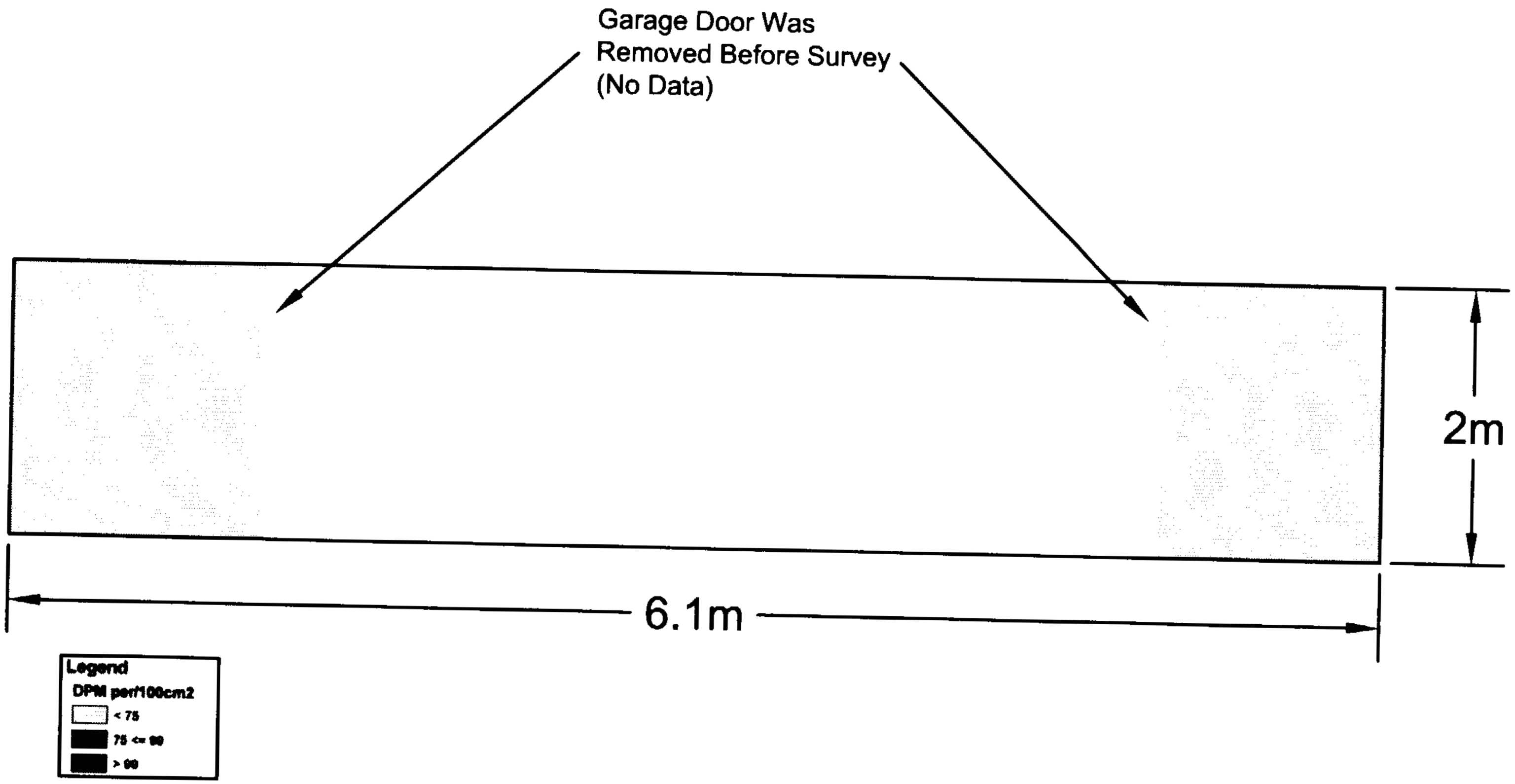

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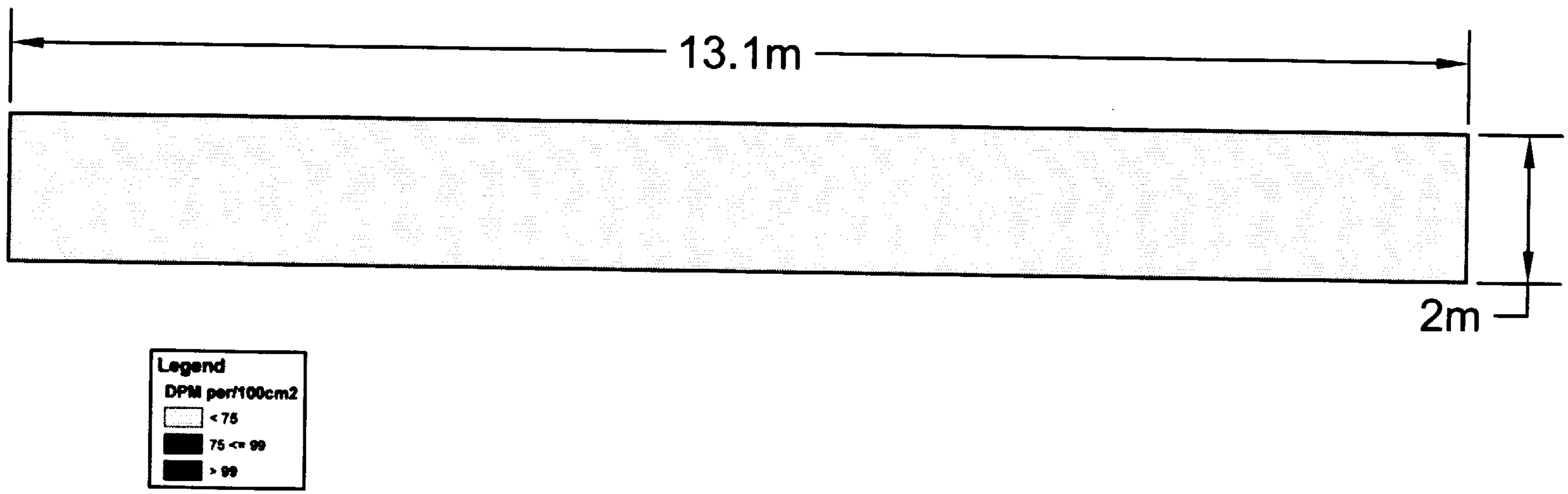
Figure:14

