DEFENSE LOGISTICS AGENCY
DEFENSE NATIONAL STOCKPILE CENTER
8725 JOHN J. KINGMAN ROAD, SUITE 3229
FORT BELVOIR, VIRGINIA 22060-6223

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IN REPLY
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REGION 1

U.S. Nuclear Regulatory Commission
Region 1, Nuclear Materials Safety Branch
Division of Nuclear Materials Safety
ATTN: Ms Betsy Ullrich
475 Allendale Road
King of Prussia, PA 19406-1415

SUBJECT: **Transmittal of Final Status Survey Plan (FSSP) for the Curtis Bay Depot**

Dear Ms Ullrich:

The FSSP for the Defense National Stockpile Center depot at Curtis Bay, MD. is enclosed for your review and approval. Please note that the plan delineates the application of a gross activity Derived Concentration Guideline Level (DCGL) per survey unit based upon approval of the request for radionuclide-specific DCGL's described in our letters of February 3, 2006 and August 8, 2006 and the Decommissioning/Remediation Plan described in our letters of September 29, 2006 and January 25, 2007.

Should you have any questions regarding this letter, please contact me. You may also call Mr. Tim Vitkus, CHP, at (865) 576-5073. Mr. Vitkus is the Senior Project Leader at the Oak Ridge Institute for Science and Education (ORISE), our decommissioning survey consultant.

Sincerely,

Michael J. Pecullan

MICHAEL J. PECULLAN
Radiation Safety Officer

Attachment

138458

NMSS/RGN1 MATERIALS-002

ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

January 31, 2007

Mr. Mike Pecullan
Defense Logistics Agency
Defense National Stockpile Center
8725 John J. Kingman Road, Suite 3229
Ft. Belvoir, VA 22060

SUBJECT: RADIOLOGICAL FINAL STATUS SURVEY PLAN FOR THE CURTIS BAY DEPOT, CURTIS BAY, MARYLAND

Dear Mr. Pecullan:

The Oak Ridge Institute for Science and Education (ORISE) is providing the enclosed final status survey plan for the Defense Logistics Agency's Defense National Stockpile Center's Curtis Bay Depot in Curtis Bay, Maryland. Comments provided on the draft plan have been incorporated.

Please contact me at 865.576.5073 or Scott Kirk at 865.574.0685 should you have any questions.

Sincerely,

Timothy J. Vitkus
Senior Project Leader
Health Physics and Technical Projects

TJV

Enclosure

c: B. Hermes, ORNL
E. Abelquist, ORISE
S. Kirk, ORISE
File/0431

Distribution approval and concurrence:	Initials
Technical Management Team Member	[handwritten initials]

Voice: 865.576.5073 Fax: 865.241.3497 E-mail: tim.vitkus@orau.org

P. O. Box 117
Oak Ridge, TN 37831

PROPOSED
RADIOLOGICAL FINAL STATUS SURVEY PLAN
FOR THE
CURTIS BAY DEPOT
CURTIS BAY, MARYLAND

Prepared by

T. J. Vitkus

Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

Prepared for the

Defense National Stockpile Center
Defense Logistics Agency

JANUARY 2007

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1.0 INTRODUCTION

1.1 OBJECTIVES

The objective of this final status (FSS) survey plan is to provide the site-specific data quality objectives (DQOs) and procedures that will be used in the planning and performance of the FSS at the Curtis Bay Depot (CBD) located in Curtis Bay, Maryland. The implementation of this plan is intended to obtain the data necessary to demonstrate compliance with the site-specific derived concentration guideline levels (DCGLs) for both structural surfaces and outdoor areas (ORISE 2006a). The DCGLs were modeled such that any residual licensed material would not exceed the U.S. Nuclear Regulatory Commission's (NRC) basic dose limit for license termination of 25 mrem/y. Specifically, when the DCGLs are applied to the final status survey and the final survey results show that the DCGLs have been satisfied, the following requirements of 10 CFR 20.1402 are met:

> "**Title 10 CFR 20.1402:** *Radiological criteria for unrestricted use.* A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."

