FINAL ADDENDUM

Public Private Venture Areas Remediation

to

Work Plan for the Remediation of the Recreation and Center Tank Areas and Site-Wide Final Status Survey

Former Monazite Sand Storage Area
Naval Station Great Lakes
Great Lakes, Illinois

Project USN 2006-003, Phase IV, Modification 1

Contract No. DAAA09-02-D-0024 Task Order 30

Prepared for:

United States Army Field Support Command
Rock Island, Illinois

Prepared by:

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION
103 E. Mt Royal Ave, Suite 2B
Baltimore, MD 21202

April 2007

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Letter of Transmittal

To: Mr. David Horton, AFSC Project Manager
US Army Joint Sustainment Command
1 Rock Island Arsenal
Rock Island, IL 61299-6000

Date: April 10, 2007

Subject: Submittal of the Final Addendum to the Work Plan for the Remediation of the Recreation and Center Tank Areas and Site-Wide Final Status Survey at the Naval Station Great Lakes, IL, JMC Project USN 2006-009

RE: Contract W52P1J-05-D-0043

We are sending the following via:

☐ Electronic ☐ U.S. Mail

☒ Second Day Service ☐ Hand Delivery

No.	Copies	Date	Description
1	1 CD 1 Paper	April 10, 2007	Mr. Dave Horton - Final Work Plan Addendum
2	1 CD	April 10, 2007	Ms. Pat Hayworth - Final Work Plan Addendum
3	1 CD 1 Paper	April 10, 2007	Mr. Howard Hickey - Final Work Plan Addendum

These are transmitted:

☒ For your use ☐ For review and comment

☐ As requested ☐ Other:

Remarks: An E-mail copy of the document will be sent to Ms. Pat Hayworth

Signed: John Eberlin

103 E. Mt Royal Ave, Suite 2B, Baltimore, MD 21202 • Phone: 410.332.8177 • Fax: 410.332.8183
www.cabreraservices.com

1.0 INTRODUCTION

The United States (U.S.) Army Joint Munitions Command has contracted with Cabrera Services, Inc. (CABRERA) to provide this Remediation and Site-Wide Final Status Survey Addendum (Addendum) to the *Naval Station Great Lakes Remediation and Site-Wide Final Status Survey Work Plan* (Remediation Work Plan) (CABRERA, 2004a). The purpose of this Addendum is to describe the methodology for the remediation and Final Status Survey (FSS) of soils located within the area of concern referred to as the Public Private Venture area at the Naval Station Great Lakes in Great Lakes, Illinois. Specifically, remediation and FSS activities will be conducted in Public Private Venture areas 3A, 3B, 3C and 3F, shown in Figure 1, as detailed in this Addendum.

CABRERA will perform remedial actions, as necessary, in the Public Private Venture areas described in this Addendum. Additional radiological surveys and/or sampling may be performed at other Public Private Venture areas to further characterize the extent of radiological contamination in soil as determined necessary by the Navy. CABRERA may also perform additional soil remediation in other Public Private Venture areas as directed by the Navy.

This Addendum allows for the sampling, remediation and Final Status Survey at any Public Private Venture area of the Naval Station Great Lakes and addresses the expanded scope of work necessary to complete this action. Unless specifically addressed in this Addendum, all other requirements and specifications in the Remediation Work Plan remain unchanged, specifically Sections 5 through 8.

Remediation of Public Private Venture area 3C is scheduled to be conducted in the spring of 2007. It is anticipated that several weeks will be required to complete the excavation, Final Status Survey, and site restoration field activities. The schedule for the remediation of other Public Private Venture areas (i.e., Areas 3A, 3B, and 3F) will be defined as funding is made available.

2.0 BACKGROUND

Radiological surveys of the Public Private Venture areas were performed by CABRERA in August, 2006 (CABRERA, 2006). These surveys consisted of a gamma walkover survey (GWS) of selected locations of suspected elevated radiological activity in soil (MACTEC, 2006). The GWS was performed in accordance with CABRERA standard operating procedures (SOPs) listed in Table 2-1 using a sodium iodide (NaI) detector coupled to a Ludlum Model 2221 survey instrument capable of storing multiple radiological survey points.

