FINAL

CHARACTERIZATION SURVEY REPORT
OUTSIDE AREAS

NEW HAVEN DEPOT
DEFENSE NATIONAL STOCKPILE CENTER

NEW HAVEN, INDIANA

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APPROVALS

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LIST OF ACRONYMS

Bgs	Below ground surface
CABRERA	Cabrera Services, Inc.
Cm/sec	Centimeter per second
COC	Chain of Custody
Cpm	Counts per minute
DCGL or $DCGL_W$	Derived Concentration Guideline Level
Depot	New Haven Depot
DLA	Defense Logistics Agency
DNSC	Defense National Stockpile Center
dpm/100 cm^2	Disintegrations per Minute per 100 Square Centimeters
ERS	Environment Radiation Safety
FSS	Final Status Survey
GPS	Global Positioning System
GSA	General Services Administration
GWS	Gamma Walkover Survey
HP	Health Physicist
JMC	Joint Munitions Command
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NAD	Normalized Absolute Difference
NORM	Naturally Occurring Radioactive Material
NaI	Sodium Iodide
NRC	U.S. Nuclear Regulatory Commission
ORPP	Occupational Radiation Protection Program
Pangea	Pangea Group
pCi/g	Picocuries Per Gram
QA	Quality Assurance
QC	Quality Control
RAM	Radioactive Materials
ROC	Radionuclide of Concern
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
STL	Severn Trent Laboratories
SU	Survey Unit
^{232}Th	Thorium-232
^{238}U	Uranium-238
WP	Characterization Survey Work Plan

EXECUTIVE SUMMARY

This Characterization Survey Report documents the findings of the outside characterization survey, which addressed the type and locations of residual radioactivity at the Depot in support of site decommissioning activities.

Gamma walkover survey (GWS) results in area 7A were not significantly elevated above background activity; however, the GWS did indicate the presence of several locations with elevated gamma levels. Systematic soil samples were collected throughout 7A biased soil samples were collected at these elevated gamma locations. Several soil samples were found to be in excess of the ^{232}Th and ^{238}U default NRC screening levels.

GWS results in outdoor areas other than area 7A were not significantly elevated above background activity.

During GWS, several areas of elevated activity were found. Upon further investigation, most of these "hotspots" were due to residual zirconium ore, often in rock form. At some locations, when the rock was removed, the gamma results returned to background levels. In other locations, removal of some rocks did not affect the elevated gamma results. Analytical soil sample results revealed that the rocks were occasionally small enough to be indistinguishable from soil. Remediation may be required depending on the DCGLs selected and approved for this site.

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the U.S. Army Joint Munitions Command (JMC). CABRERA has prepared this Characterization Survey Report for the New Haven Depot (Depot) at the Defense National Stockpile Center (DNSC) in New Haven, Indiana in accordance with CABRERA's Characterization Survey Work Plan (WP) (CABRERA, 2006a), provided in Appendix A. CABRERA implemented the WP, with field operations conducted between October 18, 2006 and November 21, 2006. CABRERA performed all work under contract to the U.S. Army Joint Munitions Command (JMC) on behalf of the DNSC.

This Characterization Survey Report documents the findings of the characterization survey, which addressed the type and locations of residual radioactivity at the Depot in support of site decommissioning activities. Results from the characterization surveys will be used to support development of a Remediation Work Plan and Final Status Survey (FSS) Plan, in accordance with U.S. Nuclear Regulatory Commission (NRC) regulations and guidance.

The results of the interior warehouse surveys performed during this field effort are not included in this report since not all measurements are complete. These results will be provided under separate cover during the FSS phase of the project.

1.1 Background

The DNSC 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 Department of Defense under the DNSC. Vehicular access is made from State Route 14 near the center of the Depot. A 6-foot high fence topped with three-strand barbed wire surrounds the Depot. A security officer controls access to the Depot. A Norfolk Southern rail line is present near the south end of the Depot. A series of rail spurs extending off the Norfolk Southern rail line cross the Depot along its east-west axis, converging at the Depot's southwestern and southeastern corners.

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 rules. The DNSC stored these materials under the authority of NRC License STC-133. Three outdoor areas contain piles of fluorspar and some warehouse bays (indoor sections) currently contain packaged materials (e.g., tungsten, columbium/tantalum, and fluorspar) with small amounts of naturally occurring uranium and thorium (not licensable quantities). These stockpiled ores emit ambient gamma radiation, which could interfere with potential radiation surveys to be conducted as part of Depot closure. According to the most recent Occupational Radiation Protection Program (ORPP) Annual Survey, all licensed radioactive materials (RAM) have been removed from the Depot; however, contamination may still remain from previous storage (Skruck, 2006).

Zirconium ore (Baddeleyite ore) is a natural zirconium oxide found in Brazil and Ceylon. The ore contains naturally occurring radioactive materials (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, as presented in Figure 1-1. Pile 111 contained 31,981,402 pounds of the ore. Pile 111A contained soil contaminated with the ore from the transfer of 2,783,706 pounds of zirconium ore from other DNSC depots. Pile 111 stood 28 feet high with a length of 296 feet and a width of 60 feet. Pile 111A was 28 feet high by 104 feet long and 50 feet wide. 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 soils at the base of the piles at these depots comprised the contents of Pile 111A.

