FINAL STATUS SURVEY PLAN

Environmental Measurements Laboratory – Department of Homeland Security,
New York, NY

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Prepared for:

U.S. Army Sustainment Command
1 Rock Island Arsenal
Building 350, 5th Floor
Rock Island, IL 61299-6000

Prepared by:

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

473 Silver Lane
East Hartford, CT 06118

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ACRONYMS AND ABBREVIATIONS

α, β, γ	Alpha, Beta, and Gamma radiation
σ	Sigma (Standard Deviation)
Δ	Delta (or Change In)
μR/hr	microRoentgen per hour
ASC	U.S. Army Sustainment Command
^{14}C	Carbon-14
cm	centimeter
CABRERA	Cabrera Services, Inc.
COC	Chain of Custody
cpm	counts per minute
DCGL	Derived Concentration Guideline Level
$DCGL_{EMC}$	Derived Concentration Guideline Level, Elevated Measurement Comparison
DHS	Department of Homeland Security
DOE	Department of Energy
dpm	disintegrations per minute
dpm/100cm^2	disintegrations per minute per 100 centimeters squared
DQO	Data Quality Objective
EMC	Elevated Measurement Comparison
EML	Environmental Measurements Laboratory
FSS	Final Status Survey
FSSP	Final Status Survey Plan
^3H	Hydrogen-3 (Tritium)
HRA	Historical Radiological Assessment
LBGR	Lower Bound of the Grey Region
LSC	Liquid Scintillation Counting
M	meter
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
MeV	mega electron volts
mrem/yr	millirem per year
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission

QA	Quality Assurance
QC	Quality Control
^{226}Ra	Radium-226
RAM	radioactive materials
ROC	Radionuclide of Concern
SOP	Standard Operating Procedure
SOR	Sum of the Ratios (equivalent to the sum of the fractions)
SU	Survey Unit
WRS	Wilcoxon Rank Sum (statistical test)

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the U.S. Army Sustainment Command (ASC) to complete project tasks in accordance with CABRERA project proposal number 06-091, dated 27 June, 2006 (DHS 2006-001*)*. The Department of Homeland Security (DHS) requires the preparation and implementation of a Final Status Survey Plan (FSSP) to address the radiological status of the Environmental Measurements Laboratory (EML) facilities in the General Services Administration building, 201 Varick Street in lower Manhattan, NY. The project plans consist of the Final Status Survey plan (FSSP) herein, a project Site Specific Health and Safety Plan, and a Quality Assurance / Quality Control (QA/QC) Plan. Data collected from this FSSP will be used to develop a Final Status Survey Report for use by DHS in obtaining unrestricted release approval by appropriate regulatory authority of all areas addressed in the Description of Work.

This FSSP has been designed using the approach outlined in NUREG-1575, rev. 1, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (Nuclear Regulatory Commission [NRC], 2000). The document offers guidance of decommissioning efforts and documentation which includes the following elements pertinent to the activities outlined in this plan:

- Identification of survey units (SUs) and classification of SUs by contamination potential
- Estimation of the number of measurement locations
- Selection of instrumentation and measurement techniques
- Data Collection
- Data Evaluation

Final Status Survey (FSS) activities, involving work with radioactive materials, will be performed in accordance with CABRERA's Radiation Protection Program, and under CABRERA's NRC Materials License No. 06-30556-01 (copy attached).

1.1 Objective

The objective of this FSS is to obtain data of sufficient quality and quantity to prove, within a specified degree of confidence, that residual radioactivity levels within the survey areas meet the limits for unrestricted release.

1.2 Site Background

EML is located in a 5-story GSA Building located in lower Manhattan, NY at 210 Varick Street. EML occupies the entire fifth floor of the facility, and small areas in the first floor and basement.

The EML facility was formerly operated by Department of Energy (DOE) as an environmental radiochemistry laboratory, and now falls under the DHS. Currently, no handling of unsealed radioactive sources occurs within the facility. Upon completion of unrestricted release of the facility, EML intends to retain possession of a handful of sealed radioactive sources under NRC licensure.

1.2.1 Radiological Contamination

Several areas of radiological contamination are known to exist on the fifth floor of the site from historical surveys. In Lab 516, 15,000 disintegrations per minute per 100 square centimeters (dpm/100cm^2) fixed beta-gamma contamination is known to exist inside a cabinet. In Lab 518, 1560 dpm/100 cm^2 of fixed alpha contamination is known on bench tops. In Lab 526, 70,000 dpm/100 cm^2 of fixed beta-gamma and 6,000 dpm/100 cm^2 fixed alpha contamination, as well as 52 dpm/100^2 of removable alpha contamination, is known to exist in drawers, cabinets, and on floors, and bench tops (Brookhaven, 2005).

In the EML area of the building basement, radium contamination is known to exist on the floor and walls. The removable contamination in this area was encapsulated by the Environmental & Waste Management Services Division of Brookhaven National Laboratory (BNL) in June of 2004 (Brookhaven, 2004). However, reported estimates of the total activity encapsulated are not considered appropriate to support release decisions and FSS requirements.

1.3 Radionuclides of Concern

Operational radiological safety surveys have been performed routinely during the use of the facility for radiochemistry. A comprehensive survey of the analytical laboratories was performed by BNL, report dated October 3, 2005. Common good laboratory practices were used to remove and dispose of contamination as it was generated or discovered. Based on the historical information available, the following is a list of radionuclides of concern (ROC) with any significant likelihood of remaining at the sight. ROCs specifically denoted as being at the facility are listed. However, the potential exists for all other nuclides with atomic numbers up to 92 to have been historically present at the site in radioanalytic samples due to the fact that the EML licenses allowed possession of all of these nuclides in varying quantities. Isotopes with half-lives of less than 6 months are not likely to be present at the site in significant activity at the present time are not included in the list.

Table 1-1. Radionuclides of Concern

Nuclide	Name	Half-Life	Principal Emissions (megaelectron volts [MeV])	Source of Radionuclide
Ni-63	Nickle-63	100.1 yr	0.067 beta	Radioanalytic Sample
Ra-226	Radium-226	5.75 yr	4.785 alpha 0.168 beta 0.186 gamma	Radioanalytic Sample
Cs-137	Cesium-137	30.17 yr	0.511 beta 0.666 gamma (from Ba-137m)	Radioanalytic Sample
Sr/Y-90	Strontium / Yttrium-90	28.6 yr	0.196 beta 0.935 beta 2.2 beta	Radioanalytic Sample
Tc-99	Technetium-99	21.3E4 yr	0.293 beta	Radioanalytic Sample
U-235	Uranium-235	7.04E8 yr	4.396 alpha (most abundant) 0.014 beta (most abundant) 0.186 gamma (most abundant)	Radioanalytic Sample
U-238	Uranium-238	4.47E9 yr	4.196 alpha (most abundant) 0.029 beta (most abundant)	Radioanalytic Sample
Pu-238	Plutonium-238	87.75 yr	5.499 alpha (most abundant) 0.021 beta (most abundant)	Radioanalytic Sample
Pu-239/240	Plutonium-239/240	2.41E4 yr	5.155 alpha (most abundant) 0.029 beta (most abundant)	Radioanalytic Sample

2.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and quantitative statements that establish a systematic procedure for defining the criteria by which data collection design is satisfied in order to make determinations regarding remediated properties. The DQOs for the Site FSS include:

- Identifying the project problem;
- Defining the data necessary for achieving the end use decisions;
- Determining the appropriate method of data collection; and
- Specifying the level of decision errors acceptable for establishing the quantity and quality of data needed to support the project decisions.

2.1 Step 1: State the Problem

Radioactive material was used within the facility during environmental sample processing and analysis activities. The objective of FSS activities is to obtain data of sufficient quality and quantity to support unrestricted release of the facility to the general public.

2.2 Step 2: Identify the Decision

2.2.1 Principal Study Question

Do the concentrations of the ROCs remaining as contamination in the building exceed applicable levels for unrestricted release?

2.2.2 Decision Statement

The following statement assumes that ROC concentrations exceed release levels. If ROC concentrations inside laboratories do not exceed the derived concentration guideline limit (DCGL), the facility will satisfy the release criterion.

- Determine whether survey unit (SU) ROC concentrations inside the building exceed background concentrations by more than the applicable release criteria.

2.3 Step 3: Identify Inputs to the Decision

This section lists the data needs, describes the sources of that data, and discusses the means of obtaining the required data. The following site information must be determined in order to resolve applicable decision statements:

- Concentration of residual ROCs in survey areas. This information will be used to determine if an area is impacted. Obtaining this data will facilitate cost effective decision-making regarding the project's direction and duration.

