ATTACHMENT 2
MINIMUM DETECTABLE CONCENTRATIONS AND ALPHA SCAN WORK INSTRUCTION

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Estimation of Minimum Detectable Concentrations

The following technical approach for establishing the MDC for gamma-emitting radionuclides utilizes the methodology and approach utilized in MARSSIM Section 6.7.2.1 (NRC, 2000) and a modified NUREG-1507 (*Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* [NRC, 1998]) method for determining the static and scan MDC for gamma-emitting radionuclides. Static and scan MDCs and scanning sensitivity utilizing a Bicron G-5 FIDLER were calculated for HEU below (as described briefly in Section 5.1).

The basic parameters of the model consist of the following:

- Radionuclide mix and source activity (i.e., energy and yield of gamma emissions)
- Density of source media and physical size of source (i.e., areal dimensions of source)
- Relative distribution of potentially-impacted material (point versus distributed source and depth of elevated activity)
- The source to detector probe geometry
- Ambient background radiation of surveyed area
- Scan rate (observation interval)
- Index of sensitivity
- Efficiency related to surveyor

A general overview of the approach to determining scan MDCs follows:

- The model parameters described above provide an estimate for the exposure rate of the detector probe
- The relationship between the detector's net count rate and the net exposure rate (counts per minute per microrem per hour, [cpm/μR/hr]) is determined
- The sodium iodide (NaI) scintillation detector background level and scan rate (observation interval) are postulated, and the (MDCR) for the ideal observer, for a given level of performance, is obtained (note that the Bicron G-5 utilizes sodium iodide scintillation crystals)
- A surveyor efficiency is selected, and then it is necessary to relate the survey MDCR ($\mathrm{MDCR}_{\mathrm{surveyor}}$) to a radionuclide concentration (in pCi/g)

The computer code Microshield® was used to model expected exposure rates from the radioactive source at the detector probe NaI crystal, and includes source to detector geometry and inter-dispersed shielding. The geometry and shielding are used to calculate the total flow of photons incident upon the detector crystal, called the gamma fluence rate, ultimately corresponding to a dose and countrate in the instrument. The overall approach provides the gamma fluence rate and hence instrument response to various photon energies based on the exposure rate from the radioactive material being measured (e.g., 15 keV, 20 keV, 30 keV, etc.). Each calculation in this process where the photon energy is a factor is therefore performed for each of these photon energies. The specific photon emission energies present within the source radionuclide(s) are modeled to establish the gamma fluence rate to exposure rate (FRER).

The amount of radioactivity the detector crystal is exposed to from the modeled source is used to determine the relationship between the detector's net count rate and the net exposure rate (counts per minute per microrem per hour, [cpm/μR/hr]). This methodology (NRC, 1998) correlates the radionuclide source to the minimum detectable net exposure rate, as the net exposure of the crystal varies with the energy of the photon emission. Typical background exposures are incorporated into the model.

Input parameters assume the presence of normalized concentrations of high-enriched enriched uranium in soil. For gamma walkover surveys using the Bicron G-5, the activity is assumed to be uniformly distributed over a disk-shaped area with a depth of six inches and a diameter of 22 inches; the 22 inch diameter pertains to the width of the path of the GWS as performed by the surveyor. Fifty years of in-growth of associated progeny was utilized in the model, pertaining to the timeframe when fuel fabrication operations began at the Site circa 1959 (refer to Section 2.0). An arbitrary concentration of one pCi/g of HEU is used for modeling purposes. This is consistent with the NUREG-1507 methodology and provides for a count rate to exposure ratio (cpm/μR/hr) to be calculated. The following text provides an overview of the NUREG-1507 factors and methodology used to calculate the HEU MDCs.