The ore was sold in October 2000, and the ore was then loaded into rail cars at the storage location by a front-end loader. The rail cars were then moved to the Depot's 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 an area where the tops were shrink-wrapped to preclude loss of the ore during transit. This ore handling process increased the possibility of contamination throughout the Depot. The areas affected 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, as presented in Figure 1-1.

1.2 Geology

The Depot is located in the Maumee Lake plain unit of the Central Lowland Physiographic Province. The Maumee Lake plain is flat and poorly drained, and was developed from lacustrine deposits from an archaic glacial lake situated east of present-day New Haven. Surficial soils in the area of the Depot belong to the Hoytville-Napanee Association, which are described as deep, somewhat poorly drained to very poorly drained, nearly level, medium-textured to finely-textured soils on uplands.

The Depot is underlain by wave-scoured, lake-bottom till. This till is part of the New Holland Member of the Largo Formation and is comprised of lacustrine deposits described as massive, firm, pale brown to light gray clay loam and silty clay loam. Local lenses of sand and plastic clay may exist. To the west and immediate south of the Depot are thin sand and gravel deposits overlying the till that developed along the ancient lake margin. These thin deposits are generally not sources of water supply.

Three sand and gravel pits were previously located where the Depot currently exists. These pits may have been remnants of historical quarrying operations during which very localized and thin lake margin deposits were removed and may correspond to the three small ponds located on the Depot. The unconsolidated deposits at the location of the Depot extend to approximately 70 feet below ground surface (bgs). Bedrock deposits of Devonian limestone and dolomite of the Traverse and Detroit rivers formations underlie the till (Parsons, 1999).

1.3 Hydrogeology

Regional groundwater in the area is believed to flow to the northwest. Based upon surface topography, the shallow, unconsolidated aquifers in the till likely flow in this direction. The bedrock surface in the area of the Depot is reported to tilt slightly to the northwest. The city of New Haven's water department purchases their water supply from the city of Fort Wayne. The city of Fort Wayne derives their water source solely from the St. Joseph River. No groundwater wells are utilized as a secondary water source. Because of the rural setting of the Depot, the local farms and small businesses in the area are expected to utilize private groundwater wells for supplying potable water (Parsons, 1999).

1.4 Previous Investigations

Environment Radiation Safety (ERS) Solutions conducted a final status survey (FSS) of all impacted outdoor areas at the Depot excluding open area 7A, where the zirconium ore was stored at the time. As noted in the FSS Report (ERS, 2002), the ore was in the form of stones, rocks or pebbles and thus did not disperse as would a powder or granulated material. 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, which was used for shrink-wrapping, had the largest accumulations of discrete zirconium ore piles. Spillage accumulations in these areas consisted of 50 or more rocks in a single location. 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 consisting of 1 to 20 rocks. Remediation efforts, performed in May 2002, were conducted at each survey unit (SU) to remove the ore. 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, 2003a). Some of the specific findings included:

- Radioactivity associated with background may not have been sufficiently characterized
- Soil samples were not collected to verify remediation efforts
- Fluorspar next to survey areas made scan surveys by themselves impractical
- Scan criteria used for Derived Concentration Guideline Levels (DCGLs) associated with Class 3 SUs were arbitrary
- Surveyed areas requested for FSS release adjacent to open area 7A will be affected during the open area 7A FSS

Pangea Group (Pangea) conducted additional removal and remediation efforts of the residual zirconium ore in open area 7A during the summer of 2004 (Pangea, 2005). Soil underlying piles 111 and 111A, and residual material, were removed and, upon detecting contamination within the footprint of the piles, Pangea removed at least the top 6 inches of soil from the entire 7A area, including the eastern access road and the railroad track bed. 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 an 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.

1.5 Radionuclides of Concern

The radionuclides of concern (ROCs) for the survey effort described in this Characterization Survey Report are natural thorium and uranium. 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 <0.004% uranium by weight. Because of the abundance of thorium and uranium, the zirconium ore was controlled by the DNSC under a license STC-133 issued by the NRC.

Since the ores containing these ROCs were simply stored at the Depot and never processed, the radioactive decay products in both the natural thorium and natural uranium chains remained in secular equilibrium with the parent radionuclide, as they were in nature.

The two parent radionuclides in the natural thorium and natural uranium decay chains, thorium-232 (^{232}Th) and uranium-238 (^{238}U) respectively, 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 was used in the design of the characterization surveys and sampling, as well as selection of appropriate survey instruments and analysis methods.

2.0 INSTRUMENTATION AND METHODS

The purpose of this section is to describe direct radiation measurements, analytical sample collection, and smear survey collection and analysis techniques that were implemented during the radiological investigations of the Depot.

2.1 Area 7A

Area 7A was the former zirconium ore storage area. The following methods and instrumentation were used in the surveys of Area 7A.

2.1.1 Gamma Walkover Survey (GWS)

Outdoor GWS measurements were performed during the characterization survey using a sodium iodide (NaI) detector coupled to a Ludlum 2221 ratemeter. The detector was coupled to a Trimble XR Pro global positioning system (GPS).