Wash Rack 2 - Alpha Scan
East Wall



Date: 11/2/2004
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Figure:15

Wash Rack 2 - Alpha Scan
West Wall

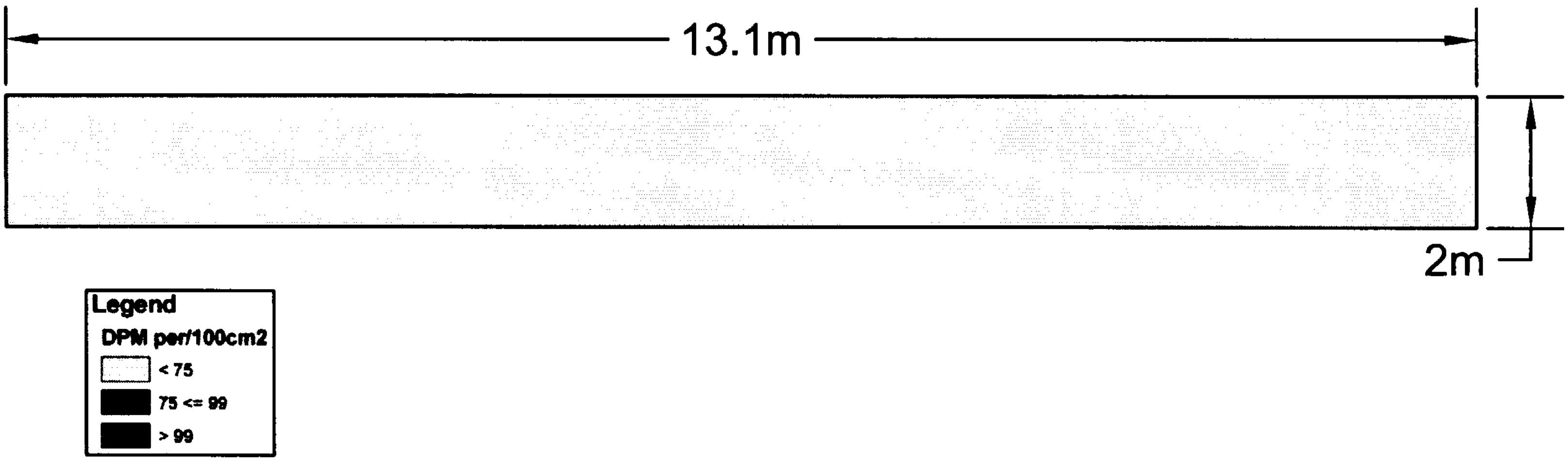

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Figure: 16