Inputs to the design of this plan were obtained through the performance of an historical site assessment (HSA), scoping surveys, and a detailed characterization survey (ORISE 2005a, 2006b and c). Furthermore, the survey plans implemented for the scoping and characterization surveys were designed following the process detailed in this plan in order to satisfy the FSS DQOs for data quantity and quality such that some or all of the data generated for those areas of the site with little potential for residual contamination may be used as FSS data (ORISE 2005b, c, and 2006d).

1.2 SITE HISTORY

The land area that is currently the CBD was originally a U.S. Army Depot built in 1918 on 798 acres of farmland. Additional acreage was acquired, increasing the site size to 815 acres. From 1918 to 1954 the site was used as an ordnance depot for receiving, shipping, and storage of ammunition.

In 1946, a National Stockpile program was established as an attempt to mitigate dependence on foreign sources of vital materials during times of national emergencies. In the late 1950s, the Defense National Stockpile Center (DNSC) became a tenant at the CBD and began storing strategic materials (bulk ores, minerals, and metals). Included in the materials stored at the CBD were chromite, ferromanganese, and ferrochrome. Additional stored materials were thorium nitrate (mantle and reactor grades, average 47 percent thorium nitrate (ThN) by weight) in fiber and steel drums, monazite sands, and sodium sulfate—radioactive materials that required a U.S. Atomic Energy Commission (AEC), predecessor to the NRC, source material license (License STC-133).

Since the establishment of the CBD, there have been a number of land transfers that reduced the footprint of the site as well as changes in government agency caretakers. Approximately 37 acres were transferred to the U.S. Army Reserve Command between 1958 and 1966. The remaining 778 acres were excessed to the General Services Administration (GSA) which had assumed accountability for the facility. In 1966, GSA sold CBD land that included the area of an old radioactive burial site to Anne Arundel County for development into an industrial park (Bay Meadows Industrial Park). In 1977, GSA notified NRC of its intention to excess empty warehouses on the site as part of a sale of U.S. Government land and buildings. In 1980, GSA sold approximately 87 acres to Anne Arundel County. This property had contained nine warehouses that were used to store thorium nitrate. The site was cleaned up and that portion released from the NRC license. The County eventually built a detention center and ball fields on the property. In 1988, National Defense Stockpile responsibility was transferred from the GSA to the Defense Logistics Agency (DLA).

The DNSC of the DLA is now in the process of closing out many of its depots across the country and seeking to remove those facilities from the NRC license. Although there have been a number of building and soil remedial actions at CBD over the past three decades, the NRC license was recently amended to conduct final site cleanup activities at CBD. All current site clean-up work at the CBD is sponsored by the DNSC Thorium Nitrate Stewardship and Disposition Program – Phase 4 – Decontamination & Decommissioning and is being supported under the Department of Energy (DOE)-Oak Ridge Operations Work for Others Program. The project is supported and coordinated by the Oak Ridge National Laboratory (ORNL), per DOE Proposal Number # 1872-M171-A1. Removal of ThN source material from the site, Phase 3 of the project, was completed in fiscal year 2005, which completed the initial phase of the current cleanup activities. In conjunction with site cleanup, at the request of ORNL, the Oak Ridge Institute for Science and Education (ORISE) performed a HSA of the Curtis Bay Depot in order to plan for future site investigations and eventual remediation activities (ORISE 2005a). Additionally, ORISE was tasked to conduct a scoping survey of the site to validate the results of the HSA and to provide information for the complete site characterization survey. Phase 1 of the scoping survey, which addressed most of the structures that could be safely surveyed and land areas, was completed in June 2005 (ORISE 2006b). The deconstruction of twenty-four (24) buildings at the site was completed by a U.S. Army Joint Munitions Command contractor, PIKA International, Inc., on October 14, 2005. ORISE performed a scoping survey of these deconstructed buildings as Phase 2 of the scoping survey during October 2005 (ORISE 2006b). The characterization survey was performed during the period of May 1 through 19, 2006 with additional characterization data gap sampling performed on July 25 and 26, 2006 (ORISE 2006c). These surveys were designed in an integrated, graded approach fashion following the radiological survey guidance and data quality objective (DQO) process provided in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2002).