Step 1: Fluence Rate to Exposure Rate (FRER)

We begin by calculating the fluence rate to exposure rate (FRER, unitless), which may be calculated using the following equation from NUREG-1507 (refer to Table 1, page B-11 for the G-5 calculation):

$$Fluence\ Rate\ (FRER) \approx \frac{1 \mu R/hr}{(E_\gamma)(\mu_{en}/\rho)_{air}}$$

Where:

E_γ energy of the gamma photon of concern (kiloelectron volts [keV])

$(\mu_{en}/\rho)_{air}$ mass energy absorption coefficient in air at the gamma photon energy of concern (centimeters squared per gram [cm^2/g])

The gamma energy photon data mass energy absorption coefficients have been applied to the 662 keV gamma photon for cesium-137 (^{137}Cs) for example:

$$(FRER) \approx \frac{1 \mu R/hr}{(E_\gamma)(\mu_{en}/\rho)_{air}} \approx \frac{1 \mu R/hr}{(662)(0.0294)} \approx 0.0514$$

Step 2: Probability of Interaction (P) Through Detector End for a Given Energy

Next, we make the reasonable assumption that the primary gamma interaction producing the detector response occurs through the end of the detector (as opposed to the sides); the probability of interaction (*P*) for a photon is calculated for each of the various photon energies including the 662 keV gamma photon for ^{137}Cs using the following equation (refer to Table 2, page B-11 for the G-5 calculation):

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

Where:

P	probability of interaction (unitless)
$(\mu/\rho)_{NaI}$	mass absorption coefficient of NaI crystal at the energy of interest (cm^2/g)
x	thickness of the thin edge of the NaI crystal (0.063 inches for the G-5 and 1 inch for the G-1)
ρ	density of the NaI crystal (3.67 g/cm^3)

Step 3: Relative Detector Response (RDR)

The relative detector response (*RDR*) for each of the various photon energies including the 662 keV gamma photon for ^{137}Cs is determined by multiplying the FRER by the probability of interaction (*P*) (refer to Table 3, page B-12 for the G-5 calculation):

$$RDR = (FRER) \times (P)$$

Step 4: Relationship Between Detector Response (cpm) and Exposure Rate (μR/hr)

Given the calculated values for the FRER, P, and RDR at the ^{137}Cs energy of 662 keV as determined in Steps 1, 2, and 3 above, the mass energy absorption coefficient for air and the mass attenuation coefficient for NaI are interpolated from tables on pages 139 and 140 in the Radiological Health Handbook (PHS, 1970).

Bicron provides an estimated response of both the G-5 and G-1 NaI crystals in a known radiation field for the ^{137}Cs energy of 662 KeV (1,287 and 300 cpm per μR/hr, respectively). The detector responses at this energy can be used to determine the response at all other energies of interest, using the following equation (refer to Table 4, page B-13 for the G-5 calculation):

$$cpm / \mu R/hr \ at \ E_i = \left({}^{137}Cs \ cpm \right) \times \frac{RDR_{Ei}}{RDR_{{}^{137}Cs}}$$

Where:

E_i	energy of the photon of interest (keV)
$^{137}Cs\ cpm$	response of detector in cpm per µR/hr at the ^{137}Cs energy of 662 KeV (cpm)
RDR_{Ei}	RDR at the energy of interest
$RDR_{^{137}Cs}$	RDR for ^{137}Cs
cpm/µR/hr at E_i	response of the detector in each energy of interest

Step 5: Relationship Between Detector Response (cpm) and Contamination Level (pCi/g)

The relationship between the detector response (i.e., *cpm/µR/hr* at E_i established in Step 4) and the contamination volume of soil modeled using Microshield® provides the inputs to determine the minimum detectable exposure rate, which in turn is used to determine the MDC. The weighted cpm per µR/hr response (weighted instrument sensitivity [WS_i]) is calculated for each of the various photon energies by multiplying the exposure rate (i.e., the Net Microshield® Exposure Rate with buildup [R_i], µR/hr at 1 pCi/g) by the corresponding *cpm/µR/hr* at E_i established in Step 4, and then dividing the result by the sum total µR/hr (at 1 pCi/g) for all photon energies (refer to Table 5, page B-13 for the G-5 calculation):

$$Weighted\ Instrument\ Sensitivity\ (WS_i) = \frac{R_i \times (cpm\ per\ \mu\mathrm{R}/hr)}{Sum\,Total\ R_i}$$