CABRERA performed GWS over 100% of the accessible parts of area 7A, and the highest gamma activity results were used to select biased soil samples in the area.

2.1.2 Analytical Sample Collection and Analysis

CABRERA has ensured that the off-site laboratory minimum detectable concentrations (MDCs) and methods used to analyze analytical samples are at or below the soil screening criteria presented in Table 2-1.

Soil and sediment samples were collected from numerous locations at the Depot. Soil and sediment samples were collected using hand auger and soil coring tools. Prior to the collection of each sample, the equipment was decontaminated by cleaning the surface with water and a Masslin cloth. Additionally, prior to the collection of each sample (including those from the same location but at multiple depths), a 1-minute gamma measurement was performed at a distance of 15 centimeters from the surface of the soil using a Ludlum 2221 with 44-20 detector. During the collection of soil samples, twigs, stones and other foreign matter were removed prior to filling sample bags. The chain of custody (COC) for these samples was maintained in accordance with CABRERA SOPs. Samples were shipped to Severn Trent Laboratories (STL) for analysis to determine sample activities of ROCs as presented in Table 2-1.

TABLE 2-1: SCREENING GUIDELINE LEVELS FOR ROCS

ROC	Screening Level	Reference
^{232}Th (soil)	1.1 pCi/g	Screening values derived using NUREG/CR-5512 Vol.3; Table 5.19.
^{232}Th (solid outside surfaces)	224 dpm/100 cm^2	Screening values are total alpha emissions for parent plus progeny in the decay chain (DLA 2006)
^{238}U (soil)	0.5 pCi/g	Screening values derived using NUREG/CR-5512 Vol.3; Table 5.19.
^{238}U (solid outside surfaces)	448 dpm/100 cm^2	Screening values are total alpha emissions for parent plus progeny in the decay chain (DLA 2006)

dpm = disintegrations per minute
cm^2 = square centimeters
pCi/g = picocuries per gram
solid outside surfaces = the rail scale, roads, and the shrink wrapping area

In general, soil samples were collected from 0 to 15 cm bgs at each location (i.e., one level or layer at each location). Within area 7A (SUs 1 through 4) the reference area, and the rail scale (see Section 4.2), additional samples were also collected from 16 to 30 cm bgs to assess the presence of subsurface contamination.

2.2 Other Outdoor Areas

The other outdoor areas include the entry road to area 7A, the paved road to the rail scale, the rail scale, the outdoor shrinkwrapping area, and the storage and transport areas. The following methods and instrumentation were used in the surveys of these areas.

2.2.1 GWS

Outdoor gamma walkover survey measurements were performed during the characterization survey using a sodium iodide (NaI) detector coupled to a Ludlum 2221 ratemeter. The detector was coupled to a Trimble XR Pro global positioning system (GPS).

The WP for the Depot specified that a gamma walkover survey (GWS) be performed over accessible Class 3 outdoor areas. It also detailed that biased scan surveys for gross alpha activity be performed on Class 3 outdoor surfaces, such as concrete pads, asphalt roads, rail lines, and rail ties, at a 10-20% rate. These surfaces include the paved road to the rail scale, the rail scale, outdoor shrink-wrapping areas, and railroad tracks used for storage or transport (CABRERA, 2006a).CABRERA performed GWS over 100% of the accessible parts of area 7A, and the highest gamma activity results were used to select biased soil samples in the area. It was definitively demonstrated during field activities that the zirconium ore emits sufficient gamma activity to detect to a level of 15 cm bgs using the equipment specified in Section 2.1 above. Therefore, it was determined that GWS were sufficient to detect the residual zirconium ore (if any) outdoors and that biased scan surveys for gross alpha activity were not necessary.

2.2.2 Integrated Direct Surface Radioactivity Measurements

MDCs have been calculated for alpha integrated surveys based on the Strom & Stansbury MDC equation (equation 3-11 of NUREG 1507; NRC, 1997). The MDCs were calculated using the integrated survey background and surface count times presented in Section 1.0 of the WP (CABRERA, 2006a). These count times ensure that integrated measurements will meet the most restrictive screening guideline requirements for alpha (^{232}Th) emitting ROCs (see Table 2-1 for screening guidelines):

Alpha measurement: MDC calculations using the 43-89 detector assume a 3 counts per minute (cpm) background and 15 percent detection efficiency based on ^{232}Th, resulting in a calculated MDC of 60 disintegrations per minute per 100 square centimeters (dpm/100 cm^2).

Integrated measurements of surface alpha activity were performed at each location during the scan surveys as described above using the Ludlum 43-89 probe with a Ludlum 2224.

Integrated measurement background and surface count times for this characterization survey were as follows:

- Alpha measurement integrated count time using the 43-89 was 1 minute

- Background measurement count time using the 43-89 was 1 minute

Methods used for determining the count times above are presented in the WP (CABRERA, 2006a) included in this report as Appendix A.

2.2.3 Smear Sample Surveys

The transferable radioactivity survey (i.e., smear survey) screening level criterion for each of the ROCs is presented in Table 2-1 under the column “Transferable Analysis Goal”. Each of these values is based on the 10% removal rate assumed in NUREG/CR-5512.