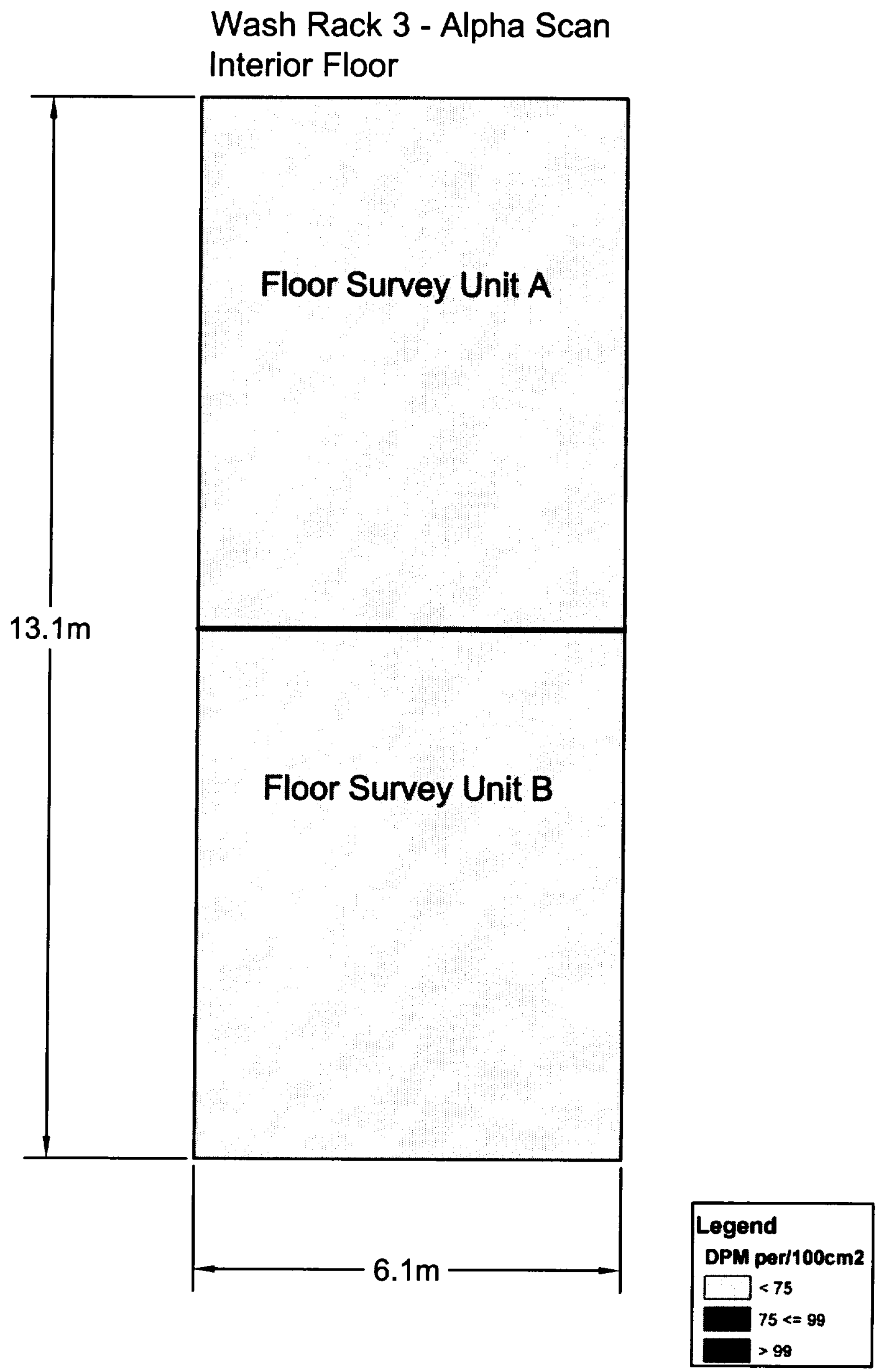

Figure: 17

Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

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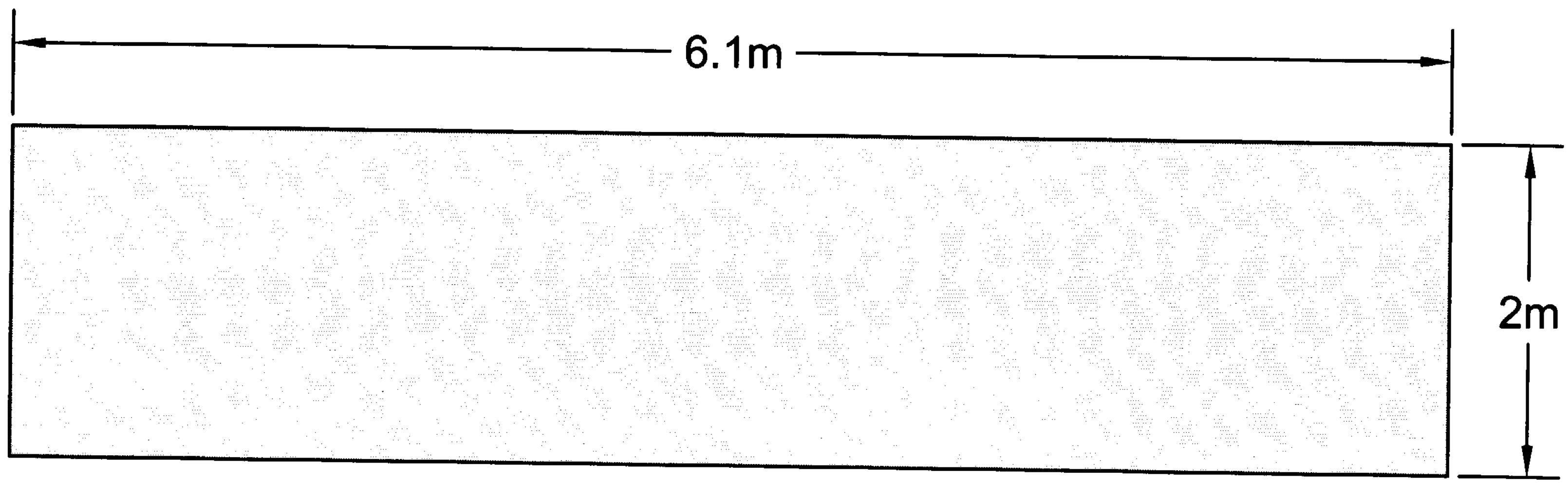
Wash Rack 3 - Alpha Scan
North Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