The percent of instrument response is then calculated by dividing the weighted instrument sensitivity by total weighted cpm per µR/hr and multiplying by 100 (refer to Table 5, page B-13 for the G-5 calculation):

$$Percent\ of\ instrument\ reponse = \frac{WS_i \times 100}{Sum\,Total\ WS_i}$$

Step 6: Calculation of Scan Minimum Detectable Count Rates

The GWS model utilizes a scan speed of 0.5 meters per second (m/s) provides an observation interval of one second for the modeled disk-shaped contaminated area. The downhole gamma model utilizes an observation interval of 60 seconds because the measurements are one-minute static counts. The observation interval is expressed as follows:

$$b_i = b \times \frac{1\,\mathrm{min.}}{60\,\mathrm{sec.}} \times i$$

Where:

b	background count rate (counts per minute)

b_i the average number of counts in the background interval (counts per second)

i the observation interval length (one second)

A "typical" measured background is 10 μR/hr in an uncontaminated area in the eastern United States when not near granite outcroppings. Background gamma radiation generally resembles the 662 keV gamma particle emitted by ^{137}Cs, which will be used as our model for ambient background radiation. Using a conversion factor based upon field measurements of 1,287 cpm per μR/hr for ^{137}Cs with the G-5 results in an estimated background count rate of 12,870 cpm. Converting this value from cpm to counts per second (cps) results in a background of 214.5 cps.

The scan MDC is calculated using the methodology in NUREG-1507 (calculations for the G-5 are shown below for illustrative purpses). The MDCR and $\text{MDCR}_{\text{surveyor}}$ parameters utilize a counting error based upon the square root of the counts in the background interval (i.e., one second):

$$s_i = d'\sqrt{b_i} = 1.38 \times \sqrt{214.5} = 20.21\, cps$$

$$s_{i,\,surveyor} = \frac{d'\sqrt{b_i}}{\sqrt{p}} = \frac{1.38 \times \sqrt{214.5}}{\sqrt{0.5}} = 28.58\, cps$$

$$MDCR = s_i \times (60/i) = 20.21 \times (60/1) = 1{,}212\ cpm$$

$$MDCR_{surveyor} = s_{i,\,surveyor} \times (60/i) = 28.58 \times (60/1) = 1{,}715\ cpm$$

Where:

s_i minimum detectable number of net source counts in the observation interval (cps)

d' detectability index from Table 6.1 of NUREG-1507; a value of 1.38 was selected, which represents a true positive detection rate of 95% and a false positive detection rate of 60%

p efficiency of a less than ideal surveyor, range of 0.5 to 0.75 (NUREG-1507); a value of 0.5 was chosen as a conservative value for the G-5

$s_{i,surveyor}$ minimum detectable number of net source counts in the observation interval by a less than ideal surveyor (cps)

$MDCR$ minimum detectable count rate (cpm)

$MDCR_{surveyor}$ MDCR by a less than ideal surveyor (cpm)

Step 7: Calculation of Scan Minimum Detectable Concentration

The minimum detectable exposure rate (MDER) can be calculated using the previously calculated weighted instrument sensitivities (WS_i established in Step 5) (refer to Table 5, page B-13 for the G-5 calculation), in cpm per µR/hr, for HEU using the following equations:

$$MDER_i = \frac{MDCR_{surveyor}}{Sum\ Total\ WS_i}$$

$$Scan\ MDC_i = C_i \times \frac{MDER_i}{R_i}$$

$$Scanning\ Sensitivity = \frac{MDCR_{surveyor}}{Scan\ MDC_i}$$

Where:

$MDER_i$	MDER for the “ith” source term, by a less than ideal surveyor, (µR/hr)
$MDCR_{surveyor}$	MDCR rate by a less than ideal surveyor (cpm)
WS_i	weighted instrument sensitivity for source term “i” (cpm per µR/hr) R_i exposure rate with buildup for the “ith” source term (µR/hr) C_i concentration of the “ith” source term (pCi/g)
Scan MDC_i	MDC for the “ith” source term (pCi/g)
Scanning Sensitivity	(cpm per pCi/g)

The calculated scan MDCs and scanning sensitivities are presented on page B-14 for the G-5 calculation, and in Table 5-1.