Concentrations of residual radioactive material in the survey units will be determined by means of:

- Direct surface radioactivity measurements
- Removable radioactivity measurements (e.g., liquid scintillation counter results)
- Exposure rate surveys

2.4 Step 4: Define the Study Boundaries

The populations of interest are the concentrations of ROCs on building surfaces and fixtures. The area of interest is horizontally and vertically limited to impacted areas located inside the building areas addressed in this FSS.

Constraints on data collection include inaccessible areas, such as pipe runs between drains and cleanout traps. In these instances, decisions may be made based on data collected from the areas where radioactive material may have entered the system.

2.5 Step 5: State the Decision Rules

2.5.1 Surface Radioactivity Scan Surveys

If areas of elevated radioactivity are identified during scan surveys, identified areas will be decontaminated as appropriate and re-surveyed. Smear samples will also be collected and analyzed from these areas.

2.5.2 Basic Procedure

The general approach to SU surveys of this FSS will be as follows:

Step 1: Perform area alpha/beta gamma scans of applicable surface areas, noting areas of contamination which exceed scan action levels.

Step 2: If contamination is found, quantify through static measurements and smears as described in this FSS. If contamination exceeds DCGL, efforts will be made to decontaminate. The SU will be reclassified as necessary, and rescanned. If no scans are above DCGL, proceed with the next step. If area is still contaminated above DCGL, repeat contamination efforts.

Step 3: After all scans have been completed and no areas exceeding DCGLS are identified, systematic static measurements and smears will be taken as per layout for the particular SU. Collect static and smear biased measurements using professional judgment.

Step 4: Apply statistical tests as described in this FSS. If the SU fails the test, or biased/statistical survey points exceed $DCGL/DCGL_{emc}$, return to Step 2. Otherwise proceed to the next Step.

Step 5: Document all survey data. SU complete.

2.6 Step 6: Define Acceptable Decision Errors

Appendix D in MARSSIM (NRC, 2000) provides a discussion regarding decision errors. This discussion includes the concept that acceptable error rates must be balanced between the need to make appropriate decisions and the financial costs of achieving high degrees of certainty.

Errors can be made when making site remediation decisions. The use of statistical methods allows for controlling the probability of making decision errors. When designing a statistical test, acceptable error rates for incorrectly determining that a site meets or does not meet the applicable decommissioning criteria must be specified. In determining these error rates, consideration should be given to the number of sample data points that are necessary to achieve them. Lower error rates require more measurements, but result in statistical tests of greater power and higher levels of confidence in the decisions. In setting error rates, it is important to balance the consequences of making a decision error against the cost of achieving greater certainty.

Acceptability decisions are often made based on acceptance criteria. If the mean and median concentrations of a contaminant are less than the associated acceptance criteria, for example, the results can usually be accepted. In cases where data results are not so clear, statistically based decisions are necessary. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions.

The first type of decision error, called a Type I error, occurs when the null hypothesis is rejected when it is actually true. The probability of a Type I error is usually denoted by alpha (α). The maximum Type I error rate is 0.05.

The second type of decision error, called a Type II error, occurs when the null hypothesis is not rejected when it is actually false. The probability of a Type II error is usually denoted by beta (β). The power of a statistical test is defined as the probability of rejecting the null hypothesis when it is false. It is numerically equal to $1-\beta$ where β is the Type II error rate. Potential consequences of Type II errors include unnecessary remediation expense and project delays.

For the purposes of this FSS, the acceptable error rate for both Type I and Type II errors is five percent (i.e., $\alpha = \beta = 0.05$).

3.0 SURVEY DESIGN AND METHODOLOGY

3.1 Determine Impacted and Non-Impacted Areas

In order to determine the scope of the FSS, a historical review of licensed radioactive material usage at the facility was performed. The purpose of the review was to:

1. Identify radionuclides used, and which rooms/labs/areas were used or were potentially contaminated,
2. Identify areas that may have been previously released, and
3. Identify and quantify actual areas of contamination.

This information was then used to determine if certain areas were impacted by radionuclide usage. Specific areas covered under this FSS Plan include the fifth floor (approximately 61,130 ft^2), a 2,500 ft^2 area on the first floor utilized by EML, and a 3,100 ft^2 area of the basement. Impacted/Non-Impacted areas are discussed in Section 3.5 of this FSS.

3.2 Area Classification Based On Contamination Potential

Impacted areas were then classified based on contamination potential as per guidance in MARSSIM sections 2.2, 4.4, 5.5.2, and 5.5.3 (NRC, 2000). Namely,

- Class 1: The area had been contaminated above the release criteria, and it is possible to find radioactivity above the release criteria;
- Class 2: The area had radioactive material use, but it is unlikely to have radioactivity above the release criteria;
- Class 3: The area had some use of radioactive material, but it is very unlikely to have radioactivity above the release criteria.

3.3 Statistical Tests

3.3.1 Sign Test

The Sign test is designed to detect uniform failure of remedial action throughout a SU. It draws direct comparisons between SU data and the chosen release criteria, i.e. DCGL. The Null Hypothesis is assumed to be true unless the statistical test indicates that it should be rejected in favor of the alternative. The null hypothesis states that the probability of a measurement less than the DCGL is less than one-half, i.e. the 50th percentile (or median) is greater than the DCGL. With this in mind, SUs may meet the release criteria even though some measurements may be greater than some reference area measurements. The result of the hypothesis test determines whether or not the SU as a whole meets the release criteria.

If all of the sample results are less than the DCGL then no Sign test statistical evaluation is required.

3.3.2 Application of Sign Test for Multiple Surfaces

The typical approach for evaluating internal building surfaces using the MARSSIM protocol involves the Wilcoxon Rank Sum (WRS) test. The WRS test requires that an appropriate background (reference) unit be surveyed for each material type in a survey unit such that gross measurements may be used for evaluating survey results. However, application of the WRS test for complex buildings with many structural surfaces can be cumbersome, as a single SU may require several background reference areas for proper evaluation. To address situations like this, a method for applying the Sign test to multiple surfaces was developed. The procedures for this are described in Chapter 12 of NUREG-1505. (NRC 1998)

NUREG-1505 states " …the Sign test may be more appropriate when there are many different materials within what would otherwise logically be a single survey unit. As indicated at the beginning of this chapter (Chapter 12), to divide such a survey unit into separate parts, each requiring its own reference area is not only impractical, but may be inconsistent with the dose models used to determine the DCGLs." "Fortunately, there is a third option - to use the Sign test with paired observations. Each measurement in the survey unit is paired with an observation on a suitable reference material. The Sign test is then performed on the difference. The tradeoff is the higher variability of the differences compared to a single measurement."

To account for this potential increased variability in measurement standard deviation from multiple surfaces, the planning sigma values used in the determination of the number of sample points per SU were doubled from their observed values during the Scoping Survey. Details of the SU design are provided in the sections to follow.

Representative background values to be used in the paired observations will be collected in unimpacted areas of the buildings on similar building materials (see Section 3.9). The selection and measurement of the background reference areas will be done prior to the execution of the field work so they can be applied directly. A minimum of five (5) 1-minute fixed-point measurements will be collected with the average used for subtraction from each systematic measurement location prior to evaluation using the Sign test.

3.3.3 Performing the Sign Test

The Sign test is applied as outlined in the following five steps from Section 8.3.2 of the MARSSIM. Each measurement will have the appropriate background reading subtracted and the difference would be subject to the Sign test, outlined in the steps below:

Step 1: List the SU measurements, X_i, $i = 1, 2, 3, \ldots, N$.

Step 2: Subtract each measurement, X_i, from the DCGL to obtain the differences:

$D_i = DCGL - X_i, i = 1, 2, 3, \ldots, N.$

Step 3: Discard each difference that is exactly zero and reduce the sample size, N, by the number of such zero measurements.

Step 4: Count the number of positive differences. The result is the test statistic (S+). Note that a positive difference corresponds to a measurement below the DCGL and contributes evidence that the SU meets the release criterion.

Step 5: Large values of S+ indicate that the null hypothesis (that the SU exceeds the release criterion) is false. The value of S+ is compared to the critical values in MARSSIM Appendix I, Table I.3. If S+ is greater than the critical value, *k*, the null hypothesis is rejected.

3.3.4 Multiple Radiation Measurements

Statistical tests will be performed for all types of radiation included in the survey (i.e. alpha & beta).

3.4 Elevated Measurement Comparison

If a measurement shows a location of elevated activity greater than the DCGL and further decontamination is not possible, then the area around the location will need to be surveyed per the EMC procedure. The EMC is performed for both measurements obtained on the systematic/random sampling grid and for locations flagged by scanning measurements. Any measurement from the survey unit that is equal to or greater than an investigation level indicates an area of relatively high concentrations that should be investigated, regardless of the outcome of the nonparametric statistical tests.