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BTD - Buildings
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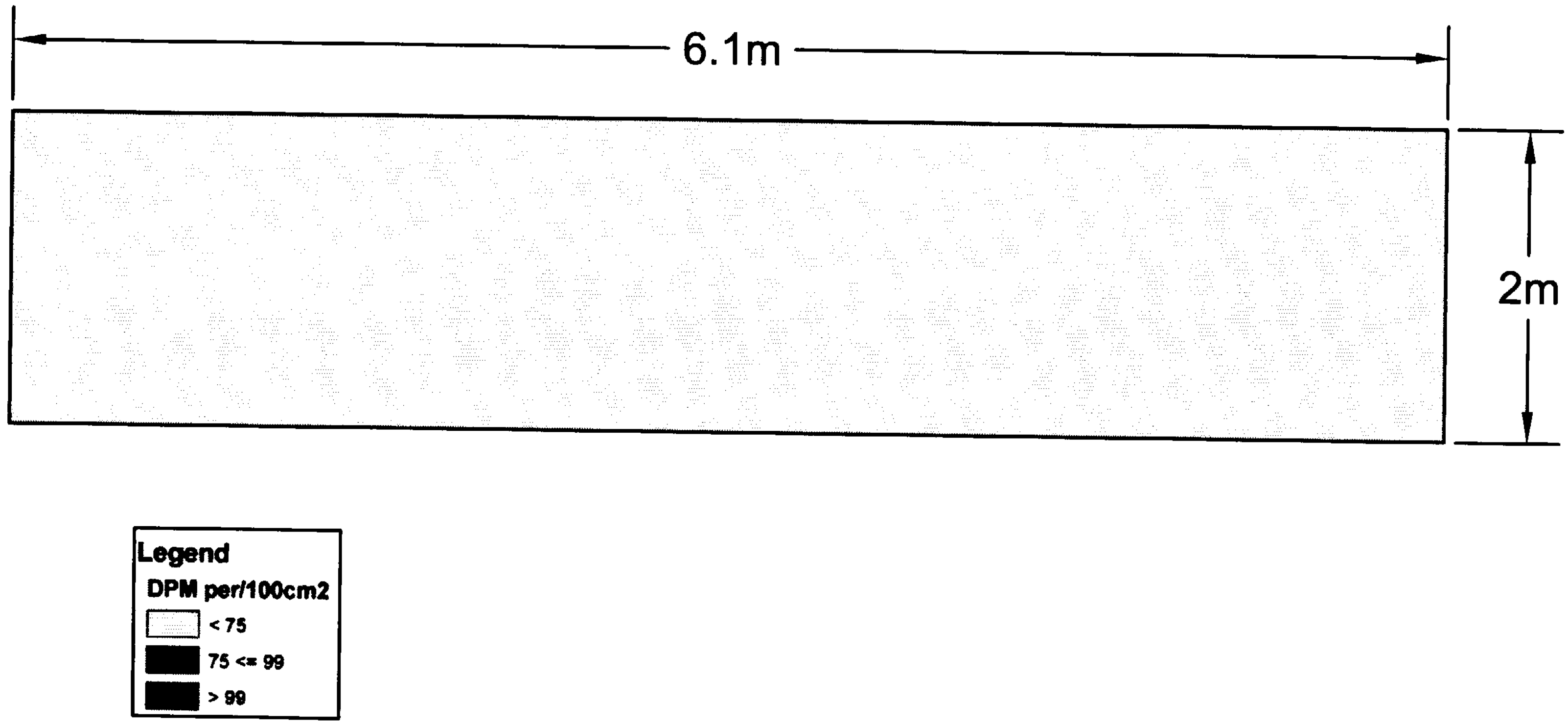
Figure:18