MDCs have been calculated for alpha transferable activity (smear) measurements based on the Strom & Stansbury MDC equation (equation 3-11 of NUREG 1507). The MDCs were calculated using the background and smear measurement count times presented in the WP. The calculated alpha MDC is 8 dpm/100 cm^2.

Smear samples were collected at biased locations, as appropriate, to quantify transferable surface alpha radioactivity. Smear surveys were performed in accordance with CABRERA SOPs. Smears were analyzed using a Ludlum 2929/43-10-1 smear counter. Smear locations and results were recorded onto survey forms. Count times for smears were set at 4 minutes for surface smear measurements and 20 minutes for background measurements.

3.0 CHARACTERIZATION SURVEY

Characterization survey activities consisted of:

- Direct alpha integrated measurements at fixed positions determined with respect to the results of scan surveys and at random locations in preparation for FSS release
- Gamma measurements and GWSs of the 7A area, and other outdoor impacted areas identified in the WP (CABRERA, 2006a)
- Collection and analysis of soil samples in the 7A area, surrounding areas, and reference area
- Smear survey collection and analysis in systematic and biased locations

Residual radioactivity screening levels are based on NRC screening criteria referenced from NUREG/CR-5512 Volume 3 (NRC, 1999). These screening values are considered conservative, lower-bounding, estimates of potential cleanup criteria and have been used to establish instrument and analysis sensitivity requirements for this survey. The screening guideline levels for each ROC are presented in Table 2-1.

4.0 RESULTS

Characterization survey results from area 7A and other outdoor areas that will guide remediation efforts are included in this section. Copies of COC forms submitted with samples for offsite analyses are included in Appendix B. A copy of the project logbook is also included in Appendix B.

4.1 Area 7A

Area 7A consists of Class 1 SUs 1 through 3 and Class 2 buffer area SU 4, which surrounded the Class 1 SUs. The area of the four SUs was as follows: SU 1 was 1,945 m^2, SU 2 was 1,944 m^2, SU 3 was 1,970 m^2, and SU 4 was 4,141 m^2. The GWS results for SUs 1 through 3 are shown on Figures 4-1 through 4-4. Sample locations for 7A are presented on Figures 4-5 and 4-6. Soil sampling results from SUs 1 through 4 are summarized in Table 4-1 below.

TABLE 4-1: SOIL SAMPLE RESULTS

^{232}Th Summary								
	Soil from 0-15 cm				Soil from 16-30 cm			
SU[1]	Average (pCi/g)[2]	Standard Deviation	Max (pCi/g)	# exceed SL[3]	Average (pCi/g)[2]	Standard Deviation	Max (pCi/g)	# exceed SL[3]
1	-0.28	0.35	0.25	0	-0.26	0.35	0.56	0
2	0.13	2.02	6.64	2	0.98	5.36	24.34	1
3	-0.38	0.44	0.36	0	-0.31	0.37	0.43	0
4	-0.12	0.31	0.59	0	-0.06	0.28	0.49	0
Entry Road	-0.15	0.11	-0.07	0	N/A[4]			
Rail Scale	4.19	N/A[5]	N/A[5]	1	-0.84	N/A[5]	N/A[5]	0
^{238}U Summary								
	Soil from 0-15 cm				Soil from 16-30 cm			
SU[1]	Average (pCi/g)[2]	Standard Deviation	Max (pCi/g)	# exceed SL[3]	Average (pCi/g)[2]	Standard Deviation	Max (pCi/g)	# exceed SL[3]
1	0.28	1.41	4.55	6	0.12	0.79	2.11	6
2	2.94	10.67	47.75	5	5.76	27.71	126.65	3
3	0.12	1.29	4.45	5	-0.23	0.58	1.65	3
4	0.05	0.88	2.75	5	-0.10	0.67	1.15	5
Entry Road	0.98	0.83	1.57	1	N/A[4]			
Rail Scale	11.94	N/A[5]	N/A[5]	1	-0.26	N/A[5]	N/A[5]	0

NOTES:1)	SU=Survey Unit
2)	Net Sample Result = Gross Result - Average Reference Area Concentration
3)	Number of Net Sample Results Exceeding NRC Default Screening Limit (SL) (^{232}Th = 1.1 pCi/g, ^{238}U = 0.5 pCi/g)
4)	Not applicable (N/A); No data
5)	Only one sample collected, unable to do statistics

4.1.1 Direct Gamma Surveys

A GWS was performed over 100% of the accessible parts of area 7A. Test pits and standing water prevented GWS in 20% of the area. GWS results identified locations with gamma fluence significantly above background activity. These locations were used to guide biased soil sampling. GWS results are presented in Figures 4-1 through 4-4.

4.1.2 Soil Samples

Within 7A, 182 soil samples were collected at 92 locations: 92 from 0-15 cm bgs and 90 from 16-30 cm bgs. Complete analytical results are presented in Appendix C.