Radiological contamination above the DCGL levels would require a breakup of the SU with reclassification to Class 1 of at least certain sections. The EMC consists of comparing each measurement from the survey unit to investigation levels (the DCGL for this survey). If such a situation arises, then the EMC procedure as specified in MARSSIM, Section 8.5.1 and/or decontamination will need to be performed.

3.5 Survey Unit Breakdown

Based primarily on the review of the *EML Facilities Historic Utilization Team Report, August 2006*, and *Radiological Surveys of EML Laboratories, September 30, 2005, Brookhaven National Laboratories*, the list below was developed identifying impacted areas based on the historical presence of radioactive materials, separating them into survey units and classifying those survey units based on the likelihood of contamination and physical locations/separations of the areas.

Impacted, Class 1 Areas: 5^{th} floor rooms; 541A, 541B, 541C, 544, 552A, 554R, 514, 515, 518, 520A, 520, 524, 525. Basement rooms B15, B15A.

Impacted, Class 2 Areas: 5^{th} floor areas: Two Class 2 SUs are defined here. First is the hall way encircling the radiochemistry laboratories. A second SU is composed of the Gamma Spec. Lab., the Machine Shop, and the Staging Area (Rooms 551L, 554T, 554X). Basement: All EML areas not classified as Class 1 areas. 1^{st} floor: Lab#1, Lab #2, and area around the Dust Collector.

Impacted, Class 3 Areas: 5^{th} floor areas: Remaining areas on eastern half of the floor excluding stairs, utility closets, pipe chases and other inaccessible areas. 1^{st} floor: remaining EML areas not listed as Class 1 or 2.

Non-Impacted Areas: 5^{th} floor areas: West Half of the floor, utility closets, stairs, pipe chases.

Graphical representations of these areas are provided in Appendix B.

3.6 Survey Unit Coverage

The coverage of beta and gamma measurements in each SU is dependent upon the survey class and the types of ROCs. General specifications for each SU class are provided below. Note that "Fixtures" includes features such as countertops, drawers, cabinets, and hoods.

The SUs are defined in this manner in order to simplify administration of the survey and handling of the data. Surveys of upper walls and ceilings are being administered as part of the survey of the lower floors and walls.

Class 1

Floors, Lower Walls (< 2 meters [m]) and Fixtures

Perform a 100% beta scan survey of surfaces. Collect fixed-point measurements at systematic locations using a triangular grid pattern. Floor areas limited to 100 square meters (m^2), where practical. Collect additional fixed-point measurements at biased locations using scan described in 3.10.1 or professional judgment.

Upper Walls (> 2m) and Ceilings

Perform a minimum 25% scan survey on walls above 2m and 10% scan survey on accessible ceiling surfaces. Collect fixed-point measurements at biased locations using professional judgment.

Class 2

Floors, Lower Walls (< 2m) and Fixtures

Perform a minimum 25% scan survey of surfaces. Collect fixed-point measurements at systematic locations using a triangular grid pattern. Floor area limit of 1,000 m^2 applied. Collect additional fixed-point measurements at biased locations using professional judgment.

Upper Walls and Ceilings

Perform a minimum 10% scan on walls above 2m and accessible ceiling surfaces. Collect fixed-point measurements at biased locations using scan described in 3.10.1 or professional judgment.

Class 3

All Surfaces and Fixtures

Perform a minimum 10% scan survey of all surfaces. Collect fixed-point measurements at biased locations using professional judgment. No floor area size limit enforced.

3.7 Release Criteria

3.7.1 Surface Contamination DCGLs

Screening values are used as the DCGLs as shown in Table 3-1. If these values are exceeded during the survey, an evaluation will need to be performed to ensure that the prospective dose due to residual radioactivity is not to exceed 25 millirem in any year. Since data about possible isotopes is scarce, the preferred method is to apply conservative screening values. For consistency with prior DOE surveys, the most restrictive contamination limits published in 10 CFR 835 Appendix D are used for this FSS.

Table 3-1. Surface Activity DCGLs for EML FSS

Agency / Reference	Alpha Total (dpm/100cm^2)	Alpha Removable (dpm/100cm^2)	Beta/Gamma Total (dpm/100cm^2)	Beta/Gamma Removable (dpm/100cm^2)
NRC 10 CFR 20.1402	Total dose to the public after decommissioning of not more than 25 mrem/yr			
NYCDOH §175.03 – Release of Materials or Facilities	2,500 Max 500 Average	100	0.2 mR/hr[b]	1,000
DOE 10 CFR 835 Appendix D	500[a]	20[a]	1,000[a]	200[a]
Chosen DCGL For DHS EML	***500[a]***	***20[a]***	***1,000[a]***	***200[a]***

Notes: a. Averaged over 1 m^2, provided no 100 cm^2 area exceeds 3 times the specified limit
b. Measured at 1 centimeter (cm) from the surface

3.8 Sampling Grid Layout

3.8.1 Relative Shift

The relative shift describes the relationship of site residual radionuclide concentrations to the DCGL and is calculated using the following equation, found in Section 5.5.2.2 of MARSSIM (NRC, 2000):

$$\frac{\Delta}{\sigma} = \frac{DCGL - LBGR}{\sigma}$$

where:

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). σ is estimated as 0.3 times the DCGL.

Δ = The width of the gray region, i.e., DCGL-LBGR

DCGL = The derived concentration guideline level (i.e., release limit)

LBGR = Concentration at the lower bound of the gray region. The LBGR effectively becomes the survey's action level. For conservatism, the LBGR will be set to 0.5 times the DCGL for this FSS.

3.8.2 Number of Sampling Points

Section 2.6 establishes the acceptable decision errors α=β=0.05. Based on these acceptable decision errors and the relative shift, the minimum number of measurement locations in each SU was calculated per MARSSIM Section 5. This calculation includes the MARSSIM recommended 20% additional samples to protect against the possibility of lost or unusable data (Table 5.5 from the MARSSIM document).

Table 3-2 shows the MARSSIM-based statistical parameters used in a calculation of the target number of samples per survey area.

Table 3-2. Summary of MARSSIM Design Parameters for the Site FSS

MARSSIM Parameter	Alpha Static Measurement[1] (cpm)	Beta Static Measurement[1] (cpm)	Alpha Smear (dpm/100 cm^2)	Beta Smear (dpm/100 cm^2)
σ	30[1,2]	60[1,2]	6[2]	60[2]
DCGL	100[4]	200[3]	20	200
LGBR	50	100	10	100
Relative Shift (Δ/σ)	1.67	1.67	1.67	1.67
Pr (from MARSSIM Tbl. 5.4)	0.95	0.95	0.95	0.95
N	14	14	14	14
N (including 20% overage)[5]	*17*	*17*	*17*	*17*

Notes:

1. Static counts to be performed with Ludlum 43-68 proportional detector. Count time = 1 min.
2. Sigma values for static measurements and smears were set at 0.3 times the DCGL to account for potential added variability (see Section 3.3.2)
3. 200 counts per minute (cpm) is equivalent to the beta DCGL of 1,000 disintegrations per minute per 100 centimeters squared (dpm/100 cm^2) assuming 20 % efficiency for the Ludlum 43-68 probe.
4. 100 counts per minute (cpm) is equivalent to the beta DCGL of 500 disintegrations per minute per 100 centimeters squared (dpm/100 cm^2) assuming 20 % efficiency for the Ludlum 43-68 probe.
5. MARSSIM Sec. 5.5.2.1 recommends that the calculated number of samples per SU (N) be increased by 20% to account for potentially lost or unusable data. Final N rounded up to nearest whole number.

The LGBR was chosen as one-half of the DCGL as per guidance provided in the MARSSIM. The standard deviation for static and smear measurements were set at 30% of the DCGL as per MARRSIM recommendation when site specific standard deviation data is not available.

The results show that all of the measurements are sufficiently sensitive to allow a relatively small number of MARSSIM-type systematic measurements to be performed in each SU (i.e., 17). Scans and biased measurements are also important in demonstrating that the residual radioactivity levels are less than the DCGLs.

3.8.3 SU Grid Spacing

Grid spacing and placement of fixed-point measurement locations within each SU will be based on a relative coordinate system.

The spacing of the data points for Class 1 and Class 2 areas is determined by:

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

where:

L = grid spacing
A = survey unit area (including wall area)
n = number of data points

The starting point is randomly selected and the data points are located within the survey unit using a triangular grid for Class 1 or Class 2 areas. The systematic locations for floor layouts will also include the first 2 meters of each wall which may be folded out or otherwise placed on the drawing of the survey area such that the floor grid also overlays the wall surface. If a grid point falls on a fixture such as a countertop, then the fixture will be measured and so noted in the documentation.