1.3 SITE DESCRIPTION

The CBD site is located approximately one mile south of Baltimore, Maryland in an industrialized area of Anne Arundel County, Maryland. The property currently consists of approximately 483 acres bounded on the north by the Army Reserve Facility and Curtis Creek, on the east by Curtis Creek, on the south by Furnace Creek, and on the west by Back Creek and the Anne Arundel County Facility. A 1,955-foot long dock belonging to the U.S. Army Reserve lies along Curtis Creek; a security fence encloses the facility. Figure A-1 shows the site plot plan.

In general, the CBD terrain is mostly flat to gently hilly with large grassy, open areas, and some lightly wooded areas. A number of roads, mostly asphalt, traverse the site; there are approximately six miles of paved roads. Also noteworthy were the large stockpiles of various ores. Most of the stockpiled materials at CBD were raw ores with no history of radioactive material storage. Ores are primarily piled on concrete pads or directly on the ground. Some piles were covered to reduce erosion through weathering and oxidation. Much of the stockpiled material has been sold and transported off site. There are two miles of railroad tracks that cross the site, a stream, and two leach fields—one in use. There are two wetland areas on the southwest and south sides of the site. Two former burial areas—for medical supplies and radioactive waste—and ordnance areas were also identified on the south and western sector of the site.

The site contains various structures (buildings and warehouses)—some functional, others in a serious state of disrepair. A few buildings are surrounded by man-made berms of earth, that over the years since their construction have been vegetated with small trees and brush. A number of these buildings/warehouses have been used to store the ThN, generally in containers. There are five different building construction types ranging in size from 10 meters (m) by 30 m to as large as 73 m by 183 m. Building construction is either of a pitched roof with transite or asphalt shingles, concrete floor, and terra cotta block walls; or a flat roof, wooden or concrete floor, and transite or terra cotta block walls. A number of the buildings have been demolished and only the concrete pad remains. Two of the buildings were known to be significantly contaminated, some were identified during the scoping surveys as having small areas of suspect contamination, and others have no known history of radioactive materials use.

The two largest warehouses on the site are designated as Buildings 1021 and 1022 and measure 73 m by 183 m. Building 1021 has no history of radioactive material storage. Building 1022 is known to have formerly stored ThN and a "clean-up action" was noted in historical documentation. The remaining storage buildings, a number of which have stored radioactive materials, are designated according to groupings as A through I Line Buildings. Two additional building lines, J and K Lines, have been completely demolished. Lastly, Building 821 was a former change house and Building 825 housed machining and carpentry equipment, neither of which have had a history of radioactive material use. Table B-1 provides a summary of the building nomenclature designation, radioactive material use, and original scoping survey classification.

1.4 SUMMARY OF PRIOR SURVEY RESULTS

The contaminant of concern for the CBD is primarily thorium with the potential for significantly smaller quantities of uranium. All scoping and survey characterization survey results for the vast majority of the pads/buildings (45 of 50) and land areas (>99%) satisfied the proposed derived concentration guideline levels ($DCGL_W$s) of 2.9 pCi/g and 2.2 pCi/g for Th-232 and U-238, respectively, and supported either the initial survey classifications or provided sufficient data to revise the classification for final status surveys. The $DCGL_W$ is the average allowable residual activity level that may remain within the site. However, the scoping and characterization surveys confirmed contamination on surfaces of the following pads/buildings: B-911 (extensive), B-912 (extensive), B-913 (isolated), F-731 (isolated), F-737 (isolated), and G-723 (isolated). In addition to structural surface contamination, there is sub-floor soil contamination, due to migration of material through floor cracks, beneath Building B-911, and also contamination beneath the loading dock. Although not investigated, there is a potential for sub-floor soil contamination beneath Building B-912 should material have migrated through the expansion joints which are intact. A complete discussion of each contaminated pad/building is provided in the characterization report (ORISE 2006c). Low-level contamination was also determined to be present on the overhead trusses in Buildings B-911 and B-912. The activity levels identified on Class 1 Buildings F-731 and F-737 surfaces were low-level, ranging from 410 to 32,000 dpm/100 cm^2, and were localized. An area of contaminated soil was also identified beneath the F-737 pad. The contamination in Building B-913 was significant but localized to two small areas. The activity measured on the Class 3 structure, G-723, was limited to one location measuring 420 dpm/100 cm^2. Surveys did not identify any indications of residual activity on all the remaining pads/buildings or debris piles, with the exception of naturally occurring radioactive material.