Wash Rack 3 - Alpha Scan
South Wall



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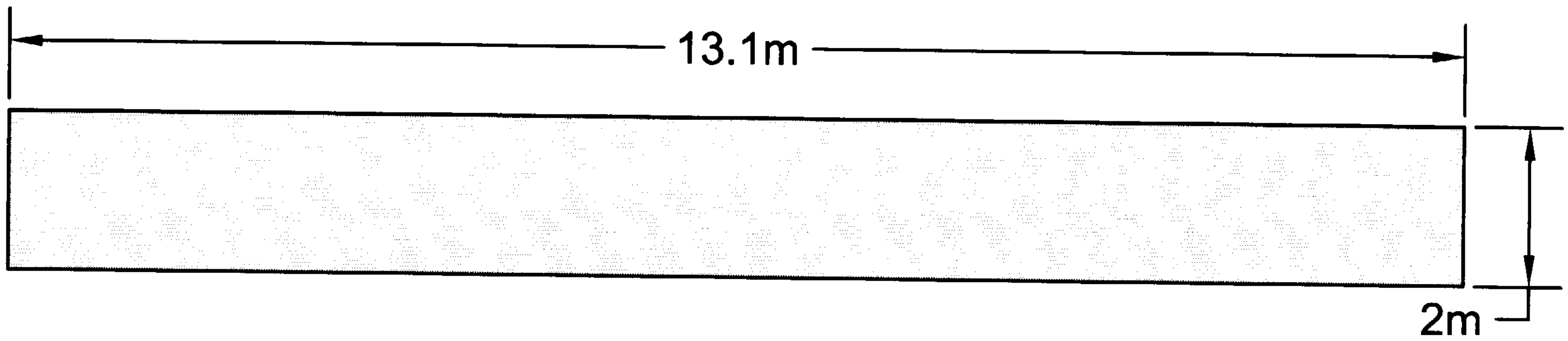
BTD - Buildings
Aberdeen Proving Ground, MD

Figure:19

Wash Rack 3 - Alpha Scan
East Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

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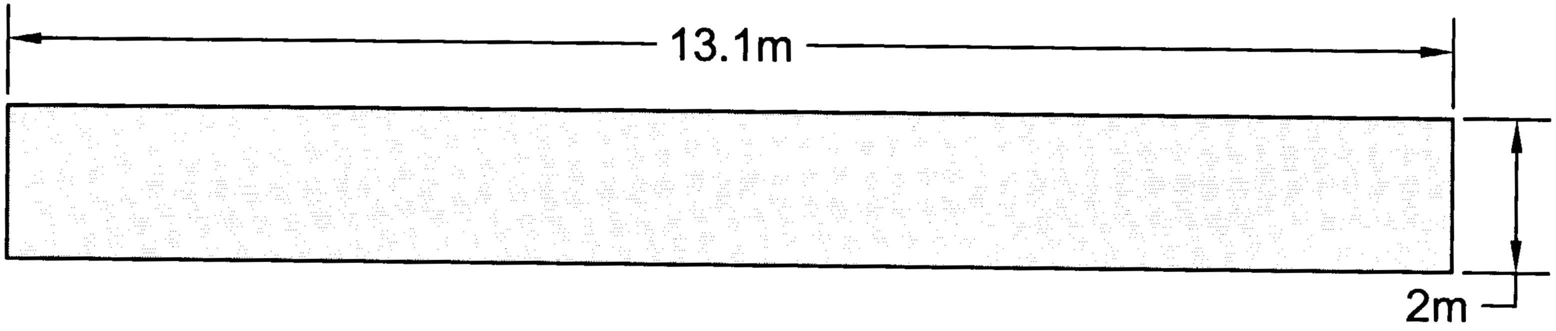
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 20

Wash Rack 3 - Alpha Scan
West Wall



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Date: 11/2/2004

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Remediation and FSS
BTD - Buildings
Aberdeen Proving Ground, MD