Locations of measurement locations in Class 3 SUs are determined by multiplying the east-west (Y) and the north-south (X) dimensions of each survey unit by a randomly generated number between 0 and 1 for each dimension. For consistency, the southwest corner of each survey unit will be the origin. Sample locations will be calculated using a computer to determine random numbers and plot data point locations on a survey map. To facilitate field measurements, the calculated coordinates will be rounded to the nearest whole number of meters.

3.9 Background Survey Areas

Determination of background values is of the utmost importance in building decommissioning projects. Since 'net' residual contamination values, or the difference between a sample count rate and background, are used to assert whether a particular SU satisfies the criteria for unrestricted release, application of accurate and applicable background values is crucial to proper decision-making. In this light, background measurements must be made in non-impacted areas on building surfaces expected during the FSS. The selection and measurement of the background reference areas must be done before the execution of field work. Representative measurements of various flooring and wall materials must be collected with each detector used so an applicable background can be applied before direct comparison with a DCGL value or application of the Sign test. In order to account for instrument response to ambient background, which can change from location to location, instrument background measurements will be performed on each material encountered.

3.10 Survey Methods and Instrumentation

The purpose of this section is to describe direct radiation measurement and sample collection and analysis techniques that will be implemented during the Site FSS. Physical and performance characteristics of each detector probe are provided in Table 3-3.

Table 3-3. FSS Detector Probe Characteristics

Detector	Application	Detector Type	Radiation Sensitivity	Active Area (cm^2)
Ludlum 44-9	Building, system, equipment surfaces; personnel frisking	Geiger-Mueller	Beta, Gamma	15
Ludlum 43-68	Large area surfaces (floor, walls, bench tops, drawers)	Gas Proportional	Alpha, Beta	126
Ludlum 239-1F Floor Monitor (,43-37 detector)	Smooth floor surfaces	Gas Proportional	Alpha, Beta	582
Ludlum 2929	Removable Contamination (Smear) Counter	Dual Channel "Phoswich"	Alpha, Beta	N/A
Bicron MicroRem, and Ludlum 44-2 (or equivalent)	Gamma radiation scans and counts	(1-inch by 1-inch Sodium Iodide [NaI])	Gamma	N/A

3.10.1 Surface Alpha/Beta Radioactivity Scans

Applicability:

Impacted areas that have the potential for alpha-emitting and beta-emitting radionuclide surface contamination shall be scanned as described in this section. For the DHS EML survey, this includes all impacted areas. Floors, walls, bench tops, and cabinet interiors shall be scanned as described in Section 3.6.

Instrumentation:

The following detectors shall be used per the judgment of the survey supervisor:

- Gas proportional detector (Ludlum 43-68, Ludlum 43-37, or equivalent) for any large surfaces
- Geiger Mueller (Ludlum 44-9 or equivalent) for small surfaces or other hard-to-reach places

Scan measurement sensitivities are presented in Appendix C.

Technique:

The surfaces will be scanned for alpha and beta contamination by moving the probe in straight paths with spacing that will ensure that the minimum surface area is covered as required by the SUs classification. The ratemeter will be set to alarm at a preset level indicating that contamination is being detected that is approaching a screening value or the technician shall be familiar with detecting an audible or visible increase in count rate over the action level. Two scans will be performed – once in alpha detection mode, and once in beta detection mode (for the 43-68 and 43-37).

If background response varies greatly during scan survey activities, instrument background measurements may be performed at representative measurement locations.

The scan survey action level will be a sustained instrument response above the ambient level. Action levels will be calculated in "gross CPM" for a given area with an asserted background level. If a survey results in locations above the action level, the following additional data will also be collected:

- A 60 second static measurement at the location ("biased count") for beta/alpha;
- A "biased" smear sample to be analyzed for alpha/beta, or sent for isotopic analysis as the need is determined.

Data Recording:

All scan readings need not be recorded. Any biased measurements resulting from an elevated scan reading shall be recorded, including location, count or count rate reading, and a description of the object of interest. Each survey unit scanned will be documented with an "average" and a "maximum" count rate as determined by the surveyor, for each area surface.

3.10.2 Fixed-Point Measurements

Applicability:

Fixed-point measurements (for both beta/alpha and low-energy beta/tritium) are defined as static counts performed with a portable instrument. They may be performed as part of the systematic or random gridded survey, or as biased measurements to investigate elevated scan readings.

Instrumentation:

Ludlum 43-68, or equivalent, will be used to perform and document fixed-point alpha/beta measurements.

Technique:

Fixed-point measurements should be at least 1-minute in duration with the instrument placed in scaler mode. If the instrument does not have scaler capability, a count rate indication is acceptable provided a 1-minute static reading is taken with the instrument's meter set to "slow response." The highest indicated count rate shall be recorded as the result of the fixed-point measurement.

The fixed-point (static) survey action level will be the DCGL plus the average background specific to the material type being evaluated.

Data Recording:

Fixed point measurements shall be recorded, including location (grid point or recognizable object), count rate (or exposure rate) reading, distance from the object of interest (if gamma reading), and a description of the object of interest as applicable.

3.10.3 Smear Sample Collection and Analysis

Applicability:

Selected building surfaces will have smear samples taken to assess the presence of removable contamination. Smears will be taken at every location that a fixed-point measurement is taken and at any other locations deemed necessary based on visual inspections and professional judgment.

Technique:

The amount of removable contamination per 100 cm^2 of surface area will be determined by wiping that area with a dry filter, applying moderate pressure, and analyzing the smears as appropriate. Smears will be counted on an on-site Ludlum 2929 alpha/beta dual-scaler and/or a liquid scintillation counter, depending upon the nature of the ROCs expected.

Data Recording:

Smear samples shall be recorded, including location (grid point or recognizable object), and a description of the object of interest as applicable. A chain of custody (COC) form must be completed if the smears are to be sent off-site for analysis.

3.10.4 Basement Radium Encapsulation

For the purpose of this field effort, the basement areas with known encapsulated Ra-226 contamination will be surveyed consistent with the directions of this FSS. More information on the extent and quantity of the fixed Ra-226 contamination is necessary to determine if the contamination needs to be removed or can remain in place. Sampling for analytical analysis and/or *in situ* gamma spectrocscopy measurements will be performed in conjunction with the surveys described in this FSS to quantify the encapsulated Ra-226 contamination. Removal, if required, and resurvey of this area would occur as a Phase II activity of the Decommissioning Plan.

4.0 SURVEY QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1.1 General

Measurements performed and samples collected for the FSS will be performed in accordance with standard QC requirements. Duplicate analyses, sample chain of custody, instrument performance checks, control of field survey data and databases, and QC investigations provide a high level of confidence in the data collected to support the survey outcome.

4.1.2 Instrument Calibration

All instruments used during the course of the survey must have been calibrated by a licensed instrument calibration firm to standards traceable to the National Institute of Standards and Technology (NIST).

4.1.3 Daily QC Checks

QC measurements must be performed daily, prior to survey data collection, for all on-site field and laboratory-based instruments. A consistent, controlled area should be used to perform these checks. Both background and check source responses shall be assessed. A check source of radioactivity shall be used that is appropriate for the type of radioactivity to be measured by the instrument. Initial instrument background and check source response shall be determined before the instrument is used for the FSS by performing 10 consecutive measurements for each test (background and source) and calculating the mean response and its standard deviation (σ). These 10 initial QC readings per test will be the basis for assessing the operability of the instruments for the duration of the FSS.

QC criteria for beta/gamma instruments to be used during daily QC checks follow:

- If any single QC check is found to be outside of 2σ (Investigation Level), the measurement is to be repeated.
- If the second count is also found to be outside of 2σ, the instrument is to be investigated to assess if any external biases or instrument physical damage is present.
- If any single reading is found to be outside of a 3σ boundary (Action Level), the instrument must be taken out of service and the situation resolved by the survey supervisor. (Highly fluctuating source or background responses may be due to a bad cable, insufficient gas purge, bad detector tube, or malfunctioning electronics.)

Background and source checks shall be documented by the survey supervisor or designate.

4.1.4 Analytical Support Services

In the event that samples are collected for analysis by a contract laboratory, the laboratory will be required to maintain an approved QA Program and current Materials License to possess radioactive material.

5.0 REFERENCES

(Brookhaven, 2005) *Radiological Surveys of EML Laboratories.* Brookhaven National Laboratories. September 30, 2005.

(Brookhaven, 2004) *Final Report for the Encapsulation of the Environmental Measurements Laboratory (EML) Basement Rooms.* Brookhaven National Laboratories, July 29, 2004.

