FINAL STATUS SURVEY PLAN

DEFENSE NATIONAL STOCKPILE CENTER
NEW HAVEN DEPOT

NEW HAVEN, INDIANA

Prepared for:

U.S. ARMY JOINT MUNITIONS COMMAND
ROCK ISLAND, IL

On behalf of:

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January 2008

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ATTACHMENTS

ATTACHMENT 1: FSS Figures

LIST OF ACRONYMS

bgs	below ground surface
CABRERA	Cabrera Services, Inc.
cm	centimeter
cm^2	square centimeter
cm/s	centimeters per second
CFR	Code of Federal Regulations
CPR	cardiopulmonary resuscitation
DCGL or $DCGL_W$	derived concentration guideline level
Depot	New Haven Depot
DNSC	Defense National Stockpile Center
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQA	data quality assessment
DQO	data quality objectives
ERS	Environment Radiation Safety
FSS	final status survey
FSSP	final status survey plan
GPS	global positioning system
GSA	General Services Administration
H_a	alternate hypothesis
H_0	null hypothesis
HAZWOPER	hazardous waste operations and emergency response
HSA	historical site assessment
JHA	job hazard analysis
JMC	Joint Munitions Command
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NORM	naturally occurring radioactive material
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
Pangea	Pangea Group
pCi/g	picocuries per gram
PPE	personal protective equipment
QA	quality assurance
RAM	radioactive material
RCOC	radiological contaminant of concern
S+	Sign test statistic
SSHP	site safety and health plan

LIST OF ACRONYMS

U.S.	United States
W_R	WRS test statistic
ZnS	zinc sulfide
^{228}Ac	actinium-228
^{214}Bi	bismuth-214
^{232}Th	thorium-232
^{235}U	uranium-235
^{238}U	uranium-238

1.0 INTRODUCTION

The Defense National Stockpile Center (DNSC) and Cabrera Services, Inc. (CABRERA) have prepared this final status survey plan (FSSP) for the New Haven Depot (Depot) in New Haven, Indiana. Because of the nature of operations, the greatest potential radiological hazard at the Depot was due to the presence of residual radioactive materials (RAM) from prior storage of commodities containing naturally occurring radioactive materials (NORM).

The proposed derived concentration guideline levels (DCGLs) for the Depot are based on the screening values published by the United States (U.S.) Nuclear Regulatory Commission (NRC) in NUREG-5512, Volume 3, Tables 5.19 (NRC 1999), for radioactive contamination on structure surfaces and site specific DCGLs for radioactive concentrations in soil (Cabrera 2008). Implementation of this FSSP is intended to obtain data necessary to demonstrate compliance with the DCGLs for both structural surfaces and outdoor areas. Specifically, when the DCGLs are applied to the final status survey (FSS) and data obtained indicates the DCGLs have been satisfied, the requirements in Title 10 Code of Federal Regulations (CFR) Part 20.1402 for unrestricted release are achieved (NRC 2006).

Inputs to the design of this FSSP were obtained through performance of an historical site assessment (HSA) (CABRERA 2006), a characterization survey performed in October and November, 2006 (CABRERA 2007a), and additional characterization surveys of outdoor areas and structures from July through September, 2007. The characterization surveys were designed and implemented such that some or all of the data generated may be used as FSS data.

2.0 FACILITY AND SITE INFORMATION

2.1 Facility Location and Description

The Depot is located on 268 acres 3 miles east of New Haven, Indiana. It is currently owned by the General Services Administration (GSA), and operated by the U.S. Department of Defense, Defense Logistics Agency, DNSC. A series of rail spurs extending off the Norfolk Southern rail line cross the site along the east-west axis, converging at the site's southwestern and southeastern corners. Vehicle access is provided from State Route 14 near the center of the site. A 6-foot high fence topped with three-strand barbed wire surrounds the site. A security officer controls access to the site.

Historically, the Depot's primary mission has been storage of metallurgical ores and materials necessary for manufacturing defense and/or strategic materials. Throughout the system of warehouses and outdoor areas at the Depot, the DNSC has stored columbium/tantalum ores and concentrates, tungsten ores and concentrates, zirconium ore, rare earth sodium sulfate, monazite, tungsten metal scrap, and bastnasite, all containing sufficient amounts of natural uranium and thorium to require licensing under NRC regulations. The DNSC stored these materials in accordance with NRC License STC-133. The materials were typically stored in outdoor piles (zirconium ore) and in wooden boxes or drums in designated bays inside large warehouses.

Due to the large volume stored and the fact that it was stored in a paved but open storage yard, zirconium ore represents the greatest potential of radioactive contamination at the site. Zirconium ore (baddeleyite) is a natural zirconium oxide found in Brazil and Ceylon. The ore contains NORM in the form of uranium and thorium. The zirconium ore at the Depot was stored in two piles designated 111 and 111A in open Area 7A in the northwest corner of the Depot (see Attachment 1, Figure 1-1). Approximately half of the zirconium ore in Pile 111 was shipped to the Depot in 1988 from the DNSC depots at Jeffersonville, Indiana and Columbus, Ohio. The contaminated soil at the base of the piles from the Jeffersonville and Columbus Depots comprised the contents of Pile 111A. Pile 111, which was 28 feet high, 296 feet long, and 60 feet wide, covering an area of approximately 1,650 square meters (m^2), contained 31,981,402 pounds of ore. Pile 111A was 28 feet high, 104 feet long, and 50 feet wide, covering an area of approximately 650 m^2. Together, Piles 111 and 111A covered a total surface area of 2,300 m^2.

In 1999, DNSC sampled the piles of zirconium ore to determine the percent abundance of thorium and uranium. The analysis showed that the percent abundance of thorium and uranium for the piles met the criteria established by the NRC to require licensing. Pile 111 contained 0.091% thorium and 0.204% uranium by weight. Pile 111A contained 0.081% thorium and less than 0.004% uranium by weight. Because of the abundance of thorium and uranium, the zirconium ore was controlled by the DNSC in accordance with NRC license number STC-133.

The zirconium ore was sold in October 2000 and was loaded directly into rail cars at the Area 7A storage location by a front-end loader. The rail cars were then moved to the rail scale where the amount of ore in the car was adjusted to maintain an acceptable weight. After achieving the maximum weight, the cars were moved to the shrink-wrapping Area where the tops were shrink-wrapped to preclude loss of the ore during offsite transit. During the loading process, it is likely that some of the ore was inadvertently deposited onto the ground surface. The areas potentially impacted during this process were the railway and roadways used for the transport of the ore, the rail scale area, and the building used for shrink-wrapping the rail cars.

The zirconium ore stored was clastic (pebble sized clasts and finer grained fragments) and thus, was not easily dispersible in the air. Spillage of the ore occurred from either the front-end loader or from the bottom of the rail cars. The paved road from open Area 7A to the rail scale, the rail scale, and the railroad tracks at the southern end of the Depot in front of Building 111, had the largest accumulations of discrete zirconium residue. Spillage in areas where the ore was handled (along other rail lines on the western side of the Depot) consisted of smaller discrete accumulations of ore.

In addition to the outdoor zirconium ore piles, other materials stored at the Depot contained licensable quantities of thorium and uranium and were packaged in either wooden boxes or drums. The boxes and drums were stacked in various bays throughout a series of six storage buildings (Warehouses 210 through 215) as well as other smaller buildings at the Depot. These warehouses are similar in construction and size. Each warehouse is 180 feet wide by 960 feet long, with wood, concrete, or concrete-block structural framing supporting wood roof decks, and a total floor space of approximately 16,054 m^2. The warehouses are subdivided into four equal 180-foot by 240-foot sections, with a floor space of approximately 4,013 m^2 per section. Each of these sections is further divided into 79 storage bays which are equal in size (approximately 20 feet by 20 feet). Additional buildings where licensed RAM was handled and/or stored, and considered impacted, include buildings 136, 141, 145 (currently only the footprint remains) and 146. Structures and outdoor areas where licensed RAM was stored and/or handled are also shown in Attachment 1, Figure 1-1.

2.1.1 Radiological Contaminants of Concern

Based on the composition of the metallurgical ores stored at the Depot, the radiological contaminants of concern (RCOC) are natural thorium and natural uranium. Since the ores containing these RCOCs were simply stored at the Depot and never processed, the radioactive decay products in both the natural thorium and natural uranium chains remain in secular equilibrium with the parent radionuclide, as they were in nature.

The parent radionuclides in the natural thorium and natural uranium decay chains, thorium-232 (^{232}Th) in the natural thorium decay chain, uranium-238 (^{238}U) and uranium-235 (^{235}U) in the natural uranium decay chain, emit alpha particles. The daughter products in both chains decay by emission of alpha or beta particles, some with accompanying emission of gamma rays. The decay schemes for both the natural thorium and natural uranium chains are very well documented, and this knowledge is used in the design of the FSS, as well as the selection of appropriate survey instruments and analysis methods.

2.2 Previous Radiological Studies

In 2002, Environment Radiation Safety Solutions (ERS) conducted a FSS of all impacted outdoor areas at the Depot, excluding open Area 7A where the zirconium ore was stored at the time. Based on the results of the survey, remediation efforts were conducted at each survey unit (SU) in 2002 by ERS.

For the efforts at the rail scale and in front of Warehouse 211, a backhoe was used for the removal of 33 cubic yards of debris. In the remaining affected areas, removal was performed by picking up the rocks by hand and placing the debris in buckets. All debris removed was placed in open Area 7A. After completion of the remediation efforts, surveys were performed of all areas to demonstrate successful removal of the ore and to ensure residual radioactivity was consistent with background (ERS 2002).

The NRC evaluated the FSS conducted by ERS and concluded that additional information was needed to adequately demonstrate that the Depot areas surveyed met the requirements of 10 CFR 20.1402 for unrestricted release (NRC 2006).

Pangea Group (Pangea) conducted additional removal and remediation of the residual zirconium ore in open Area 7A in 2004 (Pangea 2005). After the ore and soils Piles 111 and 111A were loaded and transported offsite, Pangea removed at least the top 6 inches of soil and residual contamination from the entire 7A area, including the eastern access road and the railroad track bed to the south. After further contamination significantly above background was detected, soil was removed to a depth of 9 inches in the most contaminated areas in open Area 7A. Excavation was then discontinued per contract specifications. Test pits that were dug in open Area 7A showed further contamination to a depth of 3 feet.

ERS performed a field audit of Pangea's remediation efforts on July 12 and 13, 2004 (ERS 2004). Elevated gamma results were found along the outside of the planned excavated area during the audit.

As a result of the HSA (CABRERA 2006), the Depot outdoor areas and structures identified in Table 2-1 have been initially classified as impacted. The initial survey unit classification for these areas, following the guidance in the *Multi-Agency Radiological Survey and Site Investigation Manual* (MARSSIM) (NRC, 2000), is also presented in this table.