All soil samples were sent offsite to STL and analyzed for project ROCs, ^{232}Th and ^{238}U. Soil samples were collected from an unimpacted reference area north of area 7A. The average ROC concentration results from the reference area were classified as background and were subtracted from soil ROC concentration results obtained in area 7A and surrounding areas. All soil results below, therefore, are the net concentrations above background.

Default NRC screening limits were exceeded in several locations in the 7A area for both ^{232}Th and ^{238}U; these locations are presented in Figure 4-7.

One-minute integrated gamma measurements were performed at each sample location prior to soil sampling. Gamma results were elevated for several locations, especially biased soil sample locations. Gamma results (direct measurement and smear results) are presented in Appendix D.

4.1.2.1 SU 1

There were 17 systematic locations and 3 biased locations sampled in SU 1. At all locations, samples were collected from 0-15 cm and from 16-30 cm. Samples were sent to STL for gamma spectroscopy analysis. Screening limits were exceeded for analytical results at 4 systematic locations and 2 biased locations. A summary of results is presented in Table 4-1.

From 0-15 cm, the net soil ^{232}Th results averaged –0.28 picocuries per gram (pCi/g) with a standard deviation of 0.35 pCi/g and a maximum of 0.25 pCi/g. From 16-30 cm, the net soil ^{232}Th results averaged –0.26 pCi/g with a standard deviation of 0.35 pCi/g and a maximum of 0.56 pCi/g.

From 0-15 cm, the net soil ^{238}U results averaged 0.28 pCi/g with a standard deviation of 1.41 pCi/g and a maximum of 4.55 pCi/g. From 16-30 cm, the net soil ^{238}U results averaged 0.12 pCi/g with a standard deviation of 0.79 pCi/g and a maximum of 2.11 pCi/g.

4.1.2.2 SU 2

There were 18 systematic locations and 4 biased locations sampled in SU 2. At all locations, samples were collected from 0-15 cm and from 16-30 cm. Samples were sent to STL for gamma spectroscopy analysis. Screening limits were exceeded for analytical results at 2 systematic locations and 4 biased locations. A summary of results is presented in Table 4-1.

From 0-15 cm, the net soil ^{232}Th results averaged 0.13 pCi/g with a standard deviation of 2.02 pCi/g and a maximum of 6.64 pCi/g. From 16-30 cm, the net soil ^{232}Th results averaged 0.98 pCi/g with a standard deviation of 5.36 pCi/g and a maximum of 24.34 pCi/g.

From 0-15 cm, the net soil ^{238}U results averaged 2.94 pCi/g with a standard deviation of 10.67 pCi/g and a maximum of 47.75 pCi/g. From 16-30 cm, the net soil ^{238}U results averaged 5.76 pCi/g with a standard deviation of 27.71 pCi/g and a maximum of 126.65 pCi/g.

4.1.2.3 SU 3

There were 19 systematic locations and 8 biased locations sampled in SU 3. At all locations, samples were collected from 0-15 cm and from 16-30 cm. Samples were sent to STL for gamma spectroscopy analysis. Screening limits were exceeded for analytical results at 3 systematic locations and 4 biased locations. A summary of results is presented in Table 4-1.

From 0-15 cm, the net soil ^{232}Th results averaged –0.38 pCi/g with a standard deviation of 0.44 pCi/g and a maximum of 0.36 pCi/g. From 16-30 cm, the net soil ^{232}Th results averaged –0.31 pCi/g with a standard deviation of 0.37 pCi/g and a maximum of 0.43 pCi/g.

From 0-15 cm, the net soil ^{238}U results averaged 0.12 pCi/g with a standard deviation of 1.29 pCi/g and a maximum of 4.45 pCi/g. From 16-30 cm, the net soil ^{238}U results averaged –0.23 pCi/g with a standard deviation of 0.58 pCi/g and a maximum of 1.65 pCi/g.

4.1.2.4 SU 4

There were 24 systematic locations and 3 biased locations sampled in SU 4. At all locations, samples were collected from 0-15 cm and from 16-30 cm. Samples were sent to STL for gamma spectroscopy analysis. Screening limits were exceeded for analytical results at 6 systematic locations and 3 biased locations. A summary of results is presented in Table 4-1.

From 0-15 cm, the net soil ^{232}Th results averaged –0.12 pCi/g with a standard deviation of 0.31 pCi/g and a maximum of 0.59 pCi/g. From 16-30 cm, the net soil ^{232}Th results averaged –0.06 pCi/g with a standard deviation of 0.28 pCi/g and a maximum of 0.49 pCi/g.

From 0-15 cm, the net soil ^{238}U results averaged 0.05 pCi/g with a standard deviation of 0.88 pCi/g and a maximum of 2.75 pCi/g. From 16-30 cm, the net soil ^{238}U results averaged –0.10 pCi/g with a standard deviation of 0.67 pCi/g and a maximum of 1.15 pCi/g.

4.2 Reference Area

The reference area was located in the northwestern corner of the Depot, directly north of the entry road to area 7A. There is no evidence of radioactive materials being stored or transported any further north than the entry road in area 7A. This reference area has similar geophysical characteristics to area 7A. The area was approximately 60 meters by 60 meters. Sample locations and GWS results for the reference area are presented in Figure 4-8. Outside Area results are summarized in Table 4-1.