Table 2-1: Relevant CABRERA Standard Operating Procedures

Number	Procedure Topic
AP-005	ALARA
OP-001	Radiological Surveys
OP-004	Unconditional Release of Materials from Radiological Control Areas
OP-009	Use and Control Radioactive Check Sources

To associate radiological data to specific locations, a global positioning system (GPS) was used in conjunction with the survey instruments, providing location coordinates for each radiological measurement electronically recorded. The GWS was performed by passing the NaI detector over the surface of the soil at a height of 6 inches, while progressing at a speed of approximately one-half meter per second. Location coordinates and radiological survey data were collected at a rate of one measurement per second. Radiological data were collected and recorded in units of counts per minute. The data obtained during the August 2006 radiological survey were used to support development of the remediation approach described in this Addendum.

2.1 Radiological Survey Results

A GWS was performed at six selected property locations within the Public Private Venture area, identified as Public Private Venture areas 3A, 3B, 3C, 3D, 3E and 3F (CABRERA, 2006). The GWS results, shown in Figure 1, are discussed below.

- Public Private Venture Area 3A: This survey consisted of a GWS of surface soil in the vicinity of a 4-unit housing complex. The radiological survey results indicated two areas of elevated radioactivity in soil. One area of approximately 200 square meters on the north side of the housing unit and a smaller area of approximately 100 square meters on the east side of the same housing unit, in the vicinity of a carport, were identified.

- Public Private Venture Area 3B: This survey consisted of a GWS of surface soil in the vicinity of a ball field. The radiological survey results indicated a large area of approximately 1,500 square meters with elevated radioactivity in soil. The most

significant radioactivity was found on the northwest side of the ball field in an area where a creek borders the survey area.

- Public Private Venture Area 3C: This survey consisted of a GWS of surface soil on the east and west sides of Great Lakes Drive. The radiological survey results indicated three locations of elevated radioactivity on the west side of Great Lakes Drive, between the pavement and sidewalk. Collectively, these areas cover approximately 100 square meters. A second, smaller area of elevated radioactivity, approximately 25 square meters, was found on the east side of the street.

- Public Private Venture Area 3D: This survey consisted of a GWS of surface soil surrounding a duplex housing unit. The radiological survey results indicated an area of elevated radioactivity on the southwest side of the structure, approximately 50 square meters in size.

- Public Private Venture Area 3E: This survey consisted of a GWS of surface soil in the southeast corner of the housing area property boundary. The radiological survey results indicated an area of elevated radioactivity, approximately 200 square meters in size, exists on the downward slope of this area.

- Public Private Venture Area 3F: This survey consisted of a GWS of surface soil on the west side of a creek, south of the area identified in Survey Area 3B. The radiological survey results indicate this area of elevated radioactivity covers approximately 200 square meters.

In January 2007 CABRERA performed additional soil sampling and analysis in the six Public Private Venture areas to determine if the elevated radioactivity from the GWS was due to the presence of licensed material (monazite sand) in soil (CABRERA, 2007). The results of this effort concluded that the elevated soil radioactivity in Public Private Venture areas 3A, 3B, 3C and 3F was most likely due to the presence of monazite sand. However, the report concluded that elevated radioactivity in Public Private Venture areas 3D and 3E was not due to the presence of licensed radioactive material. Therefore, the Public Private Venture areas of concern addressed in this Addendum are limited to 3A, 3B, 3C and 3F.

2.2 Radiological Contaminant of Concern

Thorium-232 (^{232}Th) is the radiological contaminant of concern in Public Private Venture areas 3A, 3B, 3C and 3F. Soil sample analysis in these areas confirmed the presence of ^{232}Th in secular equilibrium with radioactive decay progeny due to the presence of monazite sand in soil (CABRERA, 2007). There is no evidence of chemical or physical processes that could disturb this equilibrium. Based on the composition of monazite sands and laboratory analyses, uranium series radionuclides are expected to be present, but in significantly lower concentrations than thorium series radionuclides and are not considered radiological contaminants of concern.

2.3 Soil Derived Concentration Guideline Values

The derived concentration guideline level (DCGL) for ^{232}Th, established by the Naval Sea Systems Command Detachment, Radiological Affairs Support Office (RASO), for the Naval Station Great Lakes is 1.0 picocurie per gram (pCi/g) above background for ^{232}Th (and decay products) in surface soil (CABRERA, 2004a). This DCGL value is used for determination of survey, sampling, and remediation requirements specified in this Addendum.

3.0 REMEDIATION ACTIVITIES

As discussed previously, the DCGL for ^{232}Th in soil is 1.0 pCi/g above background. The area factor table, obtained from MARSSIM (NRC, 2000) Table 5.6 and applicable to the Public Private Venture areas, is provided below. If the FSS results of soil sample analyses indicate failure of the Wilcoxon Rank Sum (WRS) test, or if elevated ^{232}Th concentrations exist in excess of the applicable elevated area DCGL ($DCGL_{EMC}$) in Table 3-1, soil remediation (removal) will be required.