Contaminated surface soils were determined to be present over a broad area on the F Line road and at the juncture of the F Line Road with Furnace Creek Road. Contaminated subsurface soil (beginning at approximately one meter below the ground surface) is present within the former radiological waste disposal area. Other isolated areas of contamination (AOCs) were identified next to roadways or associated with current or former buildings. The locations of each of these AOCs, together with the previously discussed contaminated pads/buildings, are shown on Figure A-2.

1.5 PLANNED DECONTAMINATION ACTIVITIES

A detailed decontamination/remediation plan has been prepared and submitted to NRC for review and approval (ORISE 2006e). The information provided in this plan was used to develop the scope of work requirements to be followed by the decontamination and remediation contractor. The requirements of the scope of work are to remove contamination from structures using proven remedial technologies and the excavation of contaminated soils to levels that are below the $DCGL_W$s (ORNL 2006a).

2.0 FINAL STATUS SURVEY QUALITY ASSURANCE

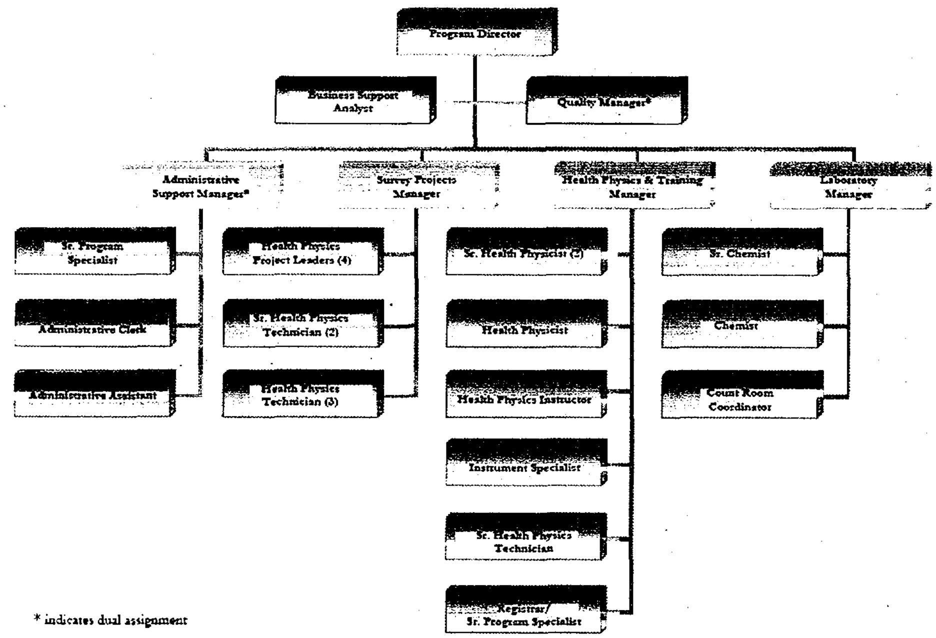
The FSS project responsibilities, training requirements, and quality assurance are described below.

2.1 ORGANIZATION AND RESPONSIBILITY

ORISE conducts radiological survey activities as one of its core competencies through the Independent Environmental Assessment and Verification Program (IEAV). Figure 2-1 represents the generic organizational structure of the IEAV survey staff.