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

WORK INSTRUCTION

To: Project File

From: Cabrera Services

Date: 24 February 2012

RE: Alpha Scan Procedure for Solid Surface Final Status Surveys during the Decommissioning of Former UNC Manufacturing Facility, New Haven, CT

Background

Cabrera Services, Inc. (Cabrera) is required to remove radiologically-contaminated soils and debris and perform a Final Status Survey (FSS) in five areas at the United Nuclear Corporation (UNC) Naval Products facility in New Haven, Connecticut. These five areas are the X-Ray Read Room, the Decon Pit, the Argyle Street Sewer, the Laydown Area, and the South Trench. The South Trench is a utility tunnel that runs under the concrete floor along the southern wall of Building 3H/6H. It contains pipes with asbestos wrapping that, in some cases, is in poor condition and has fallen on the floor of the trench. The South Trench will require asbestos abatement and debris removal before radiological surveys can be performed in the trench.

This facility was used by UNC from the 1950's into the 1970's to manufacture components for nuclear reactors. These components were primarily made under contract with the U.S. Department of Energy or its predecessor agencies. The nuclear material processed at the facility that will require remediation is uranium, some of which is highly enriched uranium (HEU) enriched up to >97% ^{235}U. The site consists of a building identified as 3H and 6H, its environs, and a connected sewer system, which is inactive. A utility trench is located on the south side of both buildings and extends past the southeast edge of the property. The site is located at the edge of an industrial park, and the building is used primarily as a warehouse. It is enclosed by a chain link fence.

The purpose of this document is to describe the specific means and methods by which Cabrera will perform FSS, including alpha scans, static measurements, and removable measurements, inside the South Trench. The scope and effort involved in the FSS of the South Trench was not fully understood at time of the writing of the project *FSS Plan* (UNC, 2006). The FSS will also be performed in accordance with all Cabrera project work plans, including the *Accident Prevention Plan*, *Radiation Protection Plan*, and *Nuclear Material Control and Accountability Plan* (Cabrera, 2010), and the project *FSS Plan*, which was designed in accordance with *Multi-Agency Radiological Survey and Site Investigation Manual* (MARSSIM; NRC, 2000).

Radionuclides of Concern

The radionuclides of concern (ROCs) that were considered during the FSS are highly-enriched uranium (HEU) (containing uranium-234 [^{234}U], uranium-235 [^{235}U], and uranium-238 [^{238}U]). Due to most of the activity from HEU being from ^{234}U, an alpha emitter, alpha surveys will be performed on all solid surfaces.

Derived Concentration Guideline Levels

As described in MARSSIM (NRC, 2000), a DCGL is a derived radionuclide activity concentration that corresponds to a dose-based release criterion; and a $DCGL_W$ is the DCGL used in non-parametric statistical testing to evaluate compliance with the dose-based criterion across a wide area (i.e., SU). For this FSS, the release criterion is 5,000 total disintegrations per minute per 100 square centimeters (dpm/100 cm^2) total alpha activity and 1,000 dpm/100 cm^2 removable alpha activity based on the levels specified in Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* (NRC, 1974). The corresponding DCGLs for structures are displayed in Table 2 in bold.

Table 2 Acceptable Surface Contamination Levels

RADIONUCLIDE(A)	**ACCEPTABLE SURFACE CONTAMINATION LEVELS (DPM/100 CM^2)**		
	REMOVABLE(B,E)	**AVERAGE**(B,C)	**MAXIMUM**(B,D)
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{221}Ac, ^{125}I, ^{129}I	20	100	300
Th-Natural, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I	200	1,000	3,000
U-Natural, ^{235}U, ^{238}U, and associated decay products	**1,000**	**5,000**	15,000
Beta-Gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above.	1,000	5,000	15,000

Notes:
(a) Where surface contamination by both alpha- and beta-gamma emitting nuclides exists, the limits established for alpha- and beta-gamma emitting nuclides should apply independently.
(b) As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
(c) Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.
(d) The maximum contamination level applies to an area not more than 100 cm^2.
(e) The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionately and the entire surface should be wiped.

Alpha static and smear measurement results will be evaluated against the DCGLs listed above to determine the suitability of a SU for release. Beta activities are also collected during the surveys for information only.

Survey Unit Determination

The South Trench asbestos abatement will be performed in one small section at a time due to size limitations of the asbestos containments. After the abatement is completed, each section will be measured and separated into survey units based on total surface area of walls and floors. The South Trench will be divided into Class 1 SUs based on the size limitation guidance in MARSSIM of 100 m^2. A total of 22 systematic locations will be placed in each survey unit (ORISE, 2007).