Surveys were performed in other outdoor areas (i.e. the paved road to rail scale, rail scale, and shrinkwrapping areas) for characterization purposes. Surveys were not expected to comply with MARSSIM FSS guidance. Future survey efforts will be designed to collect material-specific background measurements on multiple surfaces in unimpacted areas of the Site. In future data evaluations, these background results on multiple surfaces will be compared to survey results using the Sign Test.

4.2.1 Direct Gamma Surveys

A GWS was performed over 100% of the accessible parts of the reference area. GWS results did not identify areas with gamma fluence significantly above background activity. The highest gamma walkover result was used to select one biased soil sampling location.

4.2.2 Soil Samples

There were 20 systematic locations and 1 biased location sampled in the reference area. At all locations, samples were collected from 0-15 cm and from 16-30 cm. Samples were sent to STL for gamma spectroscopy analysis. The average analytical results for ROCs in soil samples collected from this reference area were used to calculate concentrations due to background. Complete analytical results are presented in Appendix C.

One minute integrated gamma measurements were performed at each sample location prior to soil sampling. Gamma results were not significantly elevated above background levels. Gamma results are presented in Appendix D.

4.3 Entry Road and Paved Road to Rail Scale

The entry road to 7A and the paved road leading to the rail scale were Class 3 areas. Soil sample locations and GWS results for the entry road and the paved road to the rail scale are presented in Figures 4-9 and 4-10.

4.3.1 Direct Gamma Surveys

A GWS was performed over all accessible parts of these areas. GWS results identified areas along the entry road with gamma fluence slightly above background activity. The highest gamma walkover result was used to select two biased soil sampling locations. It was noted during field activities that fluorspar, a NORM that is stored in a large pile across the road from the rail scale, was located along the paved road to the rail scale.

4.3.2 Direct Alpha Measurements

Twenty direct biased alpha measurements were performed over the paved road to the rail scale. The integrated measurement alpha results averaged 0 dpm/100 cm^2 with a standard deviation of 11.2 dpm/100 cm^2 and a maximum of 13.4 dpm/100 cm^2.

Surface screening limits were not exceeded for alpha measurement results. Complete results are presented in Appendix D.

4.3.3 Smear Measurements

Smears were collected at each integrated measurement location and analyzed for alpha activity using the Ludlum 2929/43-10-1. The maximum alpha smear result was 2.0 dpm/100 cm^2.

Transferable activity screening limits were not exceeded for alpha smear results. Smear data results are presented in Appendix D.

4.3.4 Soil Samples

There were 2 biased locations in the entry road area. At both locations, samples were collected from 0-15 cm. Samples were sent to STL for gamma spectroscopy analysis. Screening limits were exceeded for analytical results at 1 biased location. Complete analytical results are presented in Appendix C. A summary of results is presented in Table 4-1.

One minute integrated gamma measurements were performed at each sample location prior to soil sampling. Gamma results were slightly elevated above background levels. Gamma results are presented in Appendix D.

4.4 Rail Scale

The rail scale was a Class 2 area. Soil sample locations and GWS results for the rail scale are presented in Figure 4-11. Rail scale soil sample results are summarized in Table 4-1.

4.4.1 Direct Gamma Surveys

A GWS was performed over 100% of the accessible parts of the rail scale. GWS results identified one area with gamma fluence slightly above background activity. The highest gamma walkover result was used to select one biased soil sampling location.

4.4.2 Direct Alpha Measurements

Twenty direct biased alpha measurements were performed over the rail scale. The integrated measurement alpha results averaged 2.9 dpm/100 cm^2 with a standard deviation of 17.5 dpm/100 cm^2 and a maximum of 44.8 dpm/100 cm^2.

Surface screening limits were not exceeded for alpha measurement results. Complete results are presented in Appendix D.

4.4.3 Smear Measurements

Smears were collected at each integrated measurement location and analyzed for alpha activity using the Ludlum 2929/43-10-1. The maximum alpha smear result was 3.1 dpm/100 cm^2.

Transferable activity screening limits were not exceeded for alpha smear results. Smear data results are presented in Appendix D.

4.4.4 Soil Samples

There was 1 biased sample location in the rail scale area. The sample was collected from 0-15 cm and from 16-30 cm. Samples were sent to STL for gamma spectroscopy analysis. Screening limits were exceeded for analytical results at the biased location. It was noted during field activities that the biased sample appeared to contain fluorspar, which is located in a pile across the paved road in mass quantity. Complete analytical results are presented in Appendix C. A summary of results is presented in Table 4-1.

A 1-minute integrated gamma measurement was performed at the biased soil sample location. Gamma results were slightly elevated above background levels. Gamma results are presented in Appendix D.

4.5 Outdoor Shrinkwrapping Area

The outdoor shrinkwrapping area was a Class 3 area. GWS results are presented in Figure 4-12.

4.5.1 Direct Gamma Surveys

A GWS was performed over 100% of accessible parts of the outdoor shrinkwrapping area. GWS results did not identify areas with gamma fluence significantly above background activity. Soil samples were not necessary based on GWS results. The GWS results are presented in Figure 4-13.