(DOE, 1998) Title 10, Code of Federal Regulations, Part 835, Appendix D, *"Occupational Radiation Protection; Final Rule."*

(EML, 2006) *EML Facilities Historic Utilization Team Report.* Environmental Measurements Laboratory, August 2006

(NRC, 1998) NUREG-1505, Rev.1, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*, U.S. Nuclear Regulatory Commission, June 1998.

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

(NRC, 2003) NUREG-1757, *Consolidated NMSS Decommissioning Guidance*, Rev. 1, U.S. Nuclear Regulatory Commission, September 2003.

(NRC, 2003b) Title 10, Code of Federal Regulations, Part 20, Paragraph 1402, "*Radiological Criteria for Unrestricted Use*."

APPENDIX A

Survey Unit Sampling and Analysis Matrix

FSS Sample Collection Minimum Number and Type (see Notes page for descriptions and assumptions)					
Survey Unit No.	**Survey Unit Information & Comments**	**SU Class**	**Alpha Beta Scan**	**Alpha Beta Static Counts**	**Removable Contam. (Smears)**
5-541A	Fifth Floor Room 541A	3	a	17 d	17 e (+biased)
5-541B	Fifth Floor Room 541B	3	a	17 d	17 e (+biased)
5-541C	Fifth Floor Room 541C	3	a	17 d	17 e (+biased)
5-544	Fifth Floor Room 544	3	a	17 d	17 e (+biased)
5-552A	Fifth Floor Room 552A	3	a	17 d	17 e (+biased)
5-554R	Fifth Floor Room 554R	3	a	17 d	17 e (+biased)
5-514	Fifth Floor Room 514	3	a	17 d	17 e (+biased)
5-515	Fifth Floor Room 515	3	a	17 d	17 e (+biased)
5-518	Fifth Floor Room 518	3	a	17 d	17 e (+biased)
5-520A	Fifth Floor Room 520A	3	a	17 d	17 e (+biased)
5-520	Fifth Floor Room 520	3	a	17 d	17 e (+biased)
5-524	Fifth Floor Room 524	3	a	17 d	17 e (+biased)
5-525	Fifth Floor Room 525	3	a	17 d	17 e (+biased)
B-B15	Basement Room B15	3	a	17 d	17 e (+biased)
B-B15A	Basement Room B15A	3	a	17 d	17 e (+biased)
5-RL	Hallway surrounding the Radiochemistry Labs	2	b	17 d	17 e (+biased)

FSS Sample Collection Minimum Number and Type (see Notes page for descriptions and assumptions)					
Survey Unit No.	**Survey Unit Information & Comments**	**SU Class**	**Alpha Beta Scan**	**Alpha Beta Static Counts**	**Removable Contam. (Smears)**
5-SMG	Fifth Floor Rooms 554X (Staging), 554T (Machine Shop), and 551L (Gamma Spec Lab)	2	b	17 d	17 e (+biased)
B-R2	Basement Floor – All EML areas not Class 1	2	b	17 d	17 e (+biased)
1-L1	First Floor Lab #1	2	b	17 d	17 e (+biased)
1-L2	First Floor Lab #2	2	b	17 d	17 e (+biased)
1-Dust	First Floor – Area around Dust Collector	2	b	17 d	17 e (+biased)
5-R3	Fifth Floor – Remaining portion of eastern half of floor not designated Class 1 or 2 excluding utility closets, pipe chases, stairs	3	c	17 d	17 e (+biased)
1-R3	First Floor – Remaining portion of EML area not designated Class 1 or 2 excluding utility areas, pipe chases, stairs	3	c	17 d	17 e (+biased)

TABLE NOTES

a Perform 100% alpha/beta scan survey on floor, bench-tops, and lower wall surfaces (up to 6'), 10% scan on upper wall surfaces (> 6'), and 10% scan on accessible ceiling areas. Class 1 SUs.

b Perform 25% scan survey on floor, bench-tops, and lower wall surfaces (up to 6'). Upper walls (> 6') will be scanned only as accessible from the floor elevation. Class 2 SUs.

c Perform 10% scan survey on floor, bench-tops, and lower wall surfaces. Class 3 SUs.

d Fixed, static-count alpha/beta measurements will be performed at systematic or random locations (depending upon SU classification) in the quantities listed in the table with an alpha/beta sensitive instrument.

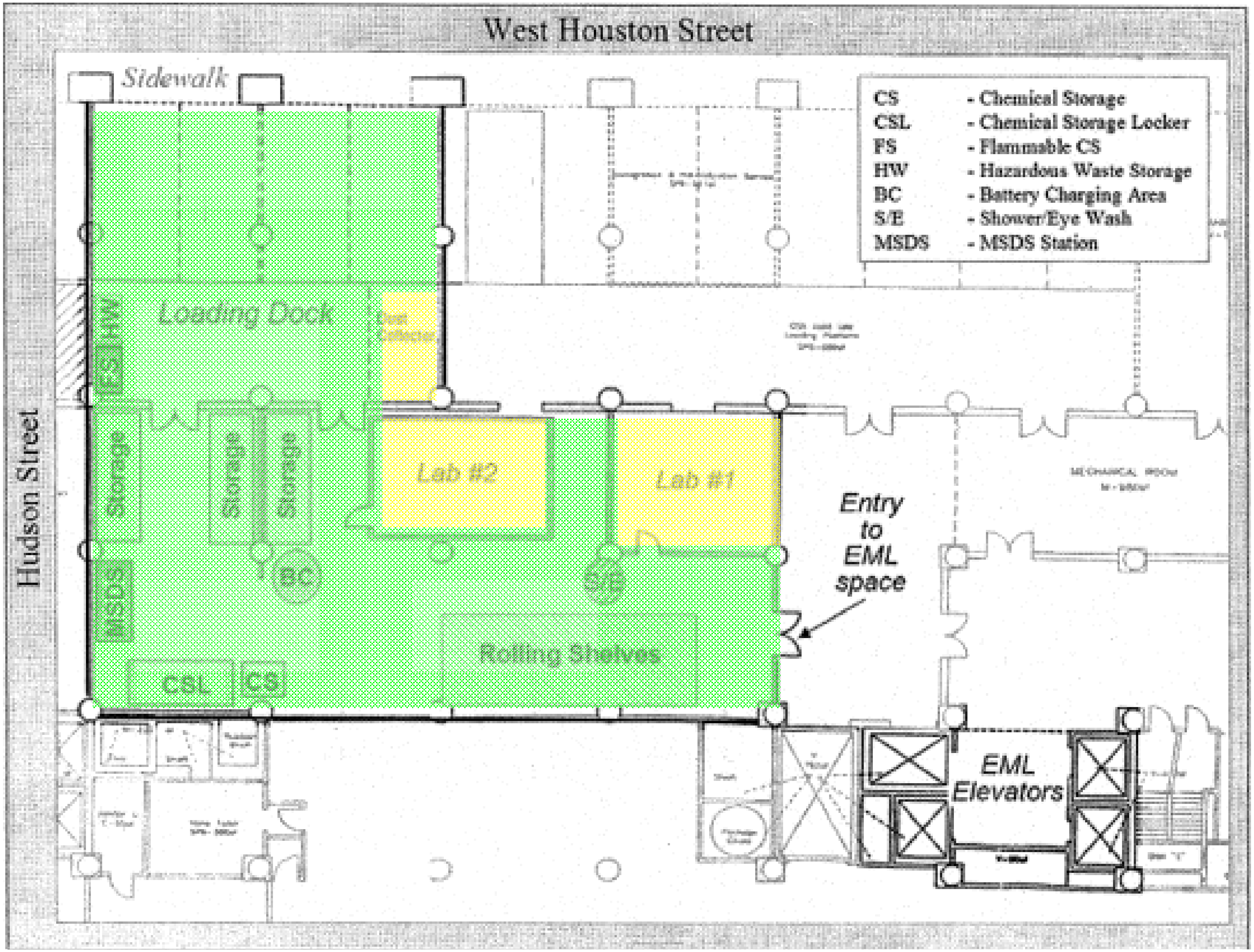
e Smears for removable contamination will be performed at systematic or random locations (depending upon SU classification) in the quantities listed in the table. Additional biased smears will be performed at points of likely or suspect contamination, and at areas of elevated scan measurements.