Health physics technicians will enter the South Trench and perform the FSS measurements. Once the results have been collected, reviewed, verified, and validated, data quality assessment will be performed to determine if the SU meets the release criterion. If the FSS data support a conclusion the SU meets the release criterion, the walls and floors will be "locked down" using an encapsulant. If the FSS data do not support a conclusion that the SU meets the release criterion, remediation of hotspots will be performed. Methods to remediate surfaces may include wiping, brushing, or scabbling of surfaces. After remediation is performed, the areas will be surveyed for release again. This process will be repeated until the SU data are determined to meet the release criterion. An industrial hygienist will then collect air samples to determine if the section meets the permissible exposure limit for asbestos. Asbestos abatement work will then continue in the next section of the South Trench.

There are four planned sections in the South Trench. The first section includes the Olin tunnels that extend east and south outside Building 3H. The next three sections encompass the remaining South Trench surfaces inside Building 3H/6H. The South Trench survey unit descriptions are listed in Table 1 below. Note: Section 4 is currently being surveyed, and survey units may be added depending on ongoing soil sampling and remediation within these areas.

Table 1: South Trench Survey Units

Section	# of Survey Units	SU Descriptions	Area Description
1	3	1 floor, 2 wall	Olin Tunnels extending east and south outside Building 6H
2	2	1 floor, 1 wall	Columns 48-41 in Building 6H
3	4	1 floor, 3 wall	Columns 41-26 in Building 6H/3H
4	5	2 floor, 3 wall	Columns 26-8 in Building 3H

FSS Instrumentation

Direct activity measurements will include scans and integrated measurements (i.e., static measurements) of surface alpha/beta radioactivity. Static measurements will be performed to compare contaminant concentrations at discrete sampling locations on the concrete surfaces of the South Trench to the release criterion and facilitate statistical testing. The Model 43-93 hand held (active area 100 cm^2) alpha/beta scintillation detectors will be used to perform scans and static activity measurements. The estimated detector sensitivity and the assumptions used for this detector are presented in Table 3. Detailed calculations and assumptions of direct alpha scan MDCs are presented in Attachment 1 of this Work Instruction.

TABLE 3: DIRECT MEASUREMENT SENSITIVITIES AND ASSUMPTIONS

Model #	Count /Bkg Time (min)	Probe Area (cm^2)	α^1 Efficiency (cpm/dpm)	α^2 Background (cpm)	α Static MDC (dpm/100 cm^2)	β Efficiency (cpm/dpm)	Background (cpm)	β Static MDC (dpm/100 cm^2)
43-93	1	100	0.07	3	190	0.10	250	790

Notes: (1) Total efficiency based on a 2-pi efficiency multiplied by the surface efficiency per guidance in ISO-7503-3. Average 2-pi efficiency calculated with field instrumentation.

(2) Backgrounds were representative of on-site background measurements.

Smear samples were collected at systematic and biased direct surface activity measurement locations to quantify transferable surface alpha and beta radioactivity. Smear samples were analyzed using a Ludlum Model 43-10-1 detector coupled to a Ludlum Model 3030E or 2360 dual scaler.

Count times for smears were set at one (1) minute for surface smear measurements and 20 minutes for background measurements. The smear sample alpha and beta MDCs and relevant assumptions are provided in Table Error**! No text of specified style in document.**-1.

TABLE ERROR! NO TEXT OF SPECIFIED STYLE IN DOCUMENT.**-1. REMOVABLE SURFACE ACTIVITY (SMEAR) SENSITIVITY ASSUMPTIONS**

LUDLUM DETECTOR MODEL NO.	**COUNT TIME (min)**	**BACKGROUND COUNT TIME (min)**	**PROBE AREA (cm^2)**	**EFFICIENCY (cpm /dpm)**	**BACKGROUND[1] (cpm)**	**MDC (dpm/100 cm^2)**
3030E (alpha)	1	20	Smear	0.34	0.2	13
3030E (beta)	1	20	Smear	0.22	55	130

min = minute(s)
dpm = disintegration(s) per minute
cpm = count(s) per minute
cm^2 = square centimeter(s)

(1) Backgrounds were representative of on-site background measurements.