TABLE 2-1: INITIAL CLASSIFICATION OF OUTDOOR AREA AND STRUCTURE SURVEY UNITS

Location		Survey Unit Classification
Outdoor Areas		
Area 7A		Class 1
Buffer Area around Area 7A		Class 2
Rail Scale (Weigh Station Area)		Class 2
Entry Road and Paved Road to Rail Scale		Class 3
Railroad Tracks Used for Shrink-Wrapping		Class 3
Railroad Tracks Used for Storage or Transport		Class 3
Structures		
Building 136		Class 3
Building 141		Class 3
Building 145 (footprint)		Class 3
Building 146		Class 3
Warehouse 210	Section 1	Class 3
	Section 2	Class 3
	Section 3	Class 3
	Section 4: Bays 2-5, 8, 9, 12-14, 32-33, 35, 43, 45, 46, 48, 52-54, 56, 58, and 76	Class 3
Warehouse 211	Section 1	Class 3
	Section 2	Class 3
Warehouse 212	Section 1: Bays 11, 31, 37, 41, 51, 61, and 71	Class 3
	Section 2: Bays 11, 12, and 21	Class 3
Warehouse 213	Section 1	Class 3
	Section 2: Bays 12, 13, 15, and 16	Class 3
	Section 3: Bays 11, 19, 21, and 29	Class 3
	Section 4	Class 3
Warehouse 214	Section 1	Class 3
	Section 2	Class 3
	Section 3: Bays 3-6, 8, 9, 12-18, 22-28, 31-34, 36-38, 41-44, 48, 56, 57, 75, and 77	Class 3
	Section 4	Class 3
Warehouse 215	Section 1: Bays 2-4, 11, 12, 13, 22, 23, 25-29, 34-37, 41, 43, 44, 45, 62, and 73-75	Class 3
	Section 2: Bays 36, 41, 42, 46, 52-54, 62, and 63	Class 3
	Section 4: Bays 15, 19, 29, 51-56, 61-65, 68, and 71-79	Class 3

Radiological characterization of outdoor areas and many of the impacted structures were completed in November 2006, with the results of the outdoor area characterization published in February 2007 (CABRERA 2007a). The surveys included outdoor Area 7A, the buffer area around Area 7A, impacted roadways to and from the rail scale, paved areas near the rail scale, outdoor shrink wrap area, outdoor storage and transport area, and the following structures:

1. Building 124
2. Building 136
3. Building 146
4. Warehouse 211
5. Warehouse 212
6. Warehouse 213
7. Warehouse 215

Additional characterization surveys performed in 2007 completed the remaining structures at the Depot and repeated some of the surveys performed in 2006 using longer instrument count times to achieve a lower detection sensitivity or minimum detectable concentration (MDC). The additional structure characterization surveys were completed for the following:

1. Building 129A
2. Building 141
3. Building 145 (remaining concrete pad)
4. Warehouse 210
5. Warehouse 214

2.3 Summary of Characterization Surveys Performed in 2006

The following sections provide summary characterization survey data for impacted structures and outdoor areas which were performed in 2006.

2.3.1 Reference Area Background

Since the RCOCs at the Depot consist of NORM, background concentrations for the RCOC were determined during the characterization survey. Surface and subsurface soil samples were collected from a portion of the Depot that was not impacted by activities or storage of licensed RAM. The background soil concentrations, in picocuries per gram (pCi/g), are provided in Table 2-2.

TABLE 2-2: 2006 REFERENCE AREA BACKGROUND SOIL CONCENTRATIONS

Location	^{232}Th (pCi/g)	^{238}U (pCi/g)
Surface Soil	1.13	1.41
Subsurface Soil	1.20	1.30

2.3.2 Outdoor Areas

Outdoor area 7A was initially divided into 4 survey units. These included 3 contiguous Class 1 survey units, identified as survey units 1, 2 and 3, each covering an area slightly less than 2,000 m^2. A single Class 2 survey unit, identified as SU 4, was established around the Class 1 survey units covering an area of 4,141 m^2. A gamma scan was performed over 100 percent of accessible areas within these survey units, with approximately 20 percent of the area inaccessible due to the presence of test pits and standing water. Systematic surface (0 to 15 centimeter [cm] below ground surface [bgs]) and subsurface (16 to 30 cm bgs) soil samples were collected from each of the survey units, as well as biased samples based on the results of gamma scans. Additional soil sampling was performed in area around the rail scale and the entry road to Area 7A.

Systematic soil sample results from these areas, corrected for the reference area background concentrations in Table 2-2, are summarized in Table 2-3. Biased soil sample results, also corrected for background concentrations, are provided in Table 2-4.

TABLE 2-3: 2006 OUTDOOR AREA SYSTEMATIC SOIL SAMPLE SUMMARY

^{232}Th								
	Surface Soil				Subsurface Soil			
Survey Unit	Average (pCi/g)[1]	Standard Deviation	Min (pCi/g)[1]	Max (pCi/g)[1]	Average (pCi/g)[1]	Standard Deviation	Min (pCi/g)[1]	Max (pCi/g)[1]
1	-0.20	0.30	-0.95	1.41	-0.34	0.32	-0.99	0.11
2	-0.47	0.36	-0.96	0.37	-0.25	0.31	-0.99	0.30
3	-0.45	0.42	-0.98	0.23	-0.39	0.35	-0.93	0.06
4	-0.10	0.25	-0.81	0.31	-0.08	0.26	-0.69	0.45
^{238}U								
1	0.01	1.08	-1.22	3.42	0.00	0.51	-0.94	0.85
2	-0.36	0.53	-1.51	0.89	-0.38	0.57	-1.13	0.70
3	-0.43	0.38	-1.21	0.21	-0.32	0.46	-0.93	0.68
4	-0.25	0.47	-1.06	0.89	-0.10	0.68	-1.50	1.20

[1] Net sample result = Gross result - average reference area concentration

TABLE 2-4: 2006 OUTDOOR AREA BIASED SOIL SAMPLE SUMMARY

^{232}Th								
	Surface Soil				Subsurface Soil			
Survey Unit	Average (pCi/g)[1]	Standard Deviation	Min (pCi/g)[1]	Max (pCi/g)[1]	Average (pCi/g)[1]	Standard Deviation	Min (pCi/g)[1]	Max (pCi/g)[1]
1	-0.52	0.59	-0.91	0.16	-0.02	0.48	-0.40	0.52
2	3.11	3.50	-0.08	6.67	5.94	12.24	-0.44	24.30
3	-0.16	0.53	-1.07	0.62	-0.26	0.45	-0.95	0.39
4	N/A[2]				N/A[2]			
Entry Road	-0.12	0.11	-0.19	-0.04	N/A[2]			
Rail Scale	4.22	N/A[3]			-0.88	N/A[3]		
^{238}U								
1	1.47	2.66	-0.51	4.49	1.16	1.51	-0.57	2.16
2	16.44	21.35	0.98	47.69	32.33	62.94	-1.00	126.70
3	1.46	1.56	-0.50	4.39	0.19	0.60	-0.40	1.70
4	N/A[2]				N/A[2]			
Entry Road	0.73	0.83	0.14	1.32	N/A[2]			
Rail Scale	11.69	N/A[3]			-0.21	N/A[3]		

[1] Net sample result = Gross result - Average reference area concentration
[2] Not applicable (N/A); no data
[3] Only one sample collected.

Individual soil sample results, primarily from the biased soil samples in Area 7A, the entry road and rail scale area, indicate that small areas of elevated radioactivity exist and additional investigation is necessary that may also result in further soil remediation. This investigation is discussed in detail in the remediation work plan prepared by CABRERA (CABRERA 2007b). Additionally, the results of biased soil sampling indicates the entry road and rail scale required designation as Class 1 survey units for the FSS.

Gamma walkover surveys were performed over 100 percent of accessible surfaces in the rail scale area and 10 to 20 percent of other Class 3 outdoor solid surfaces. Systematic direct alpha measurements were performed within these areas. Locations of biased direct alpha measurements were selected based on areas of highest contamination potential and the results of the gamma walkover survey. A smear was collected at each systematic and biased direct alpha measurement location to assess removable alpha contamination. A summary of the biased alpha measurements at these outdoor locations is provided in Table 2-5.

TABLE 2-5: 2006 OUTDOOR AREA SURFACE ACTIVITY

Location	Survey Type	Average[1]	Standard Deviation[1]	Maximum[1]
Rail Scale Road	Direct Alpha	0.0	11.2	13.4
	Removable Alpha	0.4	0.7	2.0
Rail Scale	Direct Alpha	2.9	17.5	44.8[2]
	Removable Alpha	0.6	0.9	3.1
Shrink Wrap Area	Direct Alpha	1.8	14.4	31.4
	Removable Alpha	1.8	1.7	4.0
Storage/Transport Area	Direct Alpha	-0.2	15.8	22.4
	Removable Alpha	1.2	1.1	3.3

[1] Disintegrations per minute per 100 square centimeters (dpm/100 cm^2)
[2] Direct alpha measurement influenced by fluorspar stored nearby.

2.3.3 Structures

Characterization surveys of structures consisted of a scan survey over approximately 20 percent of the accessible Class 3 survey unit surfaces, systematic and biased direct measurements, and removable contamination surveys at each of the direct measurement locations. All structures contained a minimum of 2 survey units; a floor survey unit and lower wall survey unit. A third survey unit was added for the warehouse interior structures to include overhead beams/trusses where RAM may have settled over time. Although, contamination present on overhead surfaces was not expected, these surfaces were included during the characterization survey to evaluate assumptions for further definition of Class 3 structure survey units in this FSSP. Systematic measurements were not performed in warehouse overhead survey units. Additionally, since each warehouse contained 4 sections, single floor, wall and overhead survey units were allowed if the impacted sections within the warehouse were contiguous. This was the case for all but Warehouse 215. Within this warehouse, impacted sections 1 and 2 were separated from impacted section 4 by non-impacted section 3. Therefore, separate survey units were identified for Warehouse 215, section 4. Summaries of systematic and biased direct alpha measurement results are provided in Table 2-6 and Table 2-7. Removable alpha contamination summary results are provided in Table 2-8 and Table 2-9.

TABLE 2-6: 2006 STRUCTURE SYSTEMATIC DIRECT ALPHA SUMMARY

Structure	Survey Unit	Average[1,2]	Standard Deviation[1,2]	Maximum[1,2]
124	Floor	-28.9	17.6	1.4
	Wall	-11.9	7.3	1.8
136	Floor	2.6	7.3	22.4
	Wall	-3.2	5.7	9.0
146	Floor	6.3	11.3	22.4
	Wall	1.6	11.9	26.9
Warehouse 211	Floor	-14.4	14.6	18.8
	Wall	10.6	13.4	33.2
Warehouse 212	Floor	-8.3	11.6	14.3
	Wall	-2.7	16.5	33.2
Warehouse 213	Floor	-11.0	10.6	0.9
	Wall	-16.9	17.0	44.8
Warehouse 215, Sections 1 and 2	Floor	-15.7	12.0	5.4
	Wall	2.7	11.1	26.9
Warehouse 215, Section 4	Floor	-21.5	11.9	0.9
	Wall	Not performed	Not performed	Not performed

[1] dpm/100 cm^2

[2] Corrected for material background.