Table 3-1: ^{232}Th Area Factors And $DCGL_{EMC}$ Values

Area	1 m^2	3 m^2	10 m^2	30 m^2	100 m^2	300 m^2	1000 m^2	3000 m^2	10000 m^2
Area Factor[1]	12.5	6.2	3.2	2.3	1.8	1.5	1.1	1.0	1.0
$DCGL_{EMC}$ [2]	12.5	6.2	3.2	2.3	1.8	1.5	1.1	1.0	1.0

1 Area factors are unitless values which, when multiplied by the $DCGL_w$, provide the $DCGL_{EMC}$.

2 $DCGL_{EMC}$ values are in units of pCi/g.

3.1 Area Preparation

The estimated boundaries of the Public Private Venture areas will be designated using the results of the previous GWS (CABRERA, 2006). Excavation areas will be clearly demarcated prior to commencing work. Notification of Joint Utility Locating Information for Excavators (JULIE) will be coordinated through the installation Environmental Office before the start of any earthwork, to mark out and identify any conflicting underground utilities.

Prior to beginning work, areas to be remediated will be posted as "Access Controlled Area," "RWP [Radiation Work Permit] Required for Entry" and "Authorized Personnel Only." Barrier tape or rope will be utilized to define the active work areas. Each posted area will be restricted to a single ingress/egress point and a personnel and equipment frisking station will be setup in the area.

3.2 Removal of Soil in Public Private Venture Contaminated Areas

Depending on the anticipated area and depth of soil to be removed, removal will accomplished using the most efficient tools; small areas may be excavated manually, whereas larger areas of soil may be removed using an excavator, front-end loader, or equivalent. Removed material will be packaged for transportation in an appropriate transport container, such as an intermodal container or a supersac-type container. Hand tools may also be utilized in size-restricted areas and areas near large stationary features that power machinery cannot readily access.

The materials designated for removal may be temporarily staged on and covered with polyethylene sheeting (poly). It is estimated that a maximum of 115 cubic yards of contaminated soil from Public Private Venture area 3C may require removal and off-site disposal. The soil remediation volume estimate is qualitative, based on calculation from elevated readings from the previous GWS. The volume estimates are not based on quantitative soil laboratory analysis.

On-site or off-site analysis of these soils will be completed before the containers are shipped off-site. Shipping containers will be surveyed prior to transport and disposal at a disposal facility, such as U.S. Ecology, in Grand View, Idaho.

3.3 Packaging of Waste Materials

As discussed previously, if the FSS results of soil sample analyses indicate failure of the WRS test, or if elevated ^{232}Th concentrations exist in excess of the applicable $DCGL_{EMC}$ in Table 3-1, soil remediation (removal) will be required in the subject area. If necessary, excavated soil may be temporarily staged on and covered with plastic sheeting. The excavated soil will be placed into the appropriate transport/disposal containers and, if necessary, water-absorbing materials such as cellulose may be added to assure that no freestanding water is present within the container. The loading of the containers will be controlled to ensure that applicable U.S. Department of Transportation requirements are met.

Soil removed that is determined to be below the remediation criteria will be used as backfill material in the general area from which the soil was removed.

3.4 Shipment and Disposal of Waste Materials

Existing soil sample results and, as necessary, additional soil sample analysis will be used to determine waste disposition. Soil will be chemically characterized during the field effort, as needed, for profiling information to meet the designated disposal site waste acceptance criteria. Waste profiles previously accepted by a disposal site for past Site waste shipments may be re-activated, as possible, for the shipment of waste during this remedial effort.

Waste materials will be shipped from the Site to the disposal facility shortly after loading. All containers used during the remediation effort will be inspected for container integrity and the required marking and/or labeling. All containers will also be surveyed and weighed prior to shipment.

CABRERA will use a Naval Station Great Lakes approved broker to ship the low-level radioactive waste. CABRERA will provide for exclusive-use vehicles for the shipments. CABRERA will coordinate shipments directly with the approved processor or disposal facility and Naval Station Great Lakes personnel, prior to the containers leaving Naval Station property.

The broker will prepare necessary U.S. Department of Transportation and procedurally required forms (Radioactive Shipment Record, Bill of Lading, etc.). A second quality assurance check of the container marking and/or labeling shall be performed to ensure compliance. Full, marked and/or labeled containers shall be placed in a designated storage area until shipment.