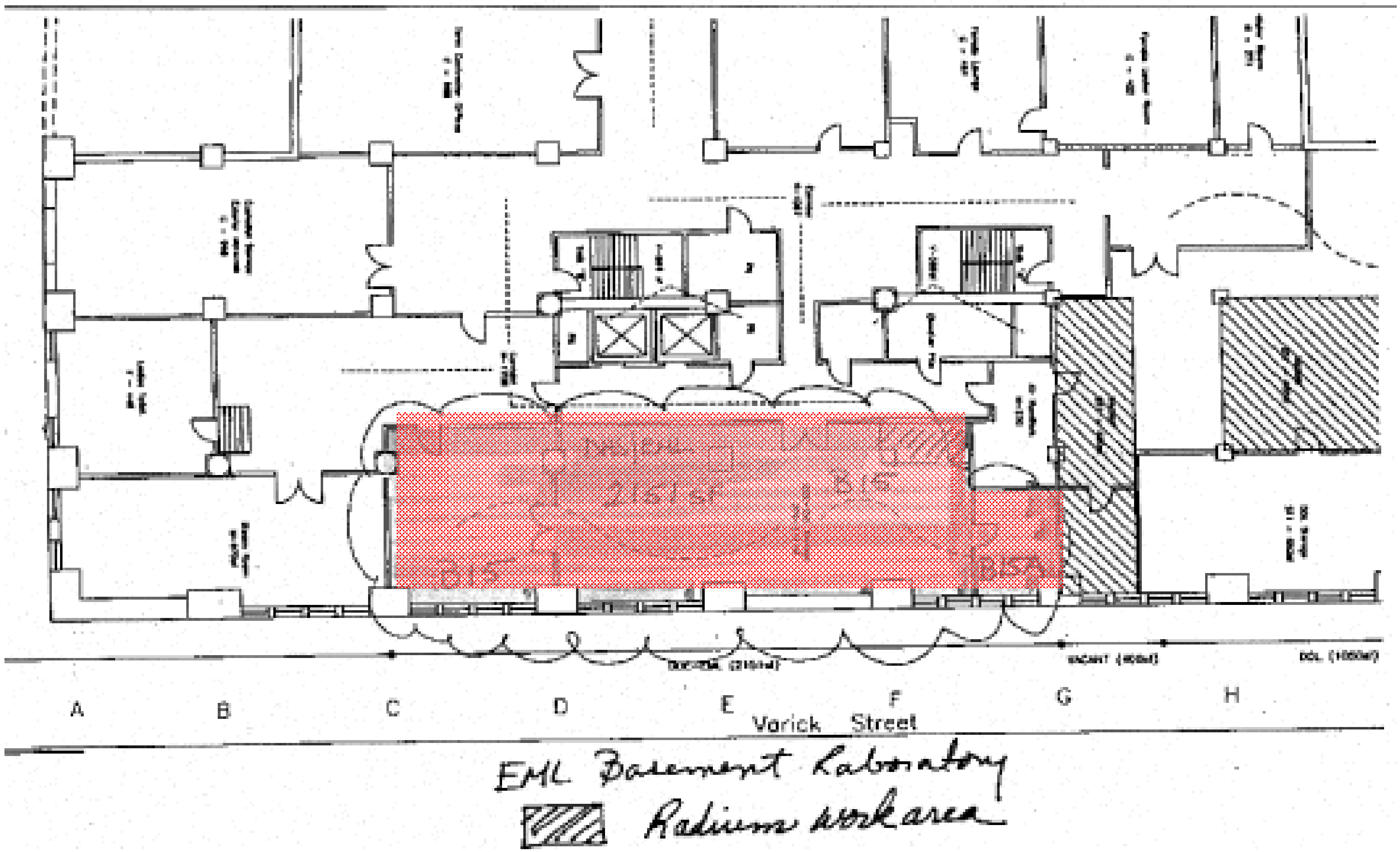
APPENDIX B

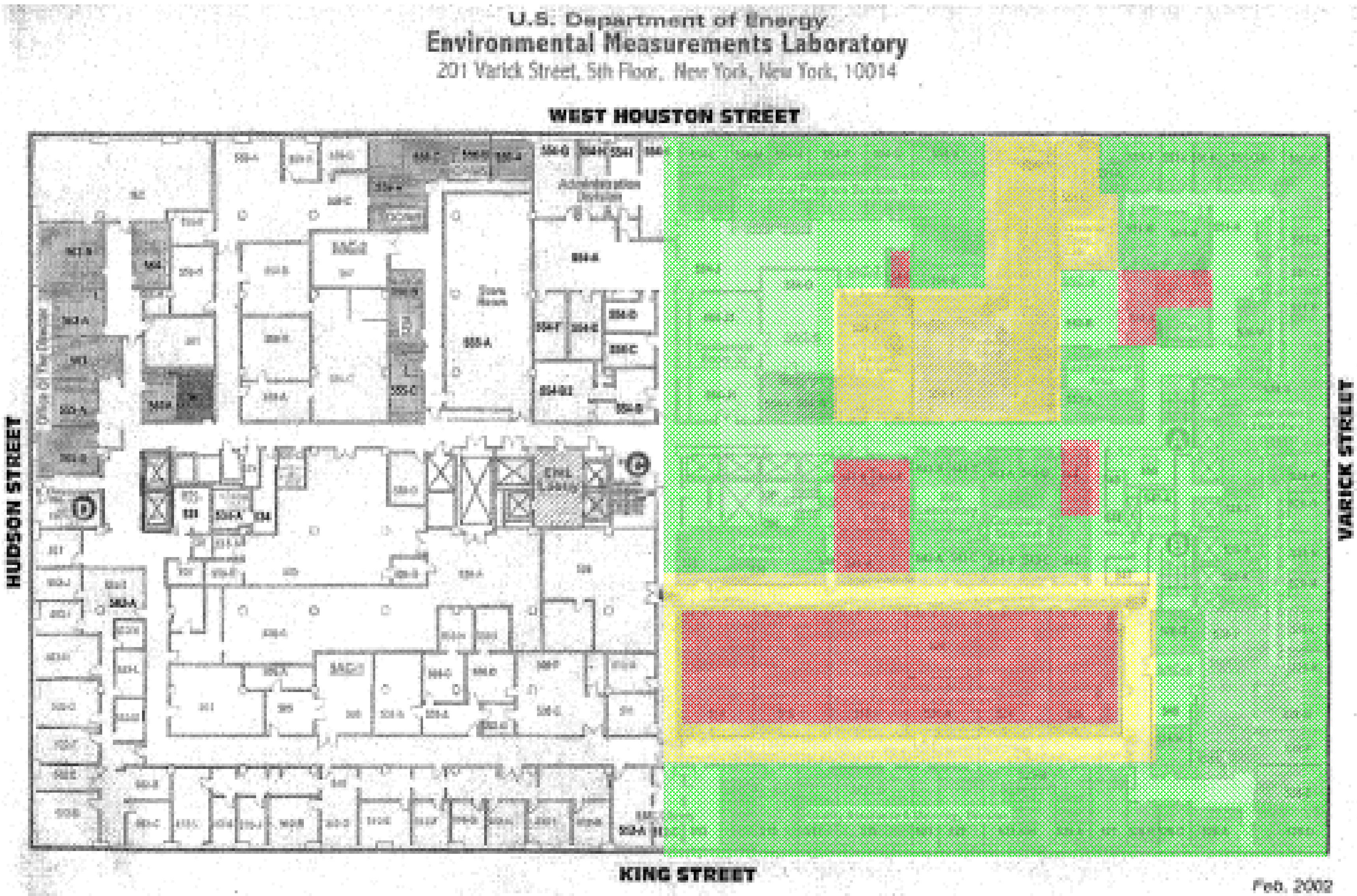
Maps of Survey Units with MARSSIM Classifications

Impacted areas addressed in this FSS are shaded in the maps.

Class 1: Red Shaded
Class 2: Yellow Shaded
Class 3: Green Shaded


West Houston Street
Sidewalk
CS - Chemical Storage
CSL - Chemical Storage Locker
FS - Flammable CS
HW - Hazardous Waste Storage
BC - Battery Charging Area
S/E - Shower/Eye Wash
MSDS - MSDS Station
Loading Dock
Dust Collector
HW
FS
Hudson Street
Storage
Storage
Storage
Lab #2
Lab #1
Entry to EML space
MSDS
BC
S/E
Rolling Shelves
CSL
CS
EML Elevators


B15
B15
B15A
A
B
C
D
E
F
G
H
Varick Street
EML Basement Laboratory
Radium work area


U.S. Department of Energy
Environmental Measurements Laboratory
201 Varick Street, 5th Floor, New York, New York, 10014
WEST HOUSTON STREET
HUDSON STREET
VARICK STREET
KING STREET
Feb. 2002

APPENDIX C

Calculation of Minimum Detectable Concentrations

Determine Scan MDC

The methodology used in NUREG-1507 was used in determining minimum detectable scan sensitivity and the results are presented below for an example instrument utilized.