TABLE 2-7: 2006 STRUCTURE BIASED DIRECT ALPHA SUMMARY

Structure	Survey Unit	Average[1,2]	Standard Deviation[1,2]	Maximum [1,2]
124	Floor	-28.9	17.6	1.4
Warehouse 211	Floor	-0.4	3.8	9.8
	Wall	14.8	5.7	22.3
	Overhead	-5.0	7.8	12.8
Warehouse 212	Floor	-2.8	4.6	10.6
	Wall	4.8	9.6	21.3
	Overhead	-5.4	6.3	4.3
Warehouse 213	Floor	-4.6	3.6	8.6
	Wall	9.0	8.7	28.9
	Overhead	-6.5	6.5	4.3
Warehouse 215, Sections 1 and 2	Floor	-4.4	2.6	3.4
	Wall	0.9	3.0	6.8
	Overhead	3.7	8.9	22.3
Warehouse 215, Section 4	Floor	-1.6	4.4	8.5
	Wall	2.6	9.2	23.4
	Overhead	-1.2	6.7	11.1

[1] dpm/100 cm^2

[2] Corrected for material background.

TABLE 2-8: 2006 STRUCTURE SYSTEMATIC REMOVABLE ALPHA SUMMARY

Structure	Survey Unit	Average[1]	Standard Deviation[1]	Maximum[1]
124	Floor	0.5	0.8	2.5
	Wall	0.1	0.6	1.0
136	Floor	-0.4	0.5	0.8
	Wall	0.1	0.9	2.2
146	Floor	0.0	0.8	2.4
	Wall	0.8	1.5	3.6
Warehouse 211	Floor	0.3	0.4	1.3
	Wall	-0.4	0.7	2.2
Warehouse 212	Floor	0.1	0.6	0.8
	Wall	0.3	0.8	2.2
Warehouse 213	Floor	0.1	0.7	1.5
	Wall	0.8	0.8	2.2
Warehouse 215, Sections 1 and 2	Floor	0.4	0.8	2.6
	Wall	0.2	0.7	1.5
Warehouse 215, Section 4	Floor	0.1	0.4	1.3
	Wall	Not performed	Not performed	Not performed

[1] dpm/100 cm^2

TABLE 2-9: 2006 STRUCTURE BIASED REMOVABLE ALPHA SUMMARY

Structure	Survey Unit	Average[1]	Standard Deviation[1]	Maximum[1]
124	Floor	0.1	0.5	1.0
Warehouse 211	Floor	0.9	1.4	5.0
	Wall	1.5	1.4	2.9
	Overhead	0.6	1.4	4.3
Warehouse 212	Floor	0.5	1.2	3.6
	Wall	0.2	1.0	2.9
	Overhead	0.5	0.9	2.9
Warehouse 213	Floor	0.6	0.9	3.6
	Wall	0.2	0.8	2.2
	Overhead	0.5	1.1	5.0
Warehouse 215, Sections 1 and 2	Floor	0.4	0.8	2.2
	Wall	0.4	1.0	2.2
	Overhead	0.6	1.3	5.0
Warehouse 215, Section 4	Floor	0.4	0.8	2.4
	Wall	0.3	1.2	2.9
	Overhead	0.5	0.9	2.2

[1] dpm/100 cm^2

Systematic and biased direct alpha measurements, as well as measurements for removable activity, support the initial classification of structures as Class 3 and did not identify areas requiring further investigation. However, the results of characterization surveys support further clarification of impacted surfaces within these areas to include only floors and lower walls, i.e., wall surfaces up to 2 meters. Upper walls, i.e., wall surfaces above 2 meters, and overhead surfaces are considered non-impacted based on the characterization survey results.

2.4 Summary of Characterization Surveys Performed in 2007

The following sections provide summary characterization survey data for impacted structures and outdoor areas which were performed in 2007.

2.4.1 Reference Area Background

As discussed in Section 2.3.1 the RCOCs at the Depot consist of NORM, similar to what is found in natural background. Although surface and subsurface soil samples were collected during the 2006 characterization survey from a portion of the Depot that was not impacted by activities or storage of licensed RAM, it was determined that a minimum of 32 soil samples would be obtained from each land area survey unit (refer to Section 4.0). Instead of simply increasing the number of surface and subsurface samples from the reference area to make up 32 samples, a new set of 32 surface and 32 subsurface soil samples were obtained and analyzed for the RCOC. The background soil concentrations, in pCi/g, are provided in Table 2-10.

TABLE 2-10: 2007 REFERENCE AREA BACKGROUND SOIL CONCENTRATIONS

Location	^{232}Th (pCi/g)	^{238}U (pCi/g)
Surface Soil	1.09	1.18
Subsurface Soil	1.20	1.14
Average	1.14	1.16

2.4.2 Outdoor Areas

Outdoor area 7A was initially divided into 4 survey units during the 2006 characterization survey. These included SU 1, SU 2, SU 3 and SU 4. A GWS was performed over these survey units, as well as adjacent areas. As a result of the GWS and biased sampling performed in other outdoor areas in 2006, additional Class 1 survey units were identified. These include:

- The area immediately west of and adjacent to Area 7A SU 1 (SU 5),
- The western third of the entry road to Area 7A (SU 6), and
- The soil area around the rail scale (SU 9).

The Class 2 survey unit, SU 4, was enlarged to encompass the perimeter of all contiguous Class 1 survey units in Area 7A (SU 1, SU 2, SU 3, SU 5 and SU 6).

The remaining two thirds of the entry road to Area 7A and the paved road to the rail scale were combined into a single Class 3 survey unit (SU 7). Additional Class 3 survey units include:

- An outdoor area used for shrink wrapping rail cars (SU 10), and
- An additional outdoor area used for storage and transport of filled rail cars, resulting in two separate storage and transport areas, one on the south side of the Depot (SU 11) and one on the west (SU 12).

A gamma scan was performed over 100 percent of accessible areas within the Class 1 survey units and 10 to 100 percent of accessible areas within the Class 2 and Class 3 survey units. Systematic surface and subsurface soil samples were collected from each of the survey units, as well as biased samples based on the results of gamma scans.

Systematic soil sample results from these areas corrected for the average reference area background concentrations in Table 2-10 are summarized in Table 2-11.

Deleted: ¶
Table 2-11

TABLE 2-11: 2007 OUTDOOR AREA SYSTEMATIC SOIL SAMPLE SUMMARY

^{232}Th								
	Surface Soil				Subsurface Soil			
Survey Unit	Average (pCi/g)[1]	Standard Deviation	Min (pCi/g)[1]	Max (pCi/g)[1]	Average (pCi/g)[1]	Standard Deviation	Min (pCi/g)[1]	Max (pCi/g)[1]
5	-0.50	0.51	-1.17	0.95	-0.46	0.43	-1.24	0.38
6	-0.19	0.44	-1.08	0.39	0.01	0.37	-1.13	0.51
7	-0.27	0.30	-0.81	0.27	-0.22	0.29	-0.74	0.40
9	-0.95	0.13	-1.14	-0.57	-0.93	0.17	-1.24	-0.52
10	-0.69	0.51	-1.14	0.29	-0.65	0.53	-1.14	0.26
11	-0.30	0.34	-1.09	0.22	-0.23	0.35	-1.07	0.19
12	-0.16	0.28	-0.78	0.25	0.04	0.27	-0.78	0.49
^{238}U								
5	0.39	1.42	-0.78	6.25	0.41	1.49	-0.87	6.80
6	0.24	0.59	-0.98	2.39	0.22	0.29	-0.98	1.07
7	0.03	0.40	-0.65	0.93	0.08	0.28	-0.54	0.51
9	-0.34	0.75	-1.05	3.10	-0.36	0.97	-0.88	4.42
10	-0.36	0.53	-0.97	0.60	-0.22	0.62	-0.97	0.79
11	0.05	0.37	-0.73	0.78	0.05	0.29	-0.69	0.59
12	0.34	0.29	-0.30	0.80	0.50	0.32	-0.44	0.97

[1] Net sample result = Gross result - average reference area concentration

2.4.3 Structures

Characterization surveys of structures consisted of a scan survey over 100 percent of the Class 1 structure surfaces and 10 to 100 percent of Class 2 and Class 3 structure surfaces which were not performed in 2006 and repeat surveys of some structures. Summaries of structure systematic direct alpha measurement results completed in 2007 are provided in Table 2-12. Removable alpha contamination summary results are provided in Table 2-13.

TABLE 2-12: 2007 STRUCTURE SYSTEMATIC DIRECT ALPHA SUMMARY

Structure	Survey Unit	Average[1, 2]	Standard Deviation[1, 2]	Maximum[1, 2]
129A	Floor & Lower Wall	-6.4	9.7	19.8
136	Floor	8.2	7.6	19.0
	Wall	-7.8	3.9	2.0
141	Floor	-2.9	5.8	4.9
145	Floor	-7.8	7.7	4.9
Warehouse 210	Floor	1.2	3.9	10.7
	Wall	0.8	4.0	6.8
Warehouse 211	Floor	-2.6	4.9	6.8
	Wall	0.6	3.6	6.8
Warehouse 213	Floor	-1.2	2.5	4.9
	Wall	-1.8	4.1	6.8
Warehouse 214	Floor	-2.6	8.7	17.4
	Wall	-1.0	4.7	7.0
Warehouse 215, Sections 1 and 2	Floor	-1.9	3.8	7.8
	Wall	-0.6	4.5	9.0
Warehouse 215, Section 4	Floor	-2.0	4.4	6.8
	Wall	-0.8	2.3	4.1

1 dpm/100 cm^2

2 Corrected for material background.

TABLE 2-13: 2007 STRUCTURE SYSTEMATIC REMOVABLE ALPHA SUMMARY

Structure	Survey Unit	Average[1]	Standard Deviation[1]	Maximum[1]
129A	Floor & Lower Wall	0.3	0.6	1.3
136	Floor	0.1	0.9	2.2
	Wall	-0.4	0.5	0.8
141	Floor	0.1	0.7	1.8
145	Floor	-0.2	0.5	0.8
Warehouse 210	Floor	0.8	0.8	2.0
	Wall	0.5	0.9	2.5
Warehouse 211	Floor	0.3	0.4	1.3
	Wall	-0.4	0.7	2.2
Warehouse 213	Floor	0.1	0.7	1.5
	Wall	0.8	0.8	2.2
Warehouse 214	Floor	0.1	0.6	1.5
	Wall	0.1	0.7	2.0
Warehouse 215, Sections 1 and 2	Floor	0.4	0.8	2.6
	Wall	0.2	0.7	1.5
Warehouse 215, Section 4	Floor	0.1	0.4	1.3
	Wall	0.6	0.8	2.3

[1] dpm/100 cm^2

Characterization surveys of structures generally confirmed the initial MARSSIM classification of all structures at the Depot and were of sufficient quantity and quality to satisfy FSS requirements. All surface activity smear results were less than 10 percent of the surface activity $DCGL_w$. Alpha scan surveys in structures did not identify areas of elevated activity on structure surfaces, with the exception of Warehouse 210. Although, elevated surface activity was not in Warehouse 210, Sections 1, 3, and 4, alpha scan surveys did locate elevated activity in the northwest corner of Section 2. These locations were found in three bays (7, 8 and 19) and floor areas adjacent to bays 7 and 8 (designated 7E and 8E) in the northwest corner of this section of the building. Follow-up direct integrated alpha measurements indicated surface activity above the $DCGL_w$ over a majority of the floor surfaces in 4 locations (bays 7, 8, 7E and 8E) and a localized area of surface activity above the $DCGL_w$ on the floor in bay 19. The results of the characterization surveys in this structure are presented in the *Characterization Survey Report, Building 210* (CABRERA 2007c). Direct alpha measurements obtained in this section of the structure are summarized in Table 2-14.