3.5 Demobilization Activities

Equipment and materials used on the project within radiological control areas will be surveyed for release and decontaminated as necessary in accordance with CABRERA field operations procedure (OP) OP-004 "Unconditional Release of Materials from Radiological Control Areas".

Postings and barriers will be removed and materials and support equipment (office facility, equipment, etc.) will be removed from the site.

3.6 Personnel ALARA Considerations

Dose rates, and the total amount of radioactive materials at the site, indicate that direct external exposure to radiation will be minimal during work activities. Measurements of radiation exposure show maximum dose rates in the area are generally well below 40 microroentgen per hour (μR/h) at 1 meter above the ground surfaces. Personnel exposures are not anticipated to exceed 5 millirem total effective dose equivalent (TEDE) for the job duration.

The potential for internal exposure is slight due to the amount of radioactive material present, the type of material that is mixed with the radioactive materials, and the method utilized for removal of the soils. Continuous sampling, using low volume air samplers, along with breathing zone air samples obtained from the breathing zone for the worker closest to the sampling or remediation area, will be used for evaluation of potential internal exposure.

No environmental releases or exposures to unmonitored personnel are anticipated. Routine monitoring for environmental exposures will be performed using low volume air samples placed in areas of maximum potential exposure. Gamma scan surveys of the areas around the excavation will be performed daily during the remediation to ensure the spread of contamination is minimized. Equipment used for remediation will be surveyed and decontaminated as necessary to minimize the spread of contamination to areas surrounding the excavation.

3.7 Detailed Work Description

3.7.1 Removal of Contaminated Soils

Public Private Venture soil areas identified as failing the WRS test, or if elevated ^{232}Th concentrations exist in excess of the applicable $DCGL_{EMC}$ in Table 3-1, require remediation. Specific work areas inside the overall controlled area may be prepared in sections of 20 to 40 square meters at a time for ease of area set-up and control of the soil resulting from the removal actions. Larger areas may be needed to accommodate machinery when used.

Clearly delineated postings that indicate the locations of personnel entry and egress from the work area will be set up. Approved waste transport containers will be staged immediately adjacent to the work area or as close as practically achievable, as dictated by site-specific conditions, to ensure the distance soils must travel from the soil staging area to the container is minimized.

Soil removal may be performed in 0.5 to 1 foot depth increments to minimize the volume of waste requiring disposal. Hand tools may be used to assist in the removal of small amounts of material near foundations, fencing, storm drains, utilities, etc. where machinery may be inappropriate. Soils will be direct loaded into the shipping container. The remediation area will be initially surveyed with a Ludlum Model 44-10 gamma scintillator (2 inch x 2 inch NaI detector) and Ludlum Model 2221 ratemeter/scaler or equivalent. The gamma scan detection system will be configured to a GPS receiver to facilitate precise geo-spatial correlation of the

gamma data. If analytical capabilities are available on-site, soil samples will be obtained and analyzed for the radiological contaminant of concern. A comparison of the gamma scan and analytical results may be performed to establish a correlation factor to be used for further remediation control gamma scan surveys. If the gamma scan or analytical results exceed the DCGL or the $DCGL_{EMC}$, as appropriate, remediation will proceed by removing the next 0.5-foot layer of soil. This process will be repeated, as necessary, until the radioactivity in soil is below the DCGL or applicable $DCGL_{EMC}$.

Following completion of soil removal actions, equipment used during the effort will undergo release surveys in accordance with approved procedures. Equipment released for unrestricted use shall have documented survey results specifying the particular equipment and verifying that applicable release criteria have been met.

3.7.2 Final Status Survey

A FSS will be performed on all subject areas following the completion of remediation activities using the guidance provided in MARSSIM (NRC, 2000). This FSS will include 100 percent gross gamma scans and systematic soil sample collection and analysis to support unrestricted radiological release of the subject areas. Additional soil samples will be included at biased sample locations, concentrating on areas of greatest contamination potential (rough cracked surfaces, drainage pathways, fence lines, wind breaks, etc.), as well as areas in which the highest gross gamma count rates are observed. The volume of sampled soil will be well mixed and placed into appropriate sample containers. Any unused soil will be placed back to the location from which it was taken. FSS activities are discussed in greater detail in Section 4.0.