Detailed responsibilities for various staff positions are documented in Position Questionnaires, which have been developed for all employees. Additional detailed information regarding various staff position responsibilities is included in the IEAV Quality Assurance Manual (ORISE 2005d).

Figure 2-1: IEAV Organizational Chart



Work described in this FSS plan will be performed under the overall direction of Eric Abelquist, Program Director. Tim Vitkus, Sr. Project Leader will be responsible for planning activities, staff direction for the implementation of this plan, and interpretation and reporting of the results. Scott Kirk, Survey Projects Manager of ORISE provides management of field staff and logistical support and direction. The cognizant ORISE site coordinator has the authority to make appropriate changes to the survey procedures as deemed necessary, after consultation with DNSC personnel. Site Coordinator is a generic title which applies to any individual designated as ORISE's representative and on-site supervisor. Any changes to the scope of this survey plan or procedures will be documented in the site logbook to include the technical basis for the change.

2.2 QUALITY ASSURANCE

The ORISE Survey Program 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 quality assurance and quality control procedures are documented in the IEAV Quality Assurance Manual (2005d).

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.

- Laboratory participation in the Mixed Analyte Performance Evaluation Program (MAPEP), NIST Radiochemistry Intercomparison Program (NRIP), and Intercomparison Testing Program (ITP) Laboratory Quality Assurance Programs.

- Training and certification of all individuals performing procedures.

- Periodic internal and external audits.

2.3 CERTIFICATION TRAINING

New employee indoctrination and orientation training is conducted to provide new survey staff with basic information about IEAV survey activities. This initial training is followed by survey and quality assurance procedure training. The training consists of studying all applicable manual procedures, oral instruction, hands-on training, written testing, and demonstration of proficiency. The veteran staff members participate in annual procedure refresher training and additional training when a procedure is revised or new procedure introduced.

In addition to survey and quality assurance procedure training, field personnel participate in training to satisfy regulatory requirements such Occupational Safety and Health Administration HAZWOPER and U.S. Department of Energy radiological worker, site-specific and generic safety, first aid and CPR, transportation, and other related requirements.

2.4 CONTROL OF MEASUREMENT EQUIPMENT

Radiological survey instruments are calibrated in accordance with IEAV Survey Procedures Manual requirements (ORISE 2006f). Procedures include electronic and NIST-traceable source calibration as well as daily operational check out requirements. Additional information on calibration and survey instrumentation is provided in Section 5.1.

2.5 HEALTH AND SAFETY

The project area has been evaluated for potential health and safety issues. Additionally, the proposed survey and sampling procedures are evaluated to ensure that any hazards inherent to the procedures themselves are addressed in current job hazard analyses (JHAs). The procedures entail minimal potential hazards that are addressed in current IEAV JHAs. Personnel will also adhere to health and safety requirements provided in the site-specific health and safety plan. FSS survey activities will be performed in accordance with the ORISE Radiation Protection Plan and radiation work permits as required. Additionally, the identification of potential buried military munitions and explosives of concern (MEC) has also been evaluated and appropriate precautions included in the site health and safety plan (ORISE 2006g). Site remediation activities may result in the creation of additional hazards that are not currently specified in the site-specific health and safety plan such as the excavations. Identification of previously unaddressed hazards that are not included in existing IEAV safety procedures will require development of task-specific JHAs prior to beginning work.

3.0 FINAL STATUS SURVEY REQUIREMENTS

There will be an FSS planned and conducted for each survey unit associated with the pads/buildings and outdoor soil areas. The FSS plans are prepared in accordance with the guidance presented in MARSSIM. The plans follow the DQOs process and ensure that all pads/buildings and land areas are surveyed with the necessary rigor that corresponds with a given pad/building or land area 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 decision errors