TABLE 2-14: BUILDING 210, SECTION 2 BIASED DIRECT ALPHA SURVEY SUMMARY

Building	Location	Average[1,2]	Standard Deviation[1,2]	Maximum[1,2]
210, Section 2	Bays 7, 8, 7E and 8E[3]	195	48	256
	Bay 19	351	67	398

1 dpm/100 cm^2

2 Corrected for material background.

3 Locations 7E and 8E are not actual bays, but designators assigned to these spaces which are between contaminated bays 7 and 8 and bays 17 and 18.

As previously discussed, elevated areas of surface activity were not found in any of the other impacted structures and elevated surface activity in Warehouse 210, Section 2 was limited to the areas presented in Table 2-14.

Since the characterization surveys and sampling performed in 2007 were of sufficient quality and quantity to satisfy FSS requirements, these results will be presented in the Depot FSS report, along with FSS sampling and surveys performed following any remediation performed.

3.0 FINAL STATUS SURVEY QUALITY ASSURANCE

The FSS project responsibilities, training requirements, and quality assurance (QA) are described in the following sections.

3.1 Organization and Responsibility

The CABRERA key positions for executing the FSSP are as follows:

- **CABRERA Program Manager**: Kim Nelson, Professional Geologist, is responsible for overall project objectives, scope, budget, and quality of submittals. She will ensure that adequate corporate resources are made available to the CABRERA Project Manager. Ms. Nelson will also provide senior technical review and support. She will communicate directly with Site personnel, as necessary.
- **CABRERA Project Manager:** John Eberlin is responsible for planning, coordinating, integrating, monitoring, and managing project activities. He is also responsible for day-to-day management and monitoring of the project budget, schedule, and scope, as well as assuring procedural compliance for all tasks. Mr. Eberlin is CABRERA'S primary point of contact with Joint Munitions Command (JMC) and the regulatory team members. He will work directly with the Field Site Manager during implementation of onsite activities.
- **Corporate Health and Safety Manager (CHSM):** Paul Schwartz is a Certified Industrial Hygienist and Certified Safety Professional. He is responsible for the development and overall implementation of the Site Safety and Health Plan (SSHP) (CABRERA 2007d) in accordance with CABRERA's Corporate Health and Safety Program and JMC's safety protocol. He is also responsible for implementing any appropriate medical monitoring programs for this project. In concert with the Corporate Radiation Safety Manager, he will review field monitoring data and authorize upgrades/downgrades in personal protective equipment (PPE). He will also perform field safety audits during field characterization activities.
- **Corporate Radiation Safety Manager:** Henry Siegrist, Certified Health Physicist, Professional Engineer, is the Radiation Safety Officer responsible for the overall implementation of the SSHP with regard to radiological issues. He is also responsible for the implementation of CABRERA's Corporate Radiation Protection Program. He will work closely with the Corporate Health and Safety Manager and Site Radiation Safety Manager to ensure the adequacy and appropriateness of radiation safety measures during field activities, and will perform field audits during field characterization activities.
- **Site Radiation Safety Manager:** The Site Radiation Safety Manager is responsible for supervising all radiation safety and other safety protocols on this project. He/she is responsible for field implementation of any medical monitoring programs under the direction of the Corporate Health and Safety Manager. He/she is also responsible for the calibration and operation of radiological safety monitoring equipment. He will work in concert with the Corporate Radiation Safety Manager, Project Health Physicist, and Corporate Health and Safety Manager to ensure that field activities are conducted in accordance with project plans and applicable procedures and regulations.

- **Field Site Manager:** The Field Site Manager is responsible for organization, scheduling, and implementation of field activities for execution of the FSSP. He/she will be in frequent communication with the Project Manager and will be the Contractor's primary onsite point of contact for other Project Team personnel. The Field Site Manager is responsible for the activities of field sampling teams and subcontractors. He is responsible for working with other team members with QA responsibility to ensure that all field activities are completed in a safe and efficient manner, in accordance with procedures as outlined in the work plans.
- **Project Health Physicist:** The Project Health Physicist is responsible for all project health physics and has authority to direct such activities, to stop and restart work if necessary, and to take appropriate actions, as required, to assure appropriate response to radiological emergency situations. He/she will work directly with the Field Site Manager, the Corporate Radiation Safety Manager, and the Site Radiation Safety Manager to ensure that FSS activities are properly implemented and followed.

3.2 Quality Assurance

CABRERA conducts field surveys in a manner that assures the quality and accuracy of developed data and provides auditable documentation of activities. Details of the field QA and quality controls are documented in CABRERA standard operating procedures.

Quality control procedures include:

- Daily instrument background and check source measurements to confirm that equipment operation is within acceptable tolerances.
- Training of all individuals executing CABRERA standard operating procedures.
- Periodic internal audits.
- Implementation of split and duplicate sampling, as well as blind spike sample analysis to evaluate the adequacy and accuracy of laboratory performance.

3.3 Training

CABRERA field personnel are initially trained in the implementation of standard operating procedures. This training includes studying applicable procedures, oral instruction, and hands-on application of procedure requirements under the supervision of a qualified, veteran field staff member. Continuing training includes annual review of procedures and additional training when a procedure is revised or new procedure is introduced.

In addition to survey and QA procedure training, field personnel participate in training commensurate with assigned responsibilities to satisfy applicable regulatory requirements such as radiological worker training, Occupational Safety and Health Administration (OSHA) hazardous waste operations and emergency response (HAZWOPER), site-specific and generic safety, first aid and cardiopulmonary resuscitation (CPR), transportation, and other related requirements.

3.4 Control of Measurement Equipment

Radiological survey instruments are calibrated in accordance with Cabrera standard operating procedures or as specified by the instrument manufacturer. Standard operating procedures include electronic and National Institute of Standards and Technology (NIST) traceable source calibration, as well as daily operational performance evaluations. Additional information on survey instrumentation is provided in Section 5.0.

3.5 Health and Safety

Field activities necessary to complete the FSS at the Depot have been evaluated for potential health and safety issues. Additionally, the proposed survey and sampling procedures are evaluated to ensure any hazards inherent to the procedures are addressed in SSHP. Personnel will also adhere to health and safety requirements provided in the SSHP. FSS survey activities will be performed in accordance with CABRERA radiation protection standard operating procedures and applicable radiation work permits. Site remediation activities may result in the creation of additional hazards that are not currently specified in the site-specific health and safety plan. Identification of previously unidentified hazards that are not included in existing safety procedures will require development of a task-specific job hazard analysis (JHA) prior to beginning work.

4.0 FINAL STATUS SURVEY REQUIREMENTS

A FSS will be planned and conducted for each survey unit associated with impacted outdoor soil areas, outdoor solid surfaces, i.e., pads, roadways, railroad tracks, and structures. The FSSP is prepared in accordance with the guidance presented in MARSSIM and follow the data quality objective (DQO) process. This ensures all impacted survey units are surveyed with the necessary rigor that corresponds with the contamination potential. The DQO process includes the following seven steps:

Step 1: State the problem

Step 2: Identify the decisions

Step 3: Identify inputs to the decisions

Step 4: Define the study boundaries

Step 5: Develop a decision rule

Step 6: Specify the decisions

Step 7: Optimize the survey design

The following sections provide the requirements for the planning phase of the FSS including DCGLs, classification and survey unit designations, survey planning parameters, instrumentation, measurement and sampling procedures, and the data quality assessments (DQAs) that will be implemented.

4.1 Derived Concentration Guideline Levels

Natural thorium and natural uranium and associated decay products have been identified through process knowledge and characterization survey results as the RCOCs. The $DCGL_w$ for natural thorium (^{232}Th+C) and natural uranium (^{238}U+C) in soil are the site specific DCGLs developed for the Depot (CABRERA, 2008). These values are presented in Table 4-1.

TABLE 4-1: SITE-SPECIFIC LAND AREA $DCGL_W$ VALUES

RCOC	$DCGL_W$
Natural thorium (^{232}Th+C)	2.5 pCi/g[1]
Natural uranium (97.8% ^{238}U+C; 2.2% ^{235}U+C)	2.3 pCi/g[1]

[1] Applies to any of the radionuclides in the ^{232}Th or ^{238}U decay series individually.

In addition, FSS planning and DQA for soil will include the appropriate application of the unity rule using the following equation:

$$\left(\frac{Concentration_{U-nat}}{DCGL_{U-nat}}\right)+\left(\frac{Concentration_{Th-nat}}{DCGL_{Th-nat}}\right)<1$$

The natural thorium and natural uranium surface activity $DCGL_w$s are based on the surface activity screening values published in NUREG/CR-5512, Volume 3, Table 5.19 (P_{crit} = 0.90). The primary method of surface activity measurements for both total and removable activity will be through use of alpha monitoring instrumentation. Therefore, the surface activity screening values have been calculated based on the total number of alphas emitted in each of the applicable radioactive decay chains, and for natural uranium, the percent contribution from the applicable decay chain, as shown in Table 4-2.

TABLE 4-2: SURFACE ACTIVITY $DCGL_W$

RCOC		NUREG/CR-5512 Screening Level[1]	Total Alphas per Decay	Alpha Based Screening Level[1]	RCOC Alpha $DCGL_w$[1]
Natural thorium (^{232}Th+C)		6.03	6	36.2	36.2
Natural uranium	97.8% ^{238}U+C	19.5	8	156.0	119.2
	2.2% ^{235}U+C	1.48	7	10.4	

[1] disintegrations per minute per 100 square centimeters (dpm/100 cm^2)

As indicated previously, various licensed RAMs were stored at the Depot. To determine the appropriate surface alpha activity $DCGL_w$ for each impacted outdoor surface or interior structure surface, the type of licensed RAM previously stored or present in the area was considered. In general, this licensed material was of 2 types: material predominated by natural uranium and material predominated by natural thorium. These RAMs and the average natural uranium and natural thorium activity fractions are presented in Table 4-3.