3.7.3 Laboratory Analysis

The soil samples may be analyzed using an on-site laboratory, if available, or shipped to an off-site laboratory for analysis. If an on-site laboratory is used, a minimum of 10 percent of the samples will be shipped to an off-site laboratory for analysis and comparison with on-site laboratory analysis results. The offsite laboratory used to analyze soil samples will be certified by the State in which it operates.

3.7.4 Backfill/Restoration

Following approval and authorization, the excavated area may be backfilled roughly to grade using imported or local clean soil, verified to meet Naval Station Great Lakes requirements. The backfill will be compacted using four passes of the backfilling equipment and the area surface will be hydro-seeded upon completion of backfilling.

4.0 RADIOLOGICAL FINAL STATUS SURVEYS

CABRERA will perform a FSS following completion of remediation of Public Private Venture areas. The FSS is designed to meet the guidance provided in MARSSIM (NRC, 2000). The methods and procedures to be used for the FSS are described in this section.

4.1 Detection Methods

The following radiation detection methods will be used during the radiological surveys of outdoor Public Private Venture areas:

- Gross gamma fluence (count rate) measurements
- Systematic soil sampling and analysis
- Biased soil sampling and analysis

Field survey methodology, techniques, and terminology are based on guidance contained in MARSSIM (NRC, 2000).

For soil sample data, non-parametric statistical methodologies (i.e., WRS test), described below, will be utilized to compare the post-remediation site conditions with the naturally occurring background thorium. If all sample results are less than the DCGL, use of the WRS test may not be necessary to prove that a survey unit passes FSS release criteria.

4.2 Representative Reference (Background) Area

CABRERA will use the reference area GWS results from previous FSS work to establish the background count rate for this remediation effort (CABRERA, 2004b). This reference area GWS resulted in an average of 10,211 counts per minute, with a standard deviation of 803 counts per minute. Background ^{232}Th soil activity will be determined from surface soil samples obtained from the reference area. These background sample results may be from the previous FSS work at the Site or additional surface soil samples may be obtained from the reference background area at random locations.

4.3 Survey Units

As previously indicated, the DCGL applicable to the Public Private Venture areas is 1.0 pCi/g ^{232}Th above background. To evaluate smaller elevated areas of ^{232}Th activity in soil, the area factors and $DCGL_{EMC}$ values in Table 3-1 will be used. The FSS approach for survey units in Public Private Venture areas 3A, 3B, 3C and 3F is described in the following paragraphs.

4.3.1 Public Private Venture Area 3A

Public Private Venture Area 3A contains two separate areas of contamination, designated 3A1 and 3A2.

Public Private Venture Area 3A1 consists of elevated radioactivity in soil on the east side of a 4-unit housing complex, in the vicinity of a carport, with an estimated area of 100 square meters. The maximum estimated remediation volume at this location is 92 cubic yards. One Class 1 survey unit will be established for the 100 square meter area. A single Class 2 survey unit will be established around the Class 1 area, extending 2 meters from the outer edge of the Class 1 survey unit.

Public Private Venture Area 3A2 consists of elevated radioactivity in soil on the north side of the same 4-unit housing complex, with an estimated area of 200 square meters. The maximum estimated remediation volume at this location is 183 cubic yards. One Class 1 survey unit will be established for the 200 square meter area. A single Class 2 survey unit will be established around the Class 1 area, extending 2 meters out from the outer edge of the Class 1 survey unit.

4.3.2 Public Private Venture Area 3B

Public Private Venture Area 3B consists of elevated radioactivity in soil in the vicinity of an existing recreation facility (ball field), with an estimated area of 1,500 square meters. The maximum estimated remediation volume at this location is 1,375 cubic yards. One Class 1 survey unit will be established for the 1,500 square meter area. A single Class 2 survey unit will be established around the Class 1 area, extending 2 meters from the outer edge of the Class 1 survey unit.

4.3.3 Public Private Venture Area 3C

Public Private Venture Area 3C contains two separate areas of contamination, designated 3C1 and 3C2.

Public Private Venture Area 3C1 consists of three locations of elevated soil radioactivity on the east and west sides of Great Lakes Drive between the pavement and sidewalk, in close proximity to each other. The maximum estimated remediation volume at this location is 92 cubic yards. Collectively, these three locations cover an estimated area of 100 square meters and will be treated as a single survey unit. One Class 1 survey unit will be established for the 100 square meter area. A single Class 2 survey unit will be established around the Class 1 area, extending 2 meters from the outer edge of the Class 1 survey unit.