Step 7: Optimize the survey design

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

3.1 DERIVED CONCENTRATION GUIDELINE LEVELS

Th-232 and its associated decay products and U-238 and its associated decay products have been identified through process knowledge and characterization survey results as the contaminants of concern. Proposed site-specific $DCGL_W$s for both Th-232 and U-238 on building surfaces and within soils have been developed using the RESRAD and RESRAD-BUILD computer codes and provided to the NRC for review and approval (ORISE 2006a). These $DCGL_W$s have accounted for all important decay products found in secular equilibrium, including, the slight natural contribution from U-235 and its decay products. The proposed above background $DCGL_W$s for structural surfaces are 400 dpm/100 cm^2 for Th-232 and its decay products and 800 dpm/100 cm^2 for U-238 and decay products. The pad/building FSS planning and data quality assessment will use only the proposed site-specific surface activity $DCGL_W$ for Th-232. Use of only the more restrictive Th-232 surface activity $DCGL_W$, rather than modifying the $DCGL_W$ to also account for any small percentage of natural uranium activity that may be present, will allow for simplification of the survey process yet provide an overall more conservative approach for determining future remediation requirements. For soil area FSS planning, confirmation that U-238 is present in insignificant concentrations, relative to the Th-232, was achieved by evaluating the Th-232 to U-238 ratios in scoping and characterization survey soil samples. Only those samples containing greater than 5 pCi/g of Th-232 were selected in determining the average net ratio which was approximately 14 to 1. Soil survey unit planning and data quality assessment will be compared with the proposed above background $DCGL_W$s of 2.9 pCi/g for Th-232 and 2.2 pCi/g for U-238. In addition, FSS planning and data quality assessment (DQA) for soils will include an appropriate application of the unity rule in accordance with the equation:

$$\frac{Conc._{Th-232}}{DCGL_{Th-232}} + \frac{Conc._{U-238}}{DCGL_{U-238}} < 1$$

Lastly, the potential for the concentration of Th-230 from the raw materials into the ThN product was evaluated with no impact on the Th-232 or U-238 DCGLs.

3.2 CLASSIFICATION OF AREAS BY CONTAMINATION POTENTIAL

The CBD site has 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 as follows:

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 expected $DCGL_W$.

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 expected $DCGL_W$.

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

Furthermore, pads/buildings and land areas have been or will be further subdivided into survey units, which will provide the fundamental unit for demonstrating compliance with the DCGLs. Survey unit size restrictions will generally follow the recommended size limitations provided in MARSSIM, although some Class 2 survey units will exceed the size limits. This is further discussed below in Section 3.3. With the exception of Class 1 buildings, the investigations of upper walls and overhead structures for all Class 2 and 3 buildings were determined to be non-impacted.

3.3 IDENTIFICATION OF SURVEY UNITS

All impacted pads/buildings and land areas have been or will be subdivided into Class 1, 2, or 3 survey units. Each survey unit represents a portion of the site with similar contamination potential. Table 3-1 provides the MARSSIM-recommended survey unit areas.

Table 3-1: 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

3.3.1 Land Area Survey Unit Identification

Land area survey units for FSS have been identified and are illustrated on Figure A-3. There were five Class 3 land area survey units identified, 75 Class 2 land area survey units, and 17 Class 1 land area survey units. The characterization survey for the Class 3 areas was conducted such that the DQOs developed and procedures implemented would meet FSS requirements. The DQOs implemented are provided in Sections 3.6 and 4.0. The Class 2 land areas survey units have been consolidated into 11 planning areas. The characterization data collected from within these areas are to be used for the DQO inputs for each survey unit within a specific Class 2 planning area. In general, survey unit sizes will follow the MARSSIM guidance, with the exception of the Class 2 land areas. A posting plot of the characterization data was prepared and the data carefully evaluated relative to the proposed DCGLs. This evaluation determined that most of the Class 2 land could have been down-graded in classification to Class 3. However, the planning process resulted in the decision to maintain the Class 2 designation, but to allow for larger survey unit sizes that are based on the land area that encompasses the footprint of each pad/building or former building footprint.

This results in Class 2 survey units up to 20,000 m^2 in area. Table B-2 provides land area survey unit designations, classifications, and areas.