TABLE 4-3: LICENSED MATERIAL RADIOACTIVITY FRACTIONS

Material	Natural Uranium Fraction	Natural Thorium Fraction
Columbium	0.94	0.06
Tantalum	0.95	0.05
Baddeleyite (zirconium ore)	0.91	0.09
Tungsten ore (Wolframite and Ferberite)	0.08[1]	0.92[1]
Monazite	0.11	0.89
Bastnasite	0.16	0.84

[1] Mixture based on the average fractions for Wolframite and Ferberite

The surface activity $DCGL_w$ for the mixtures of natural uranium and natural thorium in the material presented in Table 4-3 was then determined using the following formula:

$$\text{Mixture } DCGL_w = \frac{1}{\left(\frac{f_{U-nat}}{DCGL_{U-nat}}\right) + \left(\frac{f_{Th-nat}}{DCGL_{Th-nat}}\right)}$$

Where:

f = activity fraction from Table 4-3

DCGL = DCGL from Table 4-2

Applying the above formula to the natural uranium and natural thorium fractions in Table 4-3 results in the mixture $DCGL_w$ presented in Table 4-4.

TABLE 4-4: MATERIAL MIXTURE ALPHA $DCGL_W$

Material	Mixture Alpha $DCGL_w$ (dpm/100 cm^2)
Columbium	105
Tantalum	107
Baddeleyite (zirconium ore)	99
Tungsten ore (Wolframite and Ferberite)	38
Monazite	39
Bastnasite	41

To simplify the application of the mixture $DCGL_w$ for the various licensed RAM previously stored or present on outdoor surfaces and within structures, the values in Table 4-5 will be applied during the FSS.

TABLE 4-5: FSS MATERIAL ALPHA $DCGL_W$

Material	Material Alpha $DCGL_w$ (dpm/100 cm^2)
Material predominated by natural uranium (columbium, tantalum and baddeleyite)	100
Material predominated by natural thorium (tungsten ore, monazite and bastnasite)	38

To apply the material alpha $DCGL_w$ in Table 4-5, the following logic is used:

- If the only material stored or used in an area or within a structure was predominated by natural uranium or natural thorium, the applicable Table 4-5 material alpha $DCGL_w$ will be used.
- If two different materials were stored or used in an area or within a structure and one was predominated by natural uranium and the other natural thorium, the material is assumed equally distributed with 50% contribution from each. The resultant material alpha $DCGL_w$ in this instance is 55 disintegrations per minute per 100 square centimeters (dpm/100 cm^2).

- If more than two different materials were stored or used in an area or within a structure and the majority are predominated by natural uranium or natural thorium, the material alpha $DCGL_w$ for the predominant material will be used.

Based on the above logic, the alpha $DCGL_w$ applicable to impacted outdoor surface areas and structure surfaces are presented in Table 4-6 and Table 4-7.

TABLE 4-6: OUTDOOR AREA ALPHA $DCGL_W$

Impacted Outdoor Areas	Alpha $DCGL_w$ (dpm/100 cm^2)
Rail Scale	100
Entry Road and Paved Road to Rail Scale	100
Railroad Tracks Used for Shrink-wrapping	100
Railroad Tracks Used for Storage or Transport	100

TABLE 4-7: STRUCTURE ALPHA $DCGL_W$

Building	Impacted Structure Area	Alpha $DCGL_w$ (dpm/100 cm^2)
124	All locations	100
129A	All locations	100
136	All locations	38
141	All locations	100
145 (Footprint)	All locations	100
146	All locations	100
210	Sections 1, 2 and 3: All locations	38
	Section 4: Bays 2-5, 8, 9, 12-14, 32-33, 35, 43, 45, 46, 48, 52-54, 56, 58, and 76 only	100
211	Sections 1 and 2: All locations	55
212	Section 1: Bays 11, 31, 37, 41, 51, 61, and 71	100
	Section 2: Bays 11, 12, and 21	100
213	Sections 1: All locations	38
	Section 2: Bays 12, 13, 15, and 16	38
	Section 3: Bays 11, 19, 21, and 29	100
	Section 4: Bays 1, 9, 11, 15, 21, 31, 38, 39, 41, 51, 59, 67, 69, 75, 78 & 79	100
214	Section 1, 2 and 3: All locations	38
	Section 4: Bays 41-43, 45, 51, 59, 61, 69, and 75-79	55
215	Section 1: Bays 2-4, 11, 12, 13, 22, 23, 25-29, 34-37, 41, 43, 44, 45, 62, and 73-75	38
	Section 2: Bays 36, 41, 42, 46, 52-54, 62, and 63 only	38
	Section 4: Bays 15, 19, 29, 51-56, 61-65, 68, and 71-79 only	38

Removable alpha contamination limits on outdoor solid surfaces and structure surfaces are 10% of the alpha $DCGL_w$ values in Table 4-6 and Table 4-7.

4.2 Area Classification Based on Contamination Potential

Impacted areas at the Depot have been subdivided into three categories based on contamination potential as either Class 1, 2 or 3 in accordance with MARSSIM. A description of each is provided below:

Class 1: Buildings or land areas that have a significant potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys) that exceeds the $DCGL_w$.

Class 2: Buildings or land areas, often contiguous to Class 1 areas, that have a potential for radioactive contamination but at levels less than the $DCGL_w$.

Class 3: Buildings or land areas that are expected to contain little or no residual contamination based on site operating history or previous radiological surveys.

Furthermore, outdoor solid surfaces, land areas and buildings have been or will be further subdivided into survey units, which will provide the fundamental unit for demonstrating compliance with the applicable $DCGL_w$. Survey unit size restrictions will generally follow the recommended size limitations provided in MARSSIM. As previously discussed, the investigation of upper walls and overhead surfaces for all Class 3 survey units within structures resulted in the conclusion these surfaces are non-impacted.

4.3 Identification of Survey Units

All impacted outdoor surfaces, land areas and buildings have been subdivided into Class, 1, 2 or 3 survey units. Each survey unit represents a portion of the site with similar contamination potential. The MARSSIM recommended survey unit sizes are provided in Table 4-8.

TABLE 4-8: MARSSIM RECOMMENDED SURVEY UNIT SIZES

Class	Recommended Survey Area	
	Structures	Land Areas
1	Up to 100 m^2	Up to 2,000 m^2
2	100 to 1,000 m^2	2,000 to 10,000 m^2
3	No limit	No limit

4.3.1 Land Area Survey Units

During the characterization surveys, five Class 1 survey units (SU 1, SU 2, SU 3, SU 5 and SU 6) and one Class 2 survey unit (SU 4) were identified in Area 7A. The Class 2 survey unit (SU

4) was expanded to surround all Area 7A Class 1 survey units. Area 7A survey units for FSS are illustrated in Attachment 1, Figure 4-1.

The remainder of the Area 7A entry road (eastern two thirds) and paved road to the rail scale (SU 7), rail scale (SU 8 and SU 9), outdoor shrink wrapping area (SU 10), south storage and transport area (SU 11) and west storage and transport area (SU 12) contain solid surfaces, i.e., pavement, or railroad tracks, as well as soil areas. During characterization surveys, a gamma walkover survey (scan) was performed on solid surfaces, as well as the land areas. Systematic soil samples were obtained and biased soil sampling performed based on the results of the gamma walkover surveys. Survey units 7, 8, 9, 10, 11 and 12 are shown in Attachment 1, Figure 4-2, Figure 4-3, Figure 4-4 and Figure 4-5.

MARSSIM classifications for land (outdoor) area survey units are provided in Table 4-9. Survey unit size will generally follow the MARSSIM guidance in Table 4-8.

TABLE 4-9: OUTDOOR AREA SURVEY UNITS

Impacted Outdoor Areas	MARSSIM Classification	Survey Unit Number
Area 7A	1	1, 2, 3, and 5
Western Third of Entry Road to Area 7A	1	6
Land Surrounding Area 7A	2	4
Entry Road Eastern Two Thirds & Paved Road to Rail Scale	3	7
Rail Scale Concrete Pad	2	8
Rail Scale Surrounding Soil	1	9
Outdoor Shrink Wrap Area	3	10
Storage and Transport Area – South	3	11
Storage and Transport Area – West	3	12

4.3.2 Structure Survey Units

All structures at the Depot were initially designated as Class 3. However, completion of the characterization surveys has resulted in the identification of other impacted structures, as well as generated data necessitating re-classification of portions of some structures.

During characterization surveys, a small structure associated with the rail scale was identified. Since the rail scale was determined to be a Class 2 survey unit (concrete pad), the interior of the structure was added as a Class 2 survey unit. Because of the very small size of this structure, the floor and lower wall will be combined into a single survey unit. Although it is highly unlikely surface contamination is present on the upper walls and ceiling of this structure, this area was conservatively added as a Class 3 survey unit, but only requiring surface alpha scans and biased direct alpha measurements. The two Building 129A survey units are shown in Attachment 1, Figure 4-6.

The warehouse structures are large open areas consisting of numerous bays in several (4) sections. The layout in each of these warehouses is the same. A general depiction of the sections within each warehouse and the bays within each section is provided in Attachment 1, Figure 4-7 and Figure 4-8.

During performance of characterization surveys in Warehouse 210, Section 2, alpha scans of floor surfaces identified elevated activity in the northwest corner of this section (CABRERA 2007c). Further investigation concluded these locations were limited to three bays (7, 8 and 19) and floor areas adjacent to bays 7 and 8 (designated 7E and 8E). Follow-up direct integrated alpha measurements indicated surface activity above the $DCGL_w$ over a majority of the floor surfaces in 4 locations (bays 7, 8, 7E and 8E) and a localized area of surface activity above the $DCGL_w$ on the floor in bay 19. Survey results indicated the elevated activity in this section of the warehouse was limited to these areas, shown in Attachment 1, Figure 4-9.

Remediation of the floor locations in Warehouse 210, Section 2 required complete concrete slab floor removal in bays 7, 8, 7E and 8E, and surface concrete removal in bay 19. The soil area remaining after the removal of the concrete slab in bays 7, 8, 7E and 8E has been identified as a single Class 1 land area survey unit (SU 210-2-6) as shown in Figure 4-10. The concrete floor areas surrounding this area, which included the bay 19 floor area, and the lower walls adjacent to these bays in the northwest corner of section 2 were designated Class 1 structure survey units. Class 1 floor survey units include SU 210-2-1, SU 210-2-2 and SU 210-2-3. The Class 1 lower wall survey unit is designated SU 210-2-4. These survey units are shown in Attachment 1, Figure 4-11. Upper walls and overhead surfaces in this area were identified as a single Class 2 survey unit, SU 210-2-5, as shown in Attachment 1, Figure 4-12. Characterization surveys of the floor areas surrounding these Class 1 survey units did not identify elevated activity and, therefore, will remain Class 3.