Public Private Venture Area 3C2 consists of a second, smaller area of elevated radioactivity on the east side of Great Lakes Drive, with an estimated area of 25 square meters. The maximum estimated remediation volume at this location is 23 cubic yards. One Class 1 survey unit will be established for the 25 square meter area. A single Class 2 survey unit will be established around the Class 1 area, extending 2 meters out from the outer edge of the Class 1 survey unit.

4.3.4 Public Private Venture Area 3F

Public Private Venture Area 3F consists of elevated radioactivity in surface soil on the west side of Skokie Creek, south of Area 3B, approximately 200 square meters in size. The maximum estimated remediation volume at this location is 183 cubic yards. One Class 1 survey unit will

be established for the 200 square meter area. A single Class 2 survey unit will be established around the Class 1 area, extending 2 meters from the outer edge of the Class 1 survey unit.

4.4 Number of Sample Locations and Survey Coverage

4.4.1 Number of Sample Locations for Each Survey Unit

MARSSIM (NRC, 2000) provides a method to determine the number of data points required in a given survey unit. A minimum number of measurements are required in each survey unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. For the purpose of this survey, the minimum required number of measurements is based on expected radionuclide concentrations in site areas that may be suitable for release for unrestricted use. The following subsections describe the basis for, and derivation of, the minimum required measurement locations per survey unit. The number of required samples is determined using the DCGL of 1.0 pCi/g, as shown in the following sections. This DCGL will be applied to each of the Public Private Venture areas of concern.

(A) Estimation of Relative Shift

The minimum number of measurements required is dependent on the distribution of site residual radionuclide concentrations relative to the DCGL and acceptable decision error limits (α and β). The relative shift describes the relationship of site residual radionuclide concentrations to the DCGL and is calculated using the following equation, from Section 8.4.3 of MARSSIM (NRC, 2000).

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

Where: $DCGL_w$ = the derived concentration guideline level (DCGL), 1.0 pCi/g

LBGR = concentration at the lower bound of the gray region. The gray region represents a range of radioactivity concentration for the survey unit where the consequences of making a decision error are relatively minor.

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

(1) $DCGL_w$

The $DCGL_w$ used for this evaluation is 1.0 pCi/g for ^{232}Th.

(2) LBGR

The LBGR is set to 0.5 times the $DCGL_w$ and is used to calculate the number of required measurement locations (i.e., the $DCGL_w$ = 1.0 pCi/g, so the LBGR = 1.0 pCi/g x 0.5 = 0.5 pCi/g).

(3) Sigma (σ)

For the purposes of this survey, a standard deviation (sigma) of 0.3 pCi/g is assumed.

The values for relative shift for each area to be surveyed are calculated, based on the preceding. The Δ/σ value for the Public Private Venture areas is 1.7.

(B) Determination of N (Number of Required Measurement Locations)

The WRS statistical test will be used to determine whether portions of the site are suitable for release for unrestricted use, since the contaminants being measured are present in background. The minimum number of systematic measurement locations required in each survey unit for the WRS statistical test is determined using Equation 5-1 in MARSSIM (NRC, 2000). Using the acceptable α and β errors of 0.05 and the relative shift of 1.7, the minimum number of samples for each Public Private Venture survey unit is 15.

4.4.2 Required Scan Sensitivity for Class 1 Survey Unit

MARSSIM states that in Class 1 survey units, scanning sensitivity must be sufficient to detect small areas of elevated radioactivity (NRC, 2000). MARSSIM utilizes an area factor to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the DCGL while maintaining compliance with the release criterion. The following formula is provided in Section 5.5.2.4 of MARSSIM for determining the necessary scan sensitivity when incorporating the area factor:

$$\textit{Required Scan MDC (required)} = (DCGL_w) \times (\text{Area Factor})$$

If the actual scan MDC is greater than the required scan MDC, additional samples are required to ensure that the dose-based release criterion is satisfied.

For this investigation, the scan MDC has been determined to be 1.8 pCi/g for ^{232}Th from MARSSIM Table 6.7 (NRC, 2000). Application of the area factor for the MARSSIM maximum suggested Class 1 survey unit area of 2,000 square meters results in a minimum scan MDC not greater than 1.0 pCi/g for ^{232}Th compared to the MDC of 1.8. Using the minimum scan MDC and MARSSIM Equation 5-4 results in a maximum area factor of 1.8. From Table 3-1, this equates to a survey unit area of 100 square meters. Therefore, if the survey unit area is greater than 100 square meters, the number of samples in the Class 1 survey unit may need to be increased. For example, if the survey unit size is 2000 square meters, then the required number of samples is determined by dividing 2,000 by 100. In this example, the minimum number of samples is determined to be 20. Since this value is greater than the required number of samples

determined in Section 4.4.1 above, 5 additional systematic samples are required. This results in 20 total systematic soil samples in this survey unit.