4.5.2 Direct Alpha Measurements

Ten direct biased alpha measurements were performed over the outdoor shrinkwrapping area. The integrated measurement alpha results averaged 1.8 dpm/100 cm^2 with a standard deviation of 14.4 dpm/100 cm^2 and a maximum of 31.4 dpm/100 cm^2.

Surface screening limits were not exceeded for alpha measurement results. Complete results are presented in Appendix D.

4.5.3 Smear Measurements

Smears were collected at each integrated measurement location and analyzed for alpha activity using the Ludlum 2929/43-10-1. The maximum alpha smear result was 4.0 dpm/100 cm^2.

Transferable activity screening limits were not exceeded for alpha smear results. Smear data results are presented in Appendix D.

4.6 Storage/Transport Area

The outdoor storage/transport area was a Class 3 area. GWS results are presented in Figure 4-13.

4.6.1 Direct Gamma Surveys

A GWS was performed over 10% of the accessible parts of the storage/transport area. GWS results did not identify areas with gamma fluence significantly above background activity. Soil samples were not necessary based on GWS results.

4.6.2 Direct Alpha Measurements

Twenty direct biased alpha measurements were performed over the rail scale. The integrated measurement alpha results averaged –0.2 dpm/100 cm^2 with a standard deviation of 15.8 dpm/100 cm^2 and a maximum of 22.4 dpm/100 cm^2.

Surface screening limits were not exceeded for alpha measurement results. Complete results are presented in Appendix D.

4.6.3 Smear Measurements

Smears were collected at each integrated measurement location and analyzed for alpha activity using the Ludlum 2929/43-10-1. The maximum alpha smear result was 3.3 dpm/100 cm^2.

Transferable activity screening limits were not exceeded for alpha smear results. Smear data results are presented in Appendix D.

5.0 SURVEY QUALITY ASSURANCE/QUALITY CONTROL

Activities associated with this Characterization Survey Report were performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Implementation of Quality Assurance (QA) measures for this report is described herein.

Only qualified and trained personnel operated the equipment and instrumentation used in the field activities specified in this report. Personnel were trained in the technical, quality control, and health and safety aspects of the project, as well as in the calibration, maintenance, and operating procedures for their assigned equipment.

5.1 Instrumentation Requirements

The CABRERA Project Health Physicist (HP) was responsible for determining the instrumentation required to complete the requirements of this characterization survey. Only instrumentation approved by the CABRERA Project HP was used to collect radiological data. The CABRERA Project HP was responsible for ensuring individuals were appropriately trained to use project instrumentation and other equipment, and that instrumentation met the required detection sensitivities. Instrumentation were operated in accordance with either a written procedure or manufacturers' manual, as determined by the CABRERA Project HP. The procedure and/or manual provided guidance to field personnel on the proper use and limitations of the instrument.

Instrument quality control (QC) checks were performed as presented in the project WP(Cabrera, 2006a). Instruments used to obtain radiological data, including GPS equipment, were inspected for physical damage, current calibration and erroneous readings in accordance with applicable procedures and/or protocols. The individual performing these tasks documented the results in accordance with the associated instrument procedure and/or protocols. Any instrumentation not meeting the specified requirements of calibration, inspection, or response check were to be removed from operation (none needed to be removed). The instrumentation QC data results are presented in Appendix E.

5.1.1 Calibration Requirements

Instruments used during the characterization survey had current calibration and maintenance records onsite for review and inspection. The records included the following:

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

Instrumentation was maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments was maintained. Instruments were under current calibration. The calibration data for each instrument used during this characterization survey are presented in Appendix E.

5.1.2 Instrument QC Source Checks

Prior to daily use, project instrumentation was QC checked by comparing instrument response to a benchmark response. Prior to the commencement of field operations, reference locations were selected for performance of these checks; subsequent QC checks were performed at these locations. QC source checks consisted of a 1-minute integrated count with the designated source positioned in a reproducible geometry performed at the reference location. Prior to the start of initial surveys, this procedure was repeated at least ten times to establish average instrument response. The QC results for each instrument used during this characterization survey are presented in Appendix E.

5.1.2.1 Direct Radiation Measurement Instrumentation QC

Detectors used for direct radiation measurements included the Bicron Microrem meter, the Ludlum 43-89. Instrument responses to designated QC check sources were recorded and evaluated against the average established at the start of the field activities. An acceptance criterion of ± 20% was required for direct measurement detectors. A QC count outside the respective screening limit required informing the field lead, a detector evaluation and could have resulted in the detection system being removed from service for corrective action. The QC results for each instrument used during this characterization survey are presented in Appendix E.

5.1.2.2 Smear analysis instrumentation QC

The detector used to analyze smears was the Ludlum 2929/43-10-1. Instrument response to designated QC check sources were recorded and evaluated against the average established at the start of the field activities. An acceptance criterion of ±2 sigma for an investigation level and ±3 sigma for a screening limit were established for this project. The Project Engineer performing QC checks investigated results exceeding the ±2 sigma criteria and noted the results in the project QC data file. If QC check results exceed ±3 sigma criterion, the Project Engineer noted this occurrence in the data file and contacted the CABRERA field lead for further instructions. The CABRERA field lead made appropriate corrections to instrument readings if response was deviated by factors beyond personnel control, such as large humidity or temperature changes. The CABRERA field lead had authority to decide whether or not the instrument was acceptable to use or must be removed from service. The QC results for the instruments used during this characterization survey are presented in Appendix E.