Based on the results of the structure characterization surveys performed in 2006 and 2007, the designation of survey units, MARSSIM classification, and applicable alpha surface activity $DCGL_w$ for each survey unit are provided in Table 4-10.

TABLE 4-10: FSS STRUCTURE SURVEY UNITS

Structure	Class	Survey Unit	Survey Unit Number	Alpha $DCGL_w$ (dpm/100 cm^2)
124	3	Floor	124-F	100
		Lower Wall	124-W	100
129A	2	Floor and Lower Wall[1]	129A-F	100
	3	Upper Wall and Ceiling[2]	129A-C	100
136	3	Floor	136-F	38
		Lower Wall	136-W	38
141	3	Floor and Lower Wall[3]	141-F	100
145	3	Floor[4]	145-F	100
146	3	Floor	146-F	100
		Lower Wall	146-W	100
210, Section 2, Bays 6, 9, 16, 17 & 18 (and floor area bounded by these bays)	1	Floor	210-2-1, 210-2-2, 210-2-3	38
		Lower Wall	210-2-4 (north & west adjacent to bays)	38
210, Section 2, Bays 6, 9, 16, 17, 18 & 19	2	Upper Walls and Ceiling	210-2-5	38
210, Section 2, Bays 7, 8 & floor area between bays 7, 8 & 17, 18	1	Floor[5]	210-2-6	38
210, Section 1, Section 2 (all remaining bays), Section 3 & Section 4	3	Floor	210-F	Section 1, 2 & 3: 38 Section 4: 100
		Lower Wall	210-W	Section 1, 2 & 3: 38 Section 4: 100
211	3	Floor	211-F	55
		Lower Wall	211-W	55
212	3	Floor	212-F	100
		Lower Wall	212-W	100
213	3	Floor	213-F	Section 1 & 2: 38 Section 3 & 4: 100
		Lower Wall	213-W	Section 1 & 2: 38 Section 3 & 4: 100
214	3	Floor	214-F	38
		Lower Wall	214-W	38
215, Sections 1 and 2	3	Floor	215-F	38
		Lower Wall	215-W	38
215, Section 4	3	Floor	215-4-F	38
		Lower Wall	215-4-W	38

[1] Building 129A is a small structure associated with the rail scale (rail scale house). Floors and lower walls are combined as a single survey unit due to the small size of the structure.
[2] Building 129A upper walls and ceiling have very little possibility for contamination. A limited Class 3 survey consisting of alpha scans and biased direct measurements are required.
[3] Floor and lower walls are combined into a single survey unit due to building safety concerns. Survey performance limited to areas safely accessible.
[4] Building 145 is no longer present; only the former floor surface (concrete pad) remains.
[5] Following slab removal, this becomes a single Class 1 soil survey unit requiring 32 systematic surface soil samples, GWS and biased soil samples, as necessary.

4.4 Background Reference Area and Materials

Background reference areas have been selected and sampled/measured for comparing soil sample data to the applicable $DCGL_w$ and in evaluation of FSS data in accordance with the planned non-parametric Wilcoxon Rank Sum (WRS) statistical test that will be used for land area survey units. The background reference area selected shares similar geo-physical properties and has not been impacted by Depot operations. A total of 32 surface and 32 subsurface reference area background soil samples have been collected and analyzed for comparison with survey unit soil data and performance of the statistical test. Refer to Section 5.2.2 for additional considerations regarding reference area soil sample collection requirements.

Outdoor solid surface and structure survey units will be evaluated using the non-parametric Sign test. Construction material-specific background measurements have been performed in areas of similar construction but without a history of RAM use. These construction material specific measurements will be used to correct direct measurements for contribution due to background and natural radioactivity in these materials, prior to converting the data to units of dpm/100 cm^2 for comparison with the applicable $DCGL_w$.

4.5 Reference System

A reference coordinate system will be utilized for FSS measurements and sampling locations. Direct measurements on structural surfaces will be referenced to prominent building features or a grid system as implemented for the characterization surveys. Soil sample locations will be referenced to global positioning system (GPS) coordinates obtained using hand-held GPS units.

4.6 Survey Design

Structural surfaces will be assessed by collecting the required number of gross alpha surface activity measurements within each survey unit. The Sign test will be used for demonstrating compliance with the surface activity $DCGL_w$. Land area compliance with the $DCGL_w$ is demonstrated through the application of the WRS test for systematic soil sample results from each survey unit. These two statistical tests, the WRS and Sign test, are performed to evaluate the survey unit mean concentration relative to the null hypothesis (H_0). Simply stated, H_0 assumes the residual contamination in the survey unit exceeds the release criterion. Provided the statistical test is satisfied at the desired confidence level, then H_0 is rejected and the alternate hypothesis (H_a), residual contamination meets the release criterion, is accepted. The data needs for the statistical tests will be determined through the processes in the following sections.

4.6.1 Number of Sample Locations for Survey Units and Reference Area

The following sections describe the bases for and derivation of the minimum required measurements and samples per survey unit.

(A) Estimation of Relative Shift

The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated for each survey unit using the following equation:

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

Where:

$DCGL_w$ = applicable value from Table 4-1, Table 4-6 or Table 4-7

LBGR = Lower Bound of the Gray Region; normally established as the estimated mean activity within the survey unit, but may be adjusted to maximize survey design.

σ = an estimate of the standard deviation of the residual radioactivity or the actual standard deviation obtained from scoping or characterization surveys and/or sampling.

The DQOs are evaluated for each survey unit or survey area and the decision errors selected. The Type 1 error or probability of incorrectly rejecting H_0 when it is true of 0.05 was selected. The Type 2 error or probability of incorrectly accepting H_0 when it is false will be 0.05 or 0.10. Once these parameters are established and the relative shift determined, the number of data points required by the statistical test are obtained from MARSSIM Tables 5.3 (WRS test) or 5.5 (Sign test) or otherwise generated using COMPASS, Visual Sample Plan or MARSSIM Power software.

For land areas, the number of samples was determined using the results of characterization data from Area 7A and the soil $DCGL_w$ for natural uranium, which is the most restrictive soil $DCGL_w$. The LBGR was adjusted to achieve a relative shift of 1.6 while maintaining the Type 1 and Type 2 error of 0.05. This resulted in 16 samples for each survey unit. However, the minimum number of samples per survey unit has been doubled to assure sufficient survey unit sample coverage and to account for the potential presence of smaller areas of elevated RCOC concentrations in soil. This results in 32 samples for each survey unit.

For structure survey units, the number of samples was determined using the results of characterization data and the applicable surface activity alpha $DCGL_w$ from Table 4-7. For each structure, the highest sample standard deviation for both floors and lower wall survey units was chosen for determination of the minimum number of FSS systematic direct alpha measurements per survey unit and the Type 1 and Type 2 error of 0.05 maintained. The LBGR was adjusted for each to a relative shift greater than 1, but less than 3. This resulted in a minimum of 17 samples for each survey unit. Therefore, a minimum of 17 systematic direct alpha surface activity measurements will be collected from each outdoor solid surface and structure survey unit.

(B) Determining Measurement/Sampling Locations

Measurement and sampling locations will be established in either a random-start/systematic fashion for Class 1 and Class 2 survey units or at randomly generated locations for Class 3 survey units. Random start/systematic locations will follow the recommended guidance using a triangular measurement or sampling pattern to increase the probability of identifying small areas of residual activity. The spacing (L) between data points on a triangular pattern is determined by:

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

Where:

L = square grid spacing for survey unit

A = area of survey unit

N = number of sample locations

And the spacing between rows is calculated as:

0.866 x L

MARSSIM recommends the use of area factors to ensure that the survey/sampling design is sensitive enough to detect radioactivity that may be concentrated in a small area. The area factor represents the magnitude by which the concentration within the small area of elevated activity can exceed the $DCGL_w$ while maintaining compliance with the release criterion.

The scan sensitivity (i.e., the required scan MDC) necessary to detect a small area of radioactivity at the limit determined by the area factor is calculated using Equation 5-3 of MARSSIM:

Scan MDC (required) = (DCGL) x (Area Factor)

Where:

MDC = minimum detectable concentration required to be achieved by the scan procedure

$DCGL_w$ = derived concentration guideline level

Area Factor = value from Table 7-1 for land areas

For this evaluation, scan MDCs were developed for the 2 inch by 2 inch (2x2) sodium iodide (NaI) and FIDLER (Field Instrument for Detection of Low Energy Radiation) NaI detectors (See Section 5.1).. For simplicity, only the 2x2 NaI detector is used in he EMC evaluation since it has

a higher MDC for both natural thorium and natural uranium than the FILDER. Also, although soil may be contaminated with a mixture of natural thorium and natural uranium, only the natural uranium NaI detector MDC is used in this evaluation. Since the 2x2 NaI detector scan MDC for the mixture can be no lower than the natural thorium MDC nor can it be higher than the natural uranium MDC, the use of only the natural uranium MDC will result in a conservative decision regarding the adequacy of the scan surveys for detection of elevated areas of activity (refer to Section 5.1.1 for discussion of the gamma scan MDC).

For the Class 1 land survey units, the area factor is determined based on the discrete area represented by each sample location. This area is calculated as the total area of the survey unit square meter (2,000 m^2) divided by the number of proposed sample locations (32), or 62.5 m^2. Using Table 7-1 and interpolating between the natural uranium area factors for 50 and 100 m^2, the area factor is determined to be approximately 2.5. Thus, the required scan MDC is calculated as the DCGL (2.3 pCi/g) times the area factor (2.5), or 5.8 pCi/g.

The actual 2x2 NaI detector scan MDC for natural uranium is 4.1pCi/g. According to MARSSIM, if the actual scan MDC is greater than the required scan MDC, additional soil samples are required to ensure that the release criterion can be satisfied. Since the actual scan MDC is less than the required scan MDC, it is concluded that the scan sensitivity is adequate and the proposed number of samples, 32, is sufficient to ensure the detection of small areas of elevated activity.

4.7 Integrated Survey Strategy

FSS data collected for structure surfaces consists of alpha scans and direct measurements for alpha surface activity. Gamma scans will be performed on outdoor solid surfaces, such as railroads, gravel and paved roads, in lieu of alpha scans. Smear samples, although not used in the final DQA, will be collected from each direct alpha measurement location to measure removable alpha surface activity. FSS of open land areas will consist of gamma scans to identify locations of residual contamination and soil samples, analyzed for the RCOCs. Additional biased measurements and samples will be obtained, as necessary, from locations where scans indicate the potential for residual contamination.