4.4.3 Gamma Walkover Surveys and Biased Samples

Class 1 and Class 2 survey units will receive 100 percent GWS coverage. The 100 percent GWS will be performed on Class 2 survey units for the purposes of ensuring the identification of any small areas of elevated radioactivity; this equates to the performance of a Class 1 survey in this Class 2 survey unit.

If areas of elevated radioactivity are identified during the GWS, biased samples will be collected and analyzed. In addition, biased measurements may be obtained in areas of rough or cracked surfaces, drainage pathways, fence line, windbreaks, etc.

4.4.4 Area Factors and $DCGL_{EMC}$ Values

As discussed previously, 15 systematic soil samples will be obtained in each of the Public Private Venture areas of interest with survey units less than or equal to 100 square meters up to a maximum of 20 systematic samples for Class 1 survey units equal to 2,000 square meters. For survey units greater than 100 square meters and less than 2,000 square meters, the total number of systematic soil samples required is determined by dividing the survey unit size in square meters by 100 (refer to Section 4.4.2). However, the minimum number of systematic soil samples in all survey units, regardless of survey unit size, is 15. Soil samples will be obtained at 0 to 30 centimeters (0 to 12 inches) below ground surface (bgs) after the removal action has occurred.

The results of systematic soil samples will be used to perform the WRS test unless all systematic sample results are less than the DCGL which, in this case, does not require performance of the WRS test. If the systematic samples fail the WRS test, remediation will be performed, otherwise each individual systematic and biased soil sample will be evaluated as discussed in the following sections.

(A) Class 1 Survey Unit

Results of the Class 1 survey units for ^{232}Th exceeding the DCGL will be compared to the applicable $DCGL_{EMC}$ in Table 3-1 for evaluation of acceptability.

Each sample will be evaluated to determine if it exceeds the DCGL for ^{232}Th. If a sample result exceeds background by more than the DCGL, it will be compared to the applicable $DCGL_{EMC}$ in Table 3-1. Areas that exceed background by more than the $DCGL_{EMC}$ will be considered unacceptable and remediation required.

Provided the results of smaller elevated areas of radioactivity are resolved, it is still necessary to evaluate the average residual radioactivity in the survey unit for the purpose of evaluating residual results against risk. If residual radioactivity is found in an isolated area of elevated activity (in addition to residual radioactivity distributed across the survey unit), the unity rule can be used to ensure that the total dose is within the final status survey release criterion. This evaluation is performed using MARSSIM Equation 8-2 as follows:

$(d/DCGL_w) + ((\text{elevated area average concentration} - d)/(\text{Area Factor} \times DCGL_w)) < 1$

where:

d = average residual radioactivity in the survey unit

Note: The applicable $DCGL_{EMC}$ from Table 3-1 may be substituted for the denominator in the above equation (Area Factor x $DCGL_w$).

If there is more than one elevated area, a separate term (for d over the $DCGL_w$) should be included for each separate area.

(B) Class 2 Survey Unit

If a systematic or biased sample result exceeds background in the Class 2 survey unit by more than the DCGL, the survey unit will be reclassified and evaluated as a Class 1 survey unit.

5.0 REFERENCES

(CABRERA, 2004a) *Work Plan for the Remediation of the Recreation and Center Tank Areas and Site-Wide Final Status Survey, Naval Station Great Lakes, Great Lakes, IL*, November 2004.

(CABRERA, 2004b) Final Report: *Remediation and Final Status Survey Former Monazite Sand Storage Area Soil Pile and North Fence Areas Great Lakes Naval Training Station – Great Lakes, Illinois*, March 2004.

(CABRERA, 2006) Letter Report, *Results from Gamma Walkover Surveys of the Public-Private Venture Housing Area, Naval Station Great Lakes, Great Lakes, IL, Project Number USN 2000-03 Phase V*, October 2006.