Figure: 21

Concrete Pad #1 - Alpha Scan
South Survey Unit

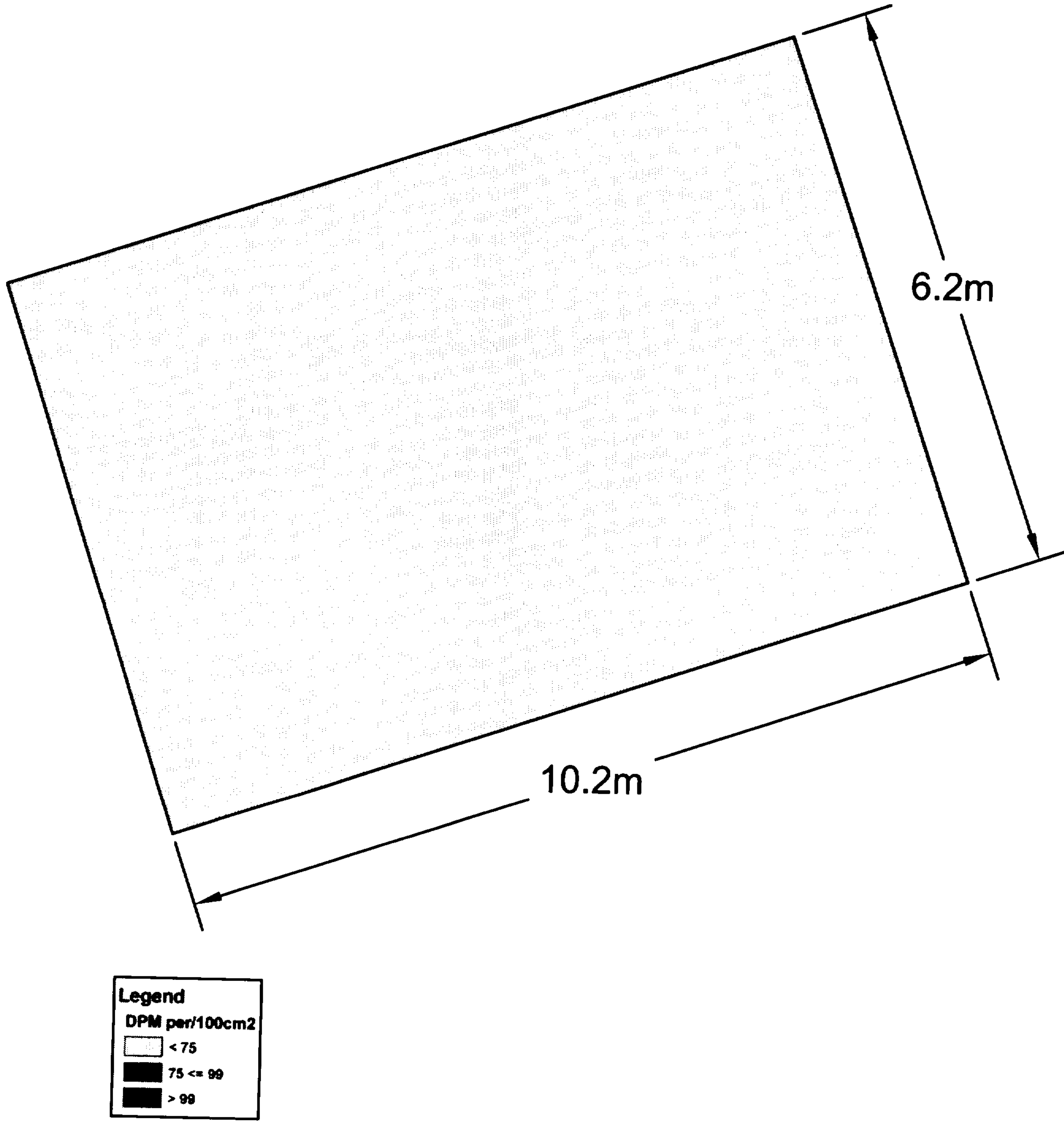
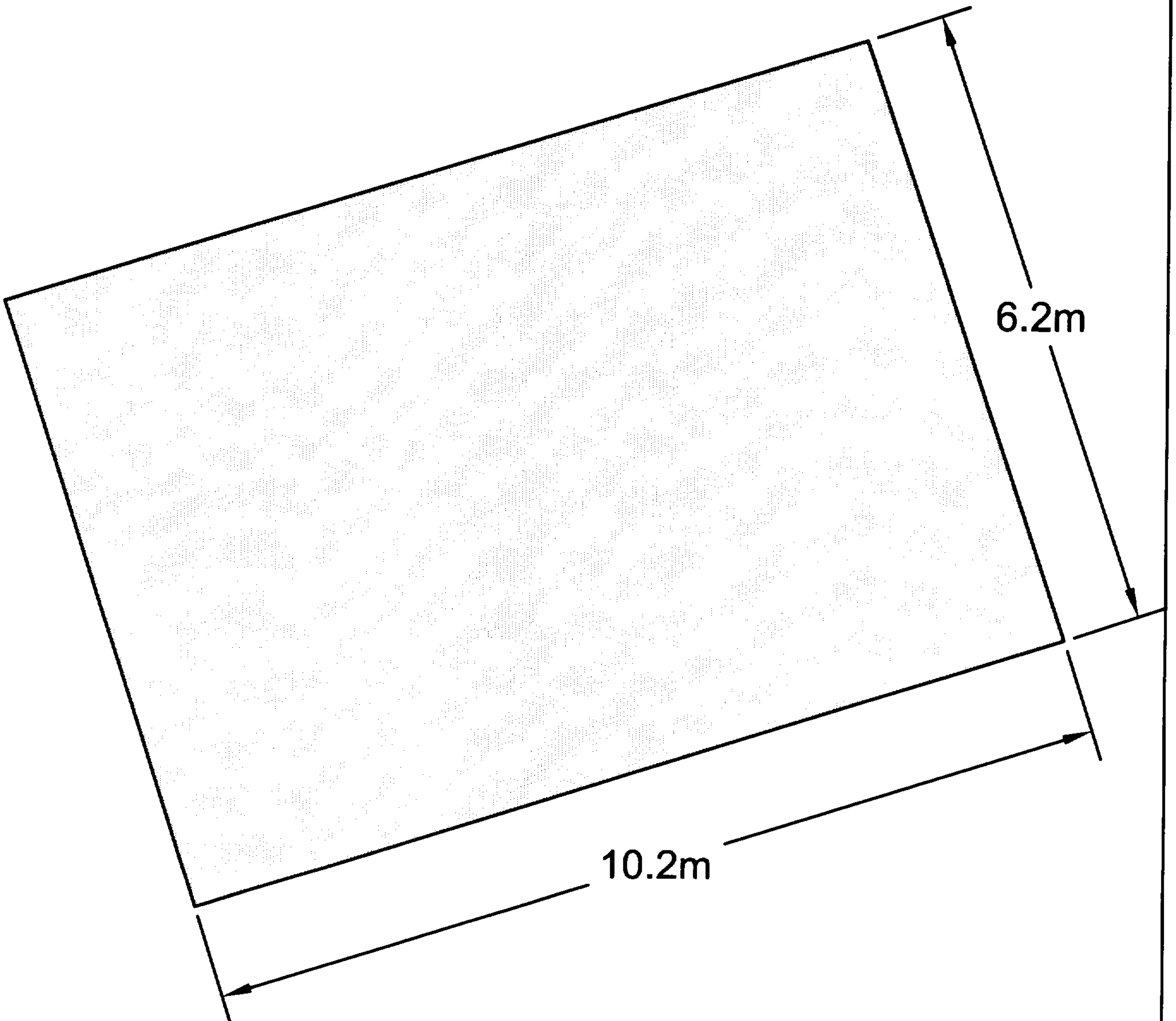