4.7.1 Surface Scans

Surface gamma scans have been or will be performed using NaI scintillation detectors over land areas and outdoor solid surfaces, such as railroad tracks, gravel and paved roads. Structure surface scans will be performed using gas proportional detectors for alpha activity. Detectors are coupled to ratemeters or ratemeter-scalers with audible indicators. Characterization gamma scans for land areas and outdoor solid surfaces, and alpha scans for structure surfaces that do not require remediation were also intended as FSS data. Recommended surface scan coverage, discussed in MARSSIM, is provided in Table 4-11.

TABLE 4-11: MARSSIM RECOMMENDED FSS SCAN COVERAGE

Class	Structures	Land Areas
1	100%	100%
2	10 to 100% floors and lower walls 10 to 50% upper walls and ceilings	10 to 100%
3	Judgmental	Judgmental

4.7.2 Soil Sampling and Surface Activity Measurements

FSS surface and subsurface soil samples are collected from Class 1 and Class 2 land areas at pre-determined random-start/systematic locations. Additionally, biased samples are collected from locations where elevated direct gamma radiation is detected by surface scans. Following collection, soil samples are maintained under formal chain-of-custody procedures and then analyzed by gamma spectroscopy, with analytical results reported in units of pCi/g. In Class 1 land area survey units 32 surface and 32 subsurface systematic soil samples will be collected, except Warehouse 210, Section 2, SU 210-2-6 ,which only requires surface soil sampling. In Class 2 land area survey units 32 systematic surface soil samples will be collected. In Class 3 land area survey units 32 surface soil samples will be collected from random locations.

FSS direct measurements to quantify total alpha activity on structure surfaces will be performed at pre-determined random-start/systematic or random locations as applicable. Additional biased measurements will be made within any areas of residual contamination identified by surface scans. Measurements will be performed using gas proportional detectors coupled to ratemeter-scalers. Surface activity data will be converted to units of dpm/100 cm^2.

(A) Class 1 Land Area Survey Units

Class 1 land area survey units in Area 7A include the 4 contiguous survey units (SU 1, SU 2, SU 3, and SU 5) and the western third of the entry road (SU 6). These survey units, along with systematic sample locations, are shown in Attachment 1, Figure 4-1. A single Class 1 land area survey unit (SU 9) surrounds the concrete rail scale. This survey unit, along with systematic soil sample locations, is shown in Attachment 1, Figure 4-3. Following removal of the concrete floor slab in Warehouse 210, Section 2, the remaining exposed soil area is a Class 1 survey unit (SU 210-2-6). This survey unit, along with systematic surface soil sample locations, is shown in Attachment 1, Figure 4-10.

A total of 32 surface and 32 subsurface systematic soil samples will be collected in SU 1, SU 2, SU 3, SU 5 and SU 6. A total of 32 surface systematic soil samples will be collected in SU 210-2-6. A gamma scan will be performed over 100% of the affected area and additional biased samples collected, if necessary.

(B) Class 2 Land Area Survey Units

A single Class 2 land area survey unit, SU 4, will be established for the area surrounding the Class 1 survey units associated with Area 7A (SU 1, SU 2, SU 3, SU 5 and SU 6). A total of 32 surface systematic soil samples will be collected in SU 4. This survey unit, along with the systematic surface soil sample locations, is shown in Attachment 1, Figure 4-1. A gamma scan will be performed over 50 to 100% of these areas, with additional biased sampling, as necessary.

(C) Class 3 Land Area Survey Units

Class 3 land area survey units include (1) the eastern two thirds of the entry road and paved road to the rail scale (SU 7), the outdoor shrink wrapping area (SU 10), the south storage and transport area (SU 11) and the west storage and transport area (SU 12). These survey units are shown in Attachment 1, Figure 4-2 (SU 7), Figure 4-4 (SU 10) and Figure 4-5 (SU 11 and SU 12). A total of 32 surface soil samples will be collected from random locations within each survey unit. For random soil sampling locations identified on solid surfaces, i.e., railroad track and paved road, the sampling location may be moved to the nearest soil location adjacent to the track outside the bounds of the track ballast or nearest soil location adjacent to the paved road. Gamma scans will be performed over a minimum of 10% of the Class 3 survey units.

(D) Class 1 Outdoor Solid Surface Survey Units

There are no Class 1 outdoor solid surface survey units.

(E) Class 2 Outdoor Solid Surface Survey Units

A single Class 2 outdoor solid surface survey unit will be established for the concrete rail scale (SU 8). This survey unit, along with systematic direct alpha measurement locations, is shown in Attachment 1, Figure 4-3. A total of 17 systematic direct alpha measurements will be obtained from the concrete rail scale. A smear will be obtained at each direct measurement location to assess removable contamination. An alpha scan will be performed over 100% of accessible surface area and additional biased direct alpha measurements obtained, if necessary.

(F) Class 3 Outdoor Solid Surface Survey Units

A single Class 3 outdoor solid surface survey unit has been identified for the paved portion of SU 7. SU 7 includes the eastern two thirds of the entry road to Area 7A and paved road to the rail scale. However, the only solid surface is the actual paved road. The entry road to Area 7A is packed soil. The paved portion (solid surface) of SU 7, is identified as SU 7A. A total of 17 direct alpha measurements will be obtained in each survey unit on solid surfaces, such as pavement. Smears for removable surface activity will be obtained at each of the systematic measurement locations. A gamma scan will be performed over a minimum of 10% of the survey unit area.

The applicable alpha surface activity $DCGL_w$ for all outdoor solid surfaces is 100 dpm/100 cm^2 as indicted in Table 4-6.

(G) Class 1, 2 and 3 Structure Survey Units

Class 1 structure survey units include the re-classified portions of Warehouse 210, Section 2, identified as SU 210-2-1, SU 210-2-2 and SU 210-2-3, and the lower walls adjacent to these survey units, identified as SU 210-2-4. These survey units, along with systematic direct alpha measurement locations are shown in Attachment 1, Figure 4-11. Class 2 structure survey units include the upper walls and ceiling associated with the Class 1 survey units in Warehouse 210, Section 2, which is designated SU 210-2-5, and the floor and lower walls of Building 129A, designated SU 129A-F. SU 210-2-5, along with systematic direct alpha measurement locations are shown in Attachment 1, Figure 4-12. SU 129A-F and Class 3 SU 129A-C are shown in Attachment 1, Figure 4-6. All other structures at the Depot are Class 3, with survey units identified in Table 4-10. This survey unit and 3 structure survey units include those identified in Table 4-10. A total of 17 direct alpha measurements will be collected in each survey unit, with the exception of SU 129A-C, which will require a scan survey and biased direct alpha measurements only. Additionally, a smear will be obtained at each direct alpha measurement location to assess removable alpha contamination. Biased direct alpha measurements will be obtained, as necessary, based on the results of alpha scans performed in the Table 4-10 survey units.

(H) Other Sampling

Floor surfaces in portions of Warehouse 214 have been coated with an epoxy paint to encapsulate asbestos. Therefore, direct measurements for alpha activity in these survey units will be supplemented with additional sampling. In these survey units, the activity now contained by the epoxy paint will be assessed by removing the coating material using mechanical methods (chisel) over an area of 100 square centimeters (cm^2) in each of the 17 sample locations. The epoxy paint will be collected, composited and analyzed for the RCOCs. Following removal, a direct alpha surface activity measurement will be performed to assess the residual activity remaining on the concrete surface.

5.0 INSTRUMENTATION AND CALIBRATION

Field and laboratory instrument calibrations are performed using NIST traceable radioactive standards (sources). Specific field and laboratory instrumentation are discussed in the following sections.

5.1 Field Instrumentation

The following, or similar, survey instrumentation will be used during the FSS.

5.1.1 Scanning Instrumentation

Alpha Scans

Alpha surface activity scans will be performed with the Ludlum Model 43-37 gas proportional detector (physical area of 582 cm^2) or the Ludlum Model 43-68 gas proportional detector (physical area of 126 cm^2), both coupled to a Ludlum ratemeter-scaler, such as the Ludlum Model 2221. The probability of observing one or more counts, scan speed in centimeters per second (cm/s) and pause times in seconds (s) for the two detectors and the three surface activity $DCGL_w$ values in Table 4-7 are provided in Table 5-1.

TABLE 5-1: ALPHA SCAN PARAMETERS

Detector	Probability	Scan Speed (cm/s)	Pause Time (s)
Surface Activity Alpha $DCGL_w$ = 38 dpm/100 cm^2			
43-68	0.69	1	18
43-37	0.79	4	4
Surface Activity Alpha $DCGL_w$ = 55 dpm/100 cm^2			
43-68	0.82	1	12
43-37	0.90	4	3
Surface Activity Alpha $DCGL_w$ = 100 dpm/100 cm^2			
43-68	0.96	1	7
43-37	0.99	4[1]	2

[1] Scan speed may be increased to 6 cm/s, with a probability of 0.93.

Gamma Scans

Gamma scans will be performed in Class 1, Class 2 and Class 3 land area survey units with a Ludlum Model 44-10 2x2 NaI detector or FIDLER NaI detector coupled to a Ludlum ratemeter-scaler, such as the Ludlum Model 2221. The 2x2 NaI detector has a natural thorium MDC of 1.6 pCi/g and natural uranium MDC of 4.1 pCi/g. The FIDLER NaI detector may be used in lieu of the 2x2 NaI detector because of the lower MDC for natural thorium, 0.4 pCi/g, and natural uranium, 1.1 pCi/g.

5.1.2 Direct Surface Activity Measurement Instrumentation

Direct measurements for surface alpha activity will be performed on outdoor solid surfaces and structure surfaces using a Ludlum Model 43-37 gas proportional detector (physical area of 582 cm^2) or Ludlum Model 43-68 gas proportional detector (physical area of 126 cm^2), both coupled to a Ludlum ratemeter-scaler, such as the Ludlum Model 2221. With a background and sample count time of 1 minute with the Ludlum Model 43-37, the alpha MDC is 18 dpm/100 cm^2. With a 10 minute background count time and 3 minute sample count time for the Ludlum Model 43-68, the alpha MDC is 15 dpm/100 cm^2.

Note: Shorter background and sample count times with the Ludlum Model 43-68 are acceptable for areas with a surface alpha $DCGL_w$ greater than 38 dpm/100 cm^2. A 1 minute background and sample count time results in an alpha MDC of 37 dpm/100 cm^2, which is acceptable for surface areas with an alpha $DCGL_w$ of 55 dpm/100 cm^2 or 100 dpm/100 cm^2.

Note: When using a large area detector such as the Ludlum Model 43-37 gas proportional detector, direct measurement results from Class 1 survey units will not be corrected for detector area. However, measurements with this detector in Class 2 and Class 3 structure survey units may be corrected for detector area. The primary concern with large area detectors is the possibility of masking (or averaging over an inappropriately large area) elevated activity associated with hot spots. However, since hot spots are not expected within Class 2 or Class 3 survey units, this is not a concern and detector area correction is acceptable.