Scanning is often performed during radiological surveys in support of decommissioning to identify the presence of any locations of elevated direct radiation (hot spots). The probability of detecting residual contamination in the field is not only affected by the sensitivity of the survey instrumentation when used in the scanning mode of operation, but also by the surveyor's ability. The surveyor must decide whether the signals represent only the background activity, or whether they represent residual contamination in excess of background.

The minimum detectable concentration of a scan survey (scan MDC) depends on the intrinsic characteristics of the detector (efficiency, window area, etc.), the nature (type and energy of emissions) and relative distribution of the potential contamination (point versus distributed source and depth of contamination), the scan rate and other characteristics of the surveyor. Some factors that may affect the surveyor's performance include the costs associated with various outcomes—e.g., cost of missed contamination versus cost of incorrectly identifying areas as being contaminated —and the surveyor's a priori expectation of the likelihood of contamination present. For example, if the surveyor believes that the potential for contamination is very low, as in an unaffected area, a relatively large signal may be required for the surveyor to conclude that contamination is present.

A discussion of the calculation of scanning minimum detectable concentration (MDC) and the scanning minimum detectable count rate (MDCR) is provided in the MARSSIM (NRC 2001). More detail on signal detection theory and instrument response is provided in NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, December 1997, from which the following discussion is drawn.

Minimum Detectable Beta Count Rate and Surveyor Efficiency

The framework for determining the scan sensitivity is based on the premise that there are two stages of scanning. That is, surveyors do not make decisions on the basis of a single indication, rather, upon noting an increased number of counts, they pause briefly and then decide whether to move on or take further measurements. Thus, scanning consists of two components: continuous monitoring and stationary sampling. In the first component, characterized by continuous movement of the probe, the surveyor has only a brief "look" at potential sources, determined by the scan speed. The surveyor's willingness to decide that a signal is present at this stage is likely to be liberal, in that the surveyor should respond positively on scant evidence, since the only "cost" of a false positive is a little time. The second component occurs only after a positive response was made at the first stage. This response is marked by the surveyor interrupting his scanning and holding the probe stationary for a period of time, while comparing the instrument output signal during that time to the background counting rate. Owing to the longer observation interval, sensitivity is relatively high. For this decision, the criterion should be more strict, since the cost of a "yes" decision is to spend considerably more time taking a static measurement or a sample.

Since scanning can be divided into two stages, it is necessary to consider the survey's scan sensitivity for each of the stages. Typically, the minimum detectable count rate (MDCR) associated with the first scanning stage will be greater due to the brief observation intervals of continuous monitoring—provided that the length of the pause during the second stage is significantly longer. Typically, observation intervals during the first stage are on the order of 1 or 2 seconds, while the second stage pause may be several seconds long. The greater value of MDCR from each of the scan stages is used to determine the scan sensitivity for the surveyor.

The minimum detectable number of net source counts in the interval is denoted by s_i. Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts by the detectability value associated with the desired performance (as reflected in d') as shown in [Equation 6-8, MARSSIM]:

$$s_i = d' (b_i)^{1/2}$$

where the value of d' is selected from MARSSIM Table 6.5 based on the required true positive and false positive rates and b_i is the number of background counts in the interval.

The minimum detectable source count rate (MDCR), in cpm, detectable during the observation interval i, in seconds, by an "ideal" surveyor may be calculated by [Equation 6-9, MARSSIM]:

$$MDCR = s_i \times (60 / i)$$

For the case of real surveyors who are not equivalent to the "ideal" construct, MARSSIM recommends assuming an efficiency value at the lower end of the observed range of 0.75 – 0.50 (i.e., p = 0.5) when making MDCR estimates. Thus, the required number of net source counts for the surveyor, $MDCR_{surveyor}$, is determined by dividing the MDCR by the square root of p.

Consider the calculation of the MDCR for the case of a 126 cm^2 gas flow proportional detector set up to detect beta radiation. The observed background level is 150 cpm. The desired level of performance, 95% correct detections and 60% false positive rate, results in a d' of 1.38 [Table 6-5, MARSSIM]. Assume a scan rate of one probe width per second, which results in an observation interval of 1 second, assuming a contaminated area of 100 cm^2. The $MDCR_{surveyor}$ may be calculated assuming a surveyor efficiency (p) of 0.5 as follows:

1) b_i = (150 cpm) × (1 sec) × (1 min/60 sec) = 2.5 counts

2) MDCR = (1.38) × (2.5) $^{1/2}$ / (1 sec) × (60 sec/1 min) = 131 cpm

3) $MDCR_{surveyor}$ = 131 / (0.5) $^{1/2}$ = 185 cpm net above background

The minimum number of source counts required to support a given level of performance for the final detection decision (second scan stage) can be estimated using the same method. As explained earlier, the performance goal at this stage will be more demanding. The required rate of true positives remains high (e.g., 95%), but fewer false positives (e.g., 20%) can be tolerated, such that d' (from Table 6.5) is now 2.48. For this second stage of the scan survey, the surveyor typically stops the probe over a suspect location for about 5 seconds before making a decision,

1) b_i = (150 cpm) × (5 sec) × (1 min/60 sec) = 12.5 counts

2) MDCR = (2.48) × (12.5) $^{1/2}$ / (5 sec) × (60 sec/1 min) = 105 cpm

MDCRsurveyor = 105 / (0.5) $^{1/2}$ = 149 cpm net above background

The greater of the calculated $MDCR_{surveyor}$ values is 185 cpm above background or approximately 335 cpm gross. This would be the value chosen for the $MDCR_{surveyor}$.

Calculations of Minimum Detectable Activities, Minimum Detectable Count Rates, and Scan Minimum Detectable Concentrations for projected Beta FSS Instrumentation can be found in the Table C-1 below:

Table C-1: Beta Surface Scan Detection Limits

Scan MDC calculations for Ludlum Detectors (Beta measurements)		
	Beta model 43-68	**Beta model 43-37**
R_B = Background Counting Rate[a], per min	150	750
T_{S+B} = Sample Counting Time (gross) (min)	1	1
T_B = Background Counting Time (min)	1	1
i=(the observation interval in sec)	1	1
ε =Efficiency of the instrument	0.2	0.2
P=Surveyor efficiency	0.5	0.5
Probe Area(cm^2)	126	582
$\mathbf{L_c}$ (critical level counts)	28.54	63.81
$\mathbf{L_d}$ (lower limit of detection)	59.95	130.35

MDA(minimum detectable Activity(dpm)	299.92	652.11
MDA(dpm/100 cm^2)	238	112
d' (Index of Sensitivity from table(6.5 MARSSIM)	1.38	1.38
b_i=Number of Back ground Counts in the interval	2.50	12.50
$S_i = d' \times \sqrt{b_i}$	2.2	4.9
MDCR(Minimum Detectable count Rate)=$S_i \times (60 \div) i$	131	293
Scan MDC[b]	**735**	**356**
DCGLs (dpm/100cm^2)	**1000**	**1000**
Note: a -assumed background counting rate . Calculations based on Strom & Stansbury (eqn 3-11 of NUREG 1507) b-Reference MARSSIM 6.7.2 Table 6.5 Equation-6.10		

General Information on Alpha Scan MDC

Scan MDCs for alpha emitters must be derived differently than scanning for beta and gamma emitters. *MARSSIM* contains formulas and probability concepts for alpha scans in Appendix J, which provides a complete derivation of the formulas used to determine the probability of observing a count when performing an alpha scan. Additional information on various material background, detector efficiencies, surface material effects, etc. may be found in NUREG-1507.

In general, when performing an alpha scan, once a count has been recorded and the surveyor stops, the surveyor should wait a sufficient period of time such that if the guideline level (or action level) of contamination is present, the probability of getting another count is at least 90%. For low background areas (alpha background of 0 to 3 cpm), it is assumed that a single count is sufficient to cause a surveyor to stop and investigate. For higher background areas or when using larger area detectors resulting in a higher background count rates such as the Ludlum Model 43-37 floor monitor (alpha background up to 10 cpm), the surveyor will usually need to get at least 2 counts while passing over the source area before stopping for further investigation.

For the purpose of determining alpha scan MDCs, the source activity, G in the following equations, is assumed to be slightly less than 20% of the alpha surface activity DCGL in Table 3-1, i.e., 100 dpm/100 cm^2.

The assumptions pertaining to scan speeds, background, efficiency, dwell times, etc. used in the evaluation of alpha scan MDCs (probability of detection) are provided in Table C-2. The probabilities of detection calculated using the equations below are also presented in Table C-2. These calculations indicate that the under the conditions presented in the assumptions, the design objective of 90% probability is achieved when scanning surfaces contaminated to 100 dpm/100 cm^2 when using the indicated detectors.