5.1.3 Duplicate Sample Analyses

CABRERA collected duplicate samples for 5% of all soil samples, as presented in the WP (CABRERA, 2006a). The samples were numbered using a unique identifier. Analyses of laboratory duplicates were compared to the initial analytical results by determining a Normalized Absolute Difference (NAD) value for each data set by the following equation:

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

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

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

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

There were 14 laboratory samples, or approximately 9% of the total number of samples collected, analyzed as duplicates. Anywhere from 10 to 14 radionuclides were identified per sample. One radionuclide laboratory measurement, or approximately 0.6% of the total number of measurements, did not pass the calculated NAD performance criteria of less than or equal to 1.96. The results are presented in Appendix E.

6.0 HEALTH AND SAFETY

Health and safety measures were employed during conduct of characterization activities, in accordance with the project Site Safety and Health Plan (SSHP) (CABRERA, 2006b).

Daily health and safety activities were performed in accordance with the project SSHP, including conducting Daily Tailgate Safety meetings, prior to the performance of survey activities each day. These daily safety meetings allowed for discussion of daily safety measures required based on the activities planned for each day. Daily Safety Tailgate Meeting records are provided in Appendix F. The SSHP was reviewed by CABRERA project and sub-contractor personnel prior to the performance of characterization survey activities. No reported injuries took place during the characterization survey field effort.

7.0 SUMMARY OF RESULTS, CONCLUSION, AND RECOMMENDATIONS

7.1 Summary of Results

The following is a summary of results from the performance of the New Haven Depot Characterization Survey. The ROCs in soil detected in excess of background were ^{232}Th and ^{238}U.

GWS results in area 7A indicated that several locations with elevated gamma levels were present. Soil samples were collected throughout 7A and at these elevated gamma locations. Several soil sample results were found to be in excess of the ^{232}Th and ^{238}U default NRC screening levels.

GWS results in the entry road to area 7A, paved road to rail scale, and the rail scale, indicated a few locations with slightly elevated gamma levels. Soil samples were collected in the entry road area and in the rail scale area at these elevated gamma locations. Soil sample results were found to be in excess of the ^{232}Th and ^{238}U default NRC screening levels. It was noted during field activities that fluorspar, a NORM that was stored in a large pile across the road from the rail scale, was located along the paved road and in the dirt in the rail scale area and may have increased soil sample results for ROCs ^{232}Th and ^{238}U.

GWS results in the outdoor shrinkwrapping area and storage/transport area did not identify gamma fluence significantly above background activity. Soil samples were not necessary based on GWS results.

7.2 Conclusions and Recommendations

During GWS, several areas of elevated activity were found. Upon further investigation, most of these "hotspots" were due to residual zirconium ore, often in rock form. At some locations, when the rock was removed, the gamma results returned to background levels. In other locations, removal of some rocks did not affect the elevated gamma results. Analytical soil sample results revealed that the rocks were occasionally small enough to be indistinguishable from soil. All the elevated areas are located in the vicinity of Area 7A and remediation will be required. The following actions will be pursued based on these findings:

- Develop DCGLs based on NRC screening criteria for submittal to NRC
- Identify specific areas requiring remediation
- Prepare a Remediation Work Plan for NRC approval as required by the DNSC NRC license
- Mobilize to the New Haven Depot to perform the remediation consisting of excavation followed by off-site transportation and disposal.
- Conduct the Final Status Survey of the outside areas
- Complete the Final Status Report for the Depot

8.0 REFERENCES

(CABRERA, 2006a) Final Plan, *"Characterization Survey Work Plan, New Haven Depot"*, Cabrera Services, Inc. dated November 2006.

(CABRERA, 2006b) Final Plan, "*Site Safety and Health Plan, New Haven Depot"*, Cabrera Services, Inc. dated August 2006.

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

(Parsons, 1999) Parsons Engineering Science, Inc., 1999. "Preliminary Assessment - New Haven, IN"; January 1999.

(Skruck, 2006) Skruck, Robert, 2006. Report Prepared by Mr. Robert Skruck, DLA/DNSC; Regarding "Occupational Radiation Protection Program Annual Survey"; February 22.

FIGURES

APPENDIX A: CHARACTERIZATION SURVEY WORK PLAN

APPENDIX B: FIELD SURVEY DOCUMENTATION

- **Chain of Custody Documentation**
- **Survey Field Notes**
- **Amendment to Work Plan**

APPENDIX C: ANALYTICAL SAMPLE RESULTS

(Provided on Accompanying Compact Disc)

APPENDIX D: DIRECT MEASUREMENT AND SMEAR RESULTS

APPENDIX E: INSTRUMENTATION QUALITY CONTROL AND CALIBRATION DATA

(Provided on Accompanying Compact Disc)

APPENDIX F: HEALTH AND SAFETY RECORDS