5.2 On-Site Laboratory Instrumentation

FSS soil, remediation support soil samples and FSS smear samples will be analyzed in accordance with CABRERA standard operating procedures. Soil samples will be analyzed by gamma spectroscopy and results reported in units of pCi/g. Smear samples will be analyzed using an alpha/beta scaler and alpha removable activity results reported in units of dpm/100 cm^2.

5.2.1 Smear Analysis Instrumentation

Smears for removable alpha activity on outdoor solid surfaces and structure surfaces will be analyzed with a Ludlum Model 2929 scaler or equivalent. The Ludlum Model 2929 employs a zinc sulfide (ZnS) scintillation detector and is capable of simultaneous analysis of alpha and beta radioactivity on media such as smears. A 20 minute background count time and 5 minute sample count time results in an alpha MDC of 3 dpm/100 cm^2.

5.2.2 Soil Sample Analysis

FSS soil samples and soil samples collected in support of remediation will be analyzed using a Canberra reverse electrode germanium (REGe), n-type detector with nominal 60% relative efficiency. The detector and samples are housed within a 2 inch thick stackable ring-style lead shield. The detector is coupled to a Canberra Inspector-2000 multi-channel analyzer. The *a priori* MDC for ^{232}Th is approximately 0.1 pCi/g (based on the 0.911 MeV photopeak from actinium-228 [^{228}Ac]) and 0.2 pCi/g for ^{238}U (based on the 0.609 MeV photopeak from bismuth-214 [^{214}Bi]), with a 10 minute count time. Alternate count times may be selected provided the resulting measurement MDC is not greater than 50% of the soil $DCGL_w$; 1.2 pCi/g ^{232}Th and 1.1 pCi/g ^{238}U.

Following collection, soil samples will be dried and placed in 1 liter plastic marinelli containers for analysis. The sample lids will be sealed with tape and the samples analyzed following a 21 day in-growth period to allow for the ^{238}U decay progeny to again reach equilibrium. In lieu of the delay in analyzing all soil samples, a correction factor for ^{238}U and ^{232}Th may be generated to account for the radionuclide in-growth based on analysis of samples counted immediately after drying and again following the 21 day in-growth period.

5.3 Off-Site Laboratory Analysis

A minimum of 5% of FSS soil samples will be prepared and submitted to an off-site laboratory for analysis. The off-site laboratory will assure procedures and analytical methods are employed to achieve a target MDC of 50% of the soil $DCGL_w$; 1.2 pCi/g ^{232}Th and 1.1 pCi/g ^{238}U.

6.0 DATA REVIEW AND INVESTIGATION THRESHOLDS

Data will be reviewed to assure that the quantity and quality are consistent with the FSSP and design assumptions. Data standard deviations have been or will be compared with the assumptions in establishing the number of data points. Individual and average data values will be compared with the applicable $DCGL_w$ and proper survey area classification will be confirmed. Individual measurements above the average background value in Table 2-10 and in excess of the $DCGL_w$ for Class 1 and 2 structure and land survey units are compared against the appropriate investigation levels discussed in Section 7.3. For Class 3 survey units, although less conservative than the recommendation provided in MARSSIM, measurements in excess of 75% of the $DCGL_w$ will be investigated. The requirement for increasing the investigation threshold is due to the low $DCGL_w$ values relative to background. Should a survey unit require investigation, reclassification, remediation, and/or re-survey, a determination of the cause will be initiated and the data conversion and assessment process repeated for new data sets.

7.0 DETERMINING COMPLIANCE WITH DCGLS

As discussed in Section 4.1 both soil concentration and surface activity DCGLs have been developed with which FSS data will be compared. These DCGLs include both the mean concentrations ($DCGL_w$) and also provide for small areas of elevated contamination in excess of the $DCGL_w$, the $DCGL_{EMC}$. Compliance demonstration with both requirements for each survey unit is discussed in the following sections.

7.1 Land Area Survey Units

Land area survey units will be evaluated using the WRS test. Survey unit and background reference area soil sample results collected from the random-start/systematic locations will be converted to unity using the equation in Section 4.1. The DCGL in this case is also established as 1. The reference area results will then be adjusted by adding the DCGL to the unity concentration value. The results for both data sets are then ranked as follows:

1. Rank all survey unit and reference area measurements in order of increasing size from 1 to N, where N is the total number of pooled measurements.

2. If several measurements have the same value, assign them the average ranking of the group of tied measurements.

3. Sum the ranks to the adjusted reference area measurements; this value is the WRS test statistic (W_R).

4. Compare the value of W_R to the critical value in MARSSIM Table I.4 for the appropriate sample size and decision level.

Prior to applying the test, if the difference between the largest survey unit result and the smallest reference area result is less than the $DCGL_w$, the survey unit will always pass the WRS test. No further evaluation is necessary as the survey unit will always pass the WRS test and the H_0 rejected. Otherwise, W_R must be calculated. If W_R is less than or equal to the critical value, the H_0 is not rejected, and the survey unit does not meet the established criteria. In this case, an investigation, remediation, reclassification, and/or re-survey should be performed as appropriate.

7.2 Outdoor Solid Surface/Structure Survey Units

Structure survey units, including outdoor solid surfaces, will be evaluated using the Sign test. Individual activity values and the average activity will be calculated. If all values from the random or random-start/systematic locations for a survey unit are less than the guideline ($DCGL_w$ for Class 1 and 2 survey units; 75% of the $DCGL_w$ for Class 3 survey units), the survey unit satisfies the criterion and no further evaluation is necessary.

If the average activity value is greater than the guideline, the survey unit does not satisfy the criterion and further investigation, possible reclassification, remediation, and/or re-survey is required. If the average activity value is less than the guideline, but some individual values are greater, data evaluation using the Sign test will be performed, as follows:

1. List each of the survey unit measurements.
2. Subtract each measurement from the guideline value.
3. Discard all differences which are "0"; determine a revised sample size.
4. Count the number of positive differences; this value is the sign test statistic (S+).
5. Compare the value of S+ to the critical value in MARSSIM Table I.3 for the appropriate sample size and decision level.

If S+ is greater than the critical value, the H_0 is rejected and the survey unit meets the established criteria. If S+ is less than or equal to the critical value, then H_0 is not rejected, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or re-survey should be performed, as appropriate.

7.3 Elevated Measurement Comparison Criteria

Soil samples or direct measurement results that exceed the $DCGL_w$ must also be evaluated for compliance with the $DCGL_{EMC}$. The statistical tests for demonstrating compliance are such that some samples/measurements may exceed the $DCGL_w$, yet still reject the H_0. Therefore, both the statistically based and biased samples exceeding the $DCGL_w$ by a predetermined threshold must be compared with a $DCGL_{EMC}$ that corresponds with the size of a given area of elevated activity, defined as the $DCGL_w$ times the Area Factor (AF).

Area factors for land survey units, generated along with the site-specific DCGL's (CABRERA 2008), are provided in Table 7-1. Default area factors for structures, obtained from MARSSIM Table 5.7, are provided in Table 7-3.

In addition to the developed AFs, an Investigation Level (IL) was derived for the New Haven site based on the Reference Area RCOC concentrations. The ILs are intentionally set conservatively below the most restrictive $DCGL_{EMC,}$ value; the 62.5 m^2 area corresponding to the largest unsampled area between systematic sample locations. The purpose of the IL was to build in a measure of conservatism when evaluating soil sample results that were found to be in excess of the $DCGL_W$. The IL threshold for soil samples from Class 1 land survey units that require investigation is defined as RCOC $DCGL_w$ plus the sum of the background reference area mean concentration plus three standard deviations of the background. Using all 64 reference area surface and subsurface background soil sample results obtained in 2007, the soil sample ILs are defined as 4.05 pCi/g for ^{232}Th and 3.95 pCi/g for ^{238}U. Therefore, if the ^{232}Th or ^{238}U net soil concentrations (reported soil concentration minus the average soil background concentration in Table 2-10) are greater than the applicable IL or the sum of the ratios for both is greater than 1, further investigation is required. A comparison of the IL versus the 62.5 m^2 $DCGL_{EMC}$ is provided in Table 7-2.

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TABLE 7-1: LAND SURVEY UNIT AREA FACTORS

Area (m^2)	1	5	10	50	100	300	1,000	3,000	10,000
Natural Th Area Factor	12.9	4.2	2.8	1.8	1.6	1.4	1.1	1.0	1.0
Natural U Area Factor	19.9	6.5	4.3	2.6	2.3	1.8	1.1	1.0	1.0

TABLE 7-2: COMPARISON OF LAND INVESTIGATION LEVELS WITH MOST RESTRICTIVE $DCGL_{EMC}$

Area (m^2)	62.5 m^2 $DCGL_{EMC}$	Investigation Level
^{232}Th	4.3	4.1
^{238}U	5.8	4.0

TABLE 7-3: STRUCTURE SURVEY UNIT AREA FACTORS

Area (m^2)	1	4	9	16	25	36
^{232}Th Area Factor	36.0	9.0	4.0	2.2	1.4	1.0
^{238}U Area Factor	35.7	9.0	4.0	2.2	1.4	1.0

When individual samples or measurements with elevated concentrations are less than the respective $DCGL_{EMC}$, the impact of multiple hot spots on the mean concentration in a survey unit must also be evaluated. This will be performed using MARSSIM Equation 8-2. Any measurement that exceeds the $DCGL_w$ within a Class 2 or Class 3 survey unit will be investigated as discussed in Section 6.0 and may require reclassification of the survey unit.

8.0 REPORTING

The results of the FSS will be compiled into a detailed report. The contents of the report will provide all applicable data and documentation necessary to support the request for removal of the Depot from the NRC license.

9.0 REFERENCES

(CABRERA 2006) *Historical Site Assessment, New Haven Depot, New Haven, IN,* Cabrera Services, Inc., October 2006.

(CABRERA 2007a) *Characterization Survey Report, Outside Areas, New Haven Depot"*, Cabrera Services, Inc., February 2007.

(CABRERA 2007b) *Radiological Remediation Work Plan For The Defense National Stockpile Center, New Haven Depot*, Cabrera Services, Inc., March 2007.

(CABRERA 2007c) *Characterization Survey Report, Building 210, New Haven Depot*, Cabrera Services, Inc., October 2007.

(CABRERA 2007d) *Site Safety and Health Plan, New Haven Depot*, Cabrera Services, Inc., February 2007.

(CABRERA 2008) *Site Specific Derived Concentration Guideline Levels, Defense National Stockpile Center New Haven Depot*, Cabrera Services, Inc., January 2008.

(ERS 2002) *Final Status Survey Report, New Haven Depot*, ERS Solutions, Inc., December 2002.

(ERS 2004) *New Haven Depot Radiological Oversight Report*, ERS Solutions, Inc., July 2004.

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

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

(NRC 2006) Title 10, Code of Federal Regulations, Part 20, Subpart E, January 2006.

(Pangea 2005) *Project Closure Report*, Pangea Group, February 2005.

ATTACHMENT 1

FIGURES