3.3.2 Pad/Building Survey Unit Identification

The original pad/building classifications are presented in Table B-1. Pad/building survey units for FSS have also been identified and are listed in Table B-3. Pads/buildings originally classified as Class 2 or 3 where contamination was identified during the scoping survey were reclassified, or a portion thereof, as Class 1. For the FSS phase, there are six pads/buildings that will have at least one associated Class 1 survey unit. Of the remaining 44 pads/buildings, 11 were surveyed during scoping/characterization as Class 2 and 33 as Class 3. The scoping surveys were designed and conducted in such a manner that the results for Class 2 and 3 pads/buildings would meet FSS requirements. The DQOs implemented are provided in Sections 3.6 and 4.0. The characterization and remedial action support data collected from within pad/building areas with Class 1 areas requiring remediation will be used for the DQO inputs to design the FSS.

3.4 BACKGROUND REFERENCE AREA AND MATERIALS

Background reference areas have been selected and sampled/measured for comparing site soil sample data to and in evaluation of the 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 as the site and has not been impacted by site operations. Structural survey units will be evaluated using the non-parametric Sign Test. Construction material-specific backgrounds were determined during scoping surveys in areas of similar construction but without a history of radioactive material use. These construction material-specific measurements will be used to correct direct measurement for background contributions, prior to converting data to the DCGL compliance unit of dpm/100 cm^2.

3.5 REFERENCE SYSTEM

FSS measurement and sampling locations will be referenced as follows. Direct measurements on structural surfaces will be referenced to prominent building features or the 5 meter × 5 meter reference grid established during scoping/characterization surveys. Soil sampling locations will be referenced to global positioning system (GPS) coordinates obtained using hand-held GPS units.

3.6 SURVEY DESIGN

Structural surfaces will be assessed by collecting the required number of gross beta surface activity measurements within each survey unit. The basis for assessing Th-232 surface activity levels via gross beta measurements is provided in Section 5.1.3. The Sign test will be applied as the non-parametric statistical test for demonstrating compliance with the $DCGL_W$. Land area compliance with the $DCGL_W$s is demonstrated through the application of the WRS test to soil sample results collected from each survey unit. Both Th-232 and U-238 activity concentrations are measured by gamma spectroscopy. These two statistical tests are performed to evaluate the survey unit mean concentration relative to the null hypothesis (H_0). Simply stated, H_0 is that the residual contamination in the survey unit exceeds the release criterion. Provided that the statistical test is satisfied at the desired confidence level, then H_0 is rejected and the alternate hypothesis (H_a), that residual contamination meets the release criterion, is accepted. The data needs for the statistical tests will be determined in accordance with the following processes.

3.6.1 Calculation of Required Number of Measurements

The relative shift (Δ/σ) is calculated for each survey unit where:

$$\Delta = DCGL - LBGR$$

DCGL = the gross or radionuclide specific guideline

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

σ = variability in concentration where:

1) The larger variability between the survey unit, σ_s, and the background reference area, σ_r, is selected for the WRS test and;

2) The survey unit and construction material-specific background count rate errors are propagated for the Sign test.

The DQOs are evaluated for each survey unit or survey area and the decision errors selected. The Type 1 decision error—the probability of incorrectly rejecting H_0 when it is true—will be 0.05 and the Type II errors—the probability of incorrectly accepting H_0 when it is false— are expected to be 0.05 or 0.10. Once the above parameters are established, the number of data points required by the statistical test will be obtained either from Tables 5.3 (WRS test) or 5.5 (Sign test) in MARSSIM or otherwise generated using either COMPASS or Visual Sampling Plan software. Tables B-4 through B-14 provide the estimated mean and standard deviation for each Class 2 land survey unit planning area. These results were determined from characterization survey data. Table B-15 provides the Class 3 land area prospective planning parameters that were generated. The prospective inputs were generated from scoping survey results and the retroospective parameters from the characterization survey, which was planned such that the data generated would satisfy the FSS DQOs. Collection of remedial action support data will be required for determining the data needs for Class 1 land areas. Tables B