Figure: 22	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Concrete Pad #1 - Alpha Scan
North Survey Unit



Legend

DPM per/100cm2

- < 75
- 75 <= 99
- > 99

Figure: 23	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Concrete Pad #2 - Alpha Scan
South Survey Unit

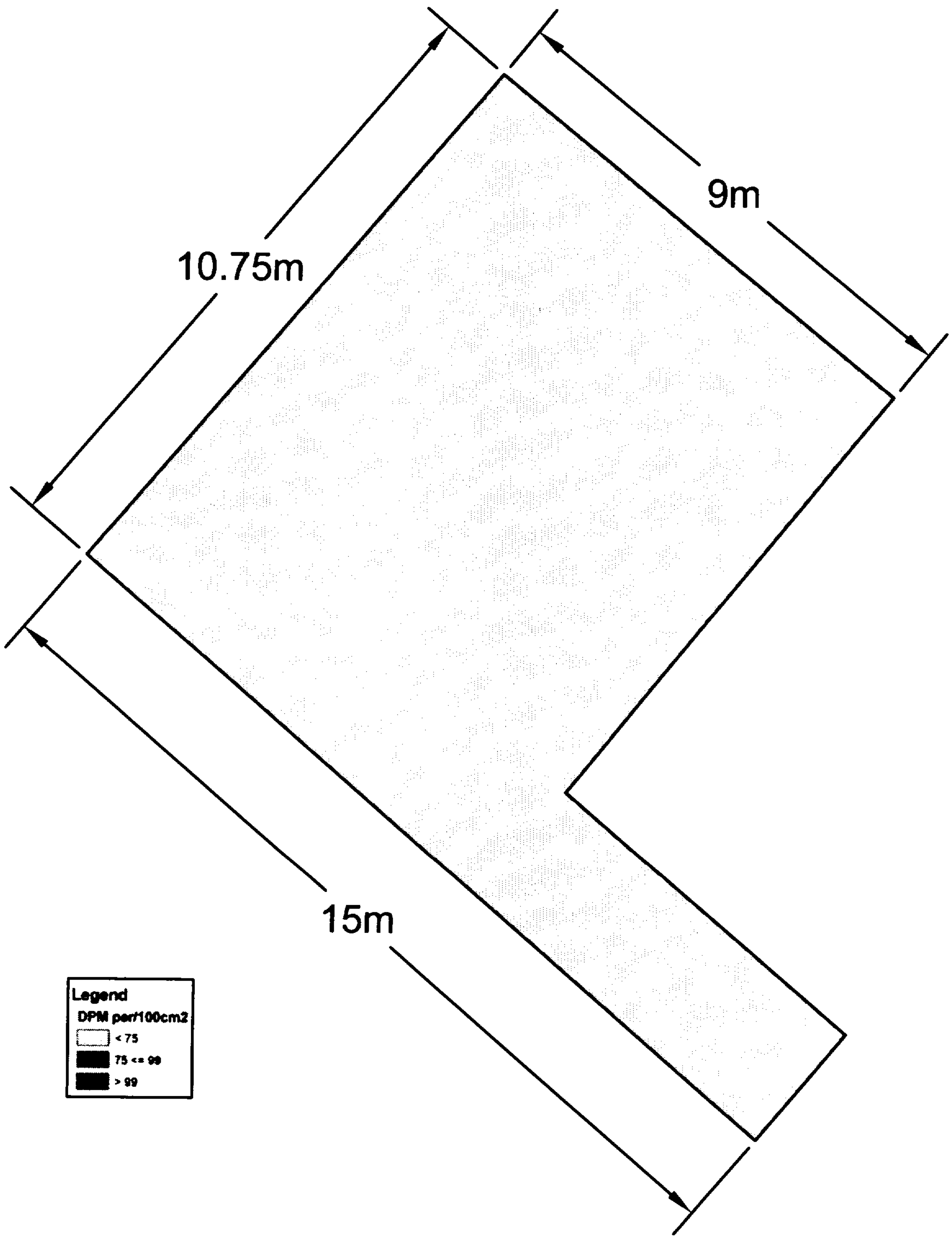


Figure: 24	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

Concrete Pad #2 - Alpha Scan
North Survey Unit

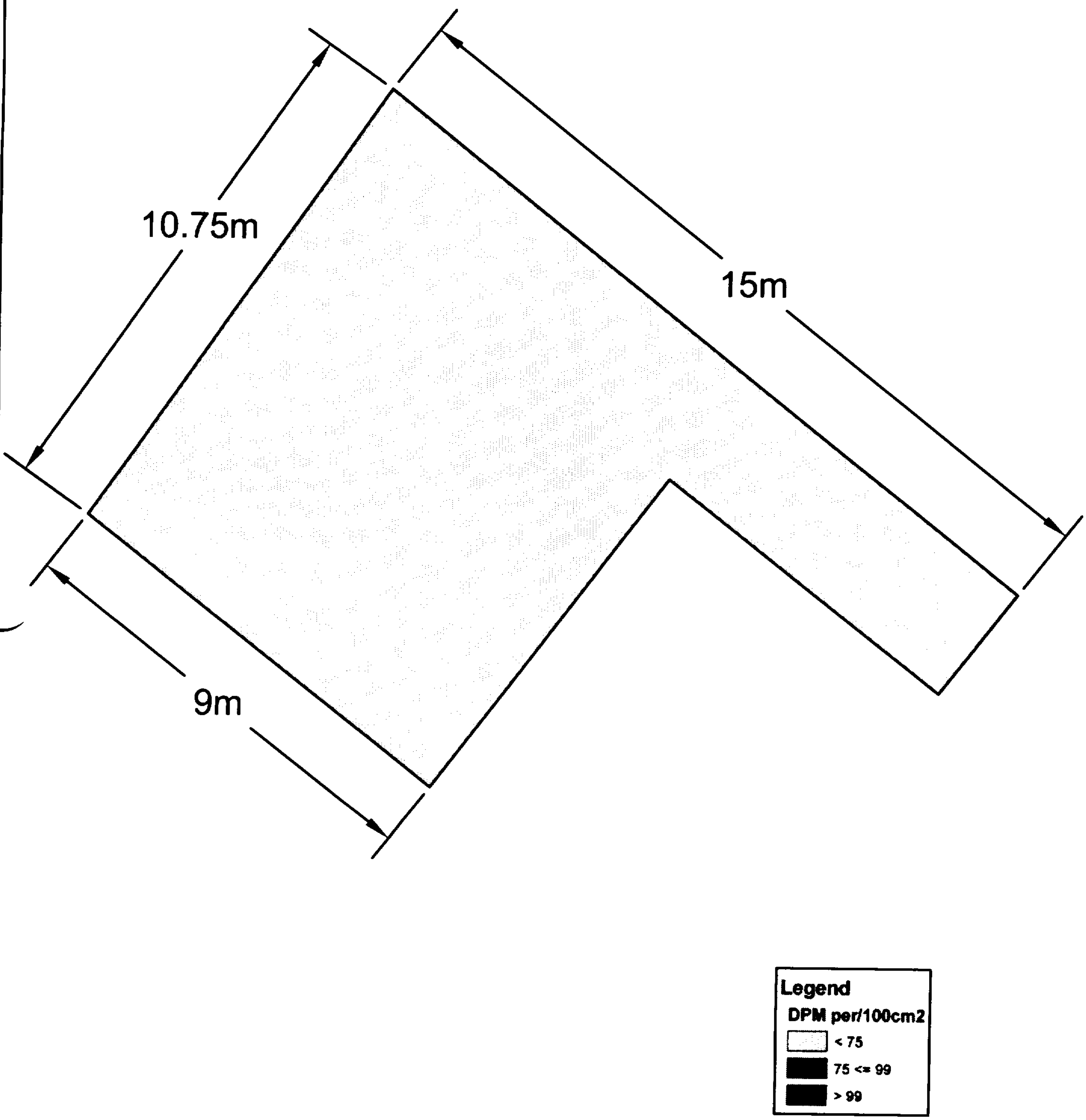


Figure: 25	Remediation and FSS Report BTD - Buildings Aberdeen Proving Ground, MD	CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	10/29/2004 Scale: N.T.S.

APPENDICES

Appendix A: Building Photographs

Appendix B: Final Status Survey Plan for BTD Armor Reclamation Facility, Aberdeen Proving Ground, Aberdeen, MD

Appendix C: Final Status Survey Plan For Wash Rack Facilities #2 and #3, Aberdeen Proving Ground, Aberdeen, MD

Appendix D: Final Status Survey Plan, Bomb Throwing Device (BTD) Site, Aberdeen Proving Ground, Aberdeen, MD

Appendix E: Survey Unit Maps and Sample Locations

Appendix F: Daily Instrument/Building Summary

Appendix G: Radiological Survey Maps

Appendix H: Survey Unit Worksheets and Data Summaries

Appendix I: Survey Instrument Quality Control and Calibration Certificates