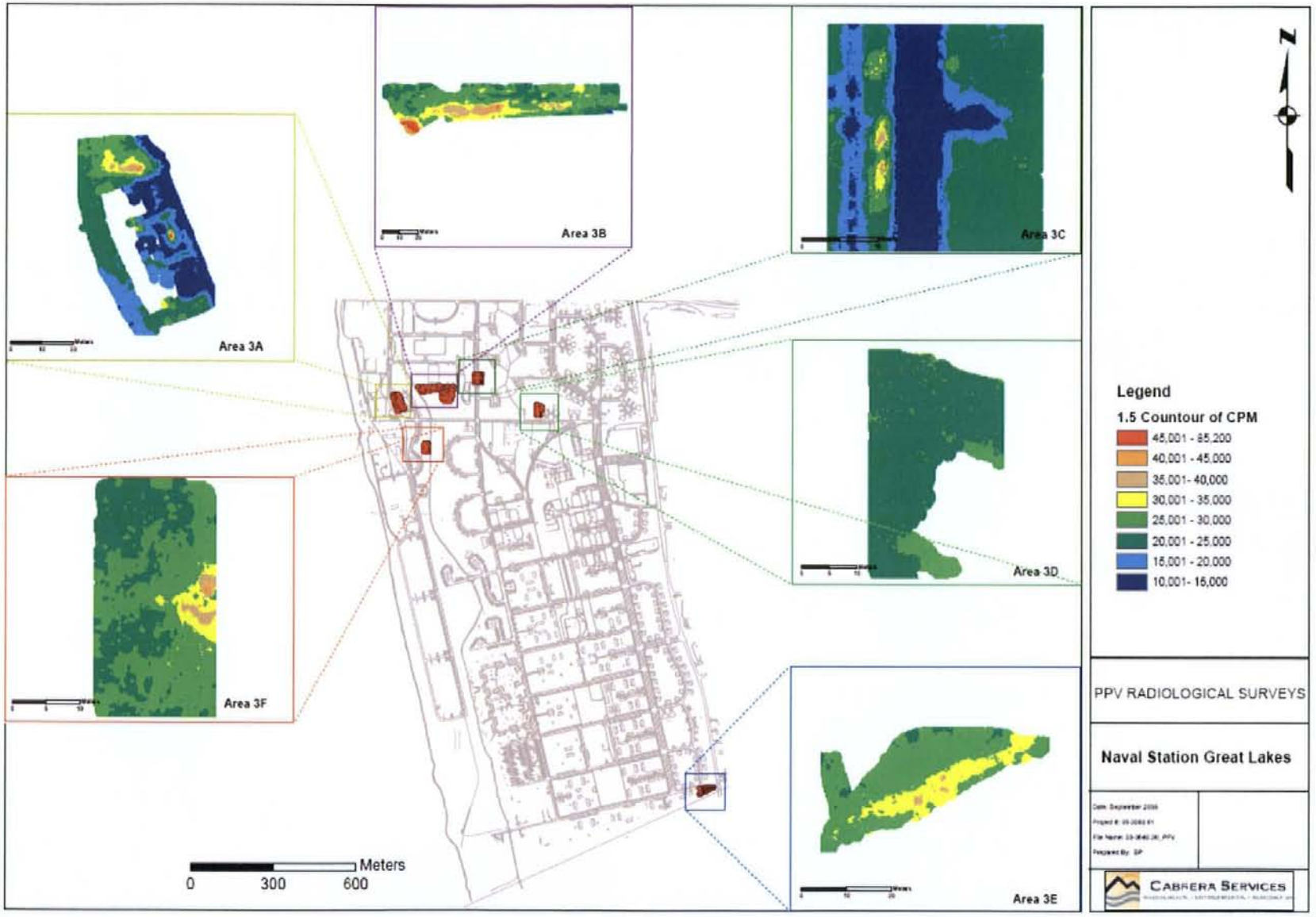
(CABRERA, 2007) *Final Coal Ash Determination Sampling Report, Naval Station Great Lakes, Great Lakes, Illinois*, March 2007.

(MACTEC, 2006) *Forrestal Village Phased-Approach Radiological Survey Report In Support of the Phase II Environmental Site Assessment, NAVSTA Great Lakes, Naval Region Midwest Family Housing Privatization*, February 2006

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

Figure 1

Public Private Venture Areas


Area 3A
Area 3B
Area 3C
Area 3D
Area 3E
Area 3F
Meters
0
300
600
N
Legend
1.5 Countour of CPM
45,001 - 85,200
40,001 - 45,000
35,001- 40,000
30,001 - 35,000
25,001 - 30,000
20,001 - 25,000
15,001 - 20,000
10,001- 15,000
PPV RADIOLOGICAL SURVEYS
Naval Station Great Lakes
CABRERA SERVICES