Table C-2: Alpha Surface Scan Assumptions

Model No.	Probe Area (cm^2)	Probe Width (cm)	α Efficiency (cpm /dpm)	α Bkgrd (cpm)	Scan Speed (cm/sec)	Pause Time (sec)	P(n>=1)	P(n>=2)
43-37	582	15	0.15*	10	6	2.5	NA	0.91
43-68	126	9	0.15*	3	1	7.3	0.90	NA

cm = centimeters
cm^2 = square centimeters
cpm = counts per minute
dpm = disintegrations per minute
sec = second
cm/sec = centimeters per second

* Manufacturer's stated 4π alpha efficiencies for these detectors have a range of 15 to 20%. For this evaluation, 15% is chosen as a conservative approach.

Ludlum Model 43-37 Scan MDC

The Ludlum Model 43-37 gas proportional detector is a large area detector (active area of 582 cm^2) with a higher background count rate compared to smaller area detectors, such as the Ludlum Model 43-68. Using *MARSSIM* Equation J-7, the probability of two or more alpha counts during the scan survey of a surface is determined as follows:

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

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

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

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 (100 dpm/100 cm^2)

E = Detector efficiency (4π)

B = Background count rate (cpm)

t = Dwell time over source (seconds)

Scans will be performed by moving the active area of the detector over the surface of interest at or below the given scan speed in Table C-2. If two or more counts occur over the indicated observation interval, a one-minute integrated or static measurement will be performed at that location prior to resuming the scan survey.

Ludlum Model 43-68 Scan MDC

If the Ludlum Model 43-68 gas proportional detector is used, then *MARSSIM* Equation J-5 and the assumptions listed in Table C-2, with a probability of at least one count occurring while surveying an area of contamination equal to the 100 dpm/100 cm^2 surface scan action level $P(n \geq 1)$, will be implemented instead of *MARSSIM* Equation J-7.

Using *MARSSIM* Equation J-5 and the assumptions listed in Table C-2 (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 derived as follows:

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

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

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 (100 dpm/100 cm^2)

E = Detector efficiency (4π)

d = Width of the detector in the direction of scan (cm)

v = Scan speed (cm/s)

Alpha scans will be performed using the Ludlum Model 43-68 detector by moving the active area of the detector over the surface of interest at the scan speed shown in Table C-2. Whenever a count is detected during the scan, the detector will be held in place over the location where the count was detected for the indicated pause time (approximately 7-8 seconds). If a second count is detected over this location during the pause time, a one minute integrated count will be performed.

Integrated Direct Surface Measurements and Smear Analysis

Integrated direct measurements (i.e., static measurements) of surface alpha and beta contamination will be performed to compare contaminant concentrations at discrete sampling locations to the appropriate action level. Smear samples will be collected at biased building surface locations, as appropriate, to quantify transferable surface alpha and beta contamination.

Integrated alpha and beta activity measurements will be performed using a Ludlum Model 43-68 gas proportional detector, or equivalent. Smears will be analyzed using a Ludlum Model 43-10-1 smear count detector attached to a Ludlum Model 2929 ratemeter, or equivalent. The static measurement and smear analysis MDC and assumptions used for each of the detectors are presented in Table C-3. The MDCs were determined using Equation 3-11 of *NUREG 1507*.

Table C-3. Static/Smear MDA Calculations

MDC calculations for Ludlum Detectors (Alpha/Beta static measurements and smears)				
	Alpha model 43-68 Static	**Alpha model 2929 Smear**	**Beta model 43-68 Static**	**Beta model 2929 Smear**
R_B = Background Counting Rate[a], per min	3	0.1	150	60
T_{S+B} = Sample Counting Time (gross) (min)	1	1	1	1
T_B = Background Counting Time (min)	1	1	1	1
ε =Efficiency of the instrument	0.2	0.37	0.2	0.26

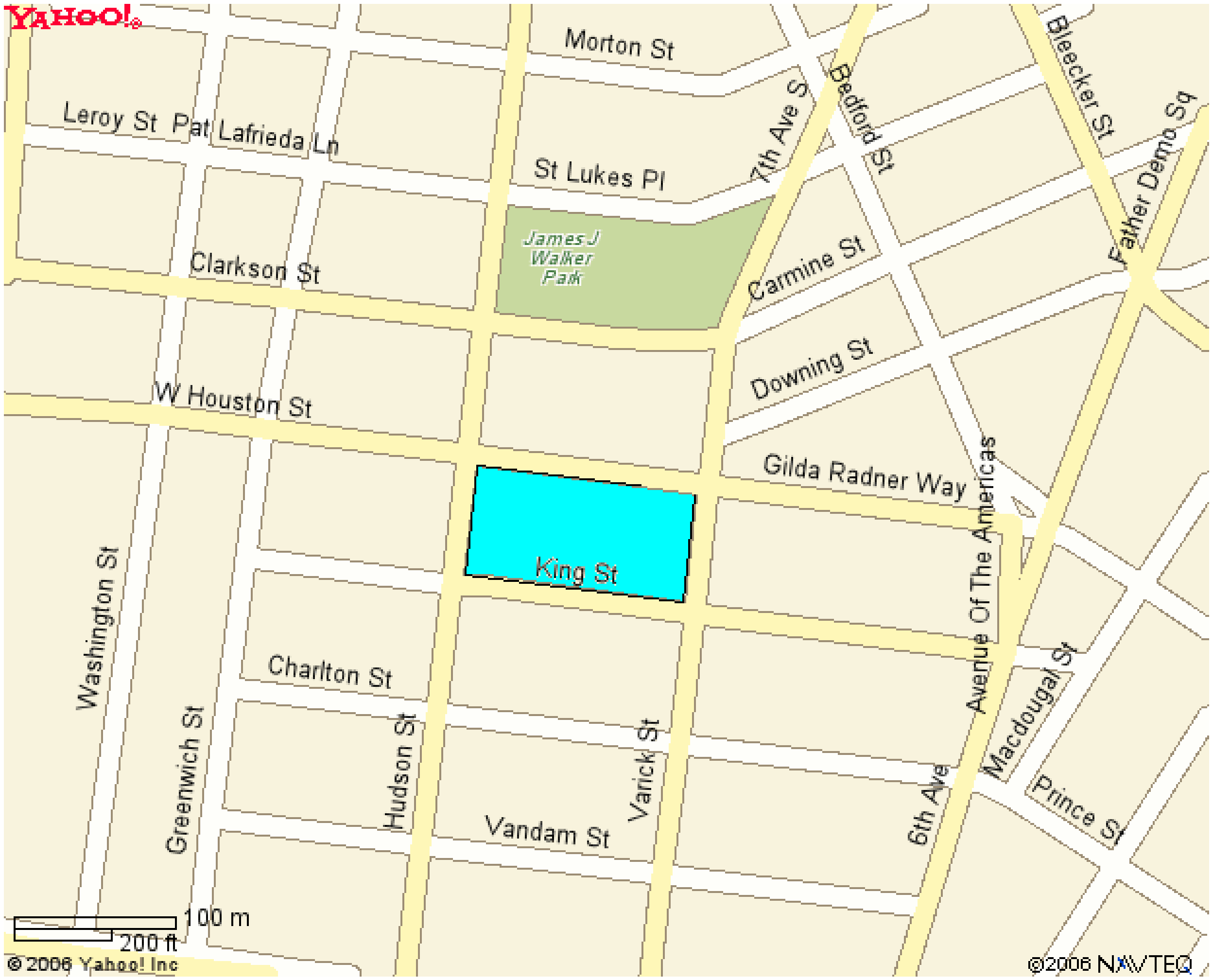
Probe Area(cm^2)	126	N/A	126	N/A
L_c (critical level counts)	4.04	0.74	28.54	18.05
L_d (lower limit of detection)	11.05	4.47	59.95	39.02
MDA(minimum detectable Activity(dpm)	55.29	12.08	299.92	150.15
MDA(dpm/100 cm^2)	**44**	**12**	**238**	**150**
DCGLs (dpm/100cm^2)	**500**	**20**	**1000**	**200**

Note:

a -assumed background counting rate

APPENDIX D

Site Maps


YAHOO!
Morton St
Leroy St
Pat Lafrieda Ln
St Lukes Pl
7th Ave S
Bedford St
Bleecker St
Father Demo Sq
James J Walker Park
Clarkson St
Carmine St
Downing St
W Houston St
Gilda Radner Way
Avenue Of The Americas
King St
Washington St
Greenwich St
Charlton St
Hudson St
Varick St
Macdougal St
6th Ave
Prince St
Vandam St
100 m
200 ft
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201 Varick Street