FSS Design

Scan Surveys

The purpose of the scan surveys is to identify areas of elevated radioactivity between systematic sample locations. The South Trench residues will be classified as Class 1 in the *FSS Plan* (UNC, 2006). Alpha scans will be performed over 100% of the South Trench concrete floors and walls. The instrumentation and minimum detectable concentration for these scan surveys are discussed in *FSS Instrumentation* section.

Alpha scans will be performed in the South Trench as follows:

- Using a chalk line, a grid will be created upon the entire surface of each SU consisting of 3 foot by 3 foot squares (or similar size depending on dimensions of floor, not exceeding 10 ft^2).
- The Ludlum Model 43-93 detector paired with a Model 2360, or equivalent, will be used to scan the surface of each SU. The 2360, or equivalent, will be set at a two minute integrated count. At the start of the alpha scan of a grid, the surveyor will begin the two minute count. Moving at a rate of 1 inch per second, the surveyor will move the detector face along the concrete surface within the grid. After the two minute count is up, the alpha/beta result will be marked on a survey form. The surveyor should have one half of the grid completed. The surveyor will start another two-minute count, scan the remainder of the grid, and record a second two-minute count on a survey form.
- The two two-minute alpha scan results from the grid will be combined. After the scans are completed in an SU, these alpha results will be compared. Grids with the highest combined scan results within a SU will be selected for a biased measurement to be

performed. The surveyor will return to the selected grids and perform a biased measurement at the location with the highest alpha activity (1-minute static measurement and collect a smear).

- If during a scan alpha activity is noted that is greater than normal background activity, the surveyor will pause and mark that location for further investigation. If an area is found to have elevated activity, a biased measurement (1-minute static measurement and smear) will be performed at that location. At least one biased measurement will be performed in Class 1 SUs at the location of the maximum scan result.

Grids will be established during the scans and evaluated one by one in each SU in order to compartmentalize scans into small sections that the surveyor can focus on and easily document survey results. It also ensures that scan surveys will be performed at the appropriate scan speed in each grid.

Background Reference Areas

The selection and measurement of material specific background areas will be conducted before FSS activities began. Material-specific measurements will be performed in non-impacted areas of Building 3H/6H on concrete surfaces outside of the South Trench, which are similar to concrete in the impacted areas. These material-specific backgrounds will be subtracted from direct measurement survey results for application to the surface activity DCGLs to determine if the data meet the unrestricted release criteria.

Attachment 1: Scan MDC and Grid Size Calculations

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Probability of Detection and Dwell Time for Alpha Scanning at GE UNC New Haven South Trench

Probability of Detecting DCGL for Alpha Scanning

5000	G - DCGL$_{as}$ (dpm/100 cm^2)
3	B - Bkg Count Rate (cpm)
0.07	E - 2 π Detector Efficiency (calculated)
7.62	d - Diameter of detector in direction of scan (cm) (manufacturers data)
2.54	v - Scan speed (cm/sec)

Determine Time Over Source

$t = {}^{d}/_{v}$ Equation J-3, MARSSIM Appendix J

t = 3

Determine Probability

$$P = 1 - \left[1 + \left(\frac{(GE + B)t}{60}\right)\right] \times \left(e^{\frac{-(GE+B)t}{60}}\right)$$ Equation 6-14 of MARSSIM

Where:

G = Contamination Activity (dpm) – DCGL
E = Detector Efficiency (2 π)
B = Background Count rate (cpm)
t = d/v
d = Width of detector in direction of scan (cm)
v = scan speed (cm/sec)

P= **100.00%**

Dwell Time Over Source

$$t = \frac{13{,}800}{CAE}$$ Equation 6-13 of MARSSIM

Where

C = Contamination Guideline (dpm/100 cm^2)
A = Physical Probe Area (cm^2)
E = Detector Efficiency (2 π * surface efficiency)

t= **0.39** seconds

Total Time Required to Complete Scan of 10 ft^2 (2X5) Grid in South Trench

3	Detector Width (in)
6.5	Detector Length (in)
24	Grid Length (in)
1	Scan Speed (in/sec)
24	Time Required to Scan Length of Grid
60	Grid Width (in)
9.231	Total Detector Passes Required Inside Grid
4.0	**Time Required to Scan Grid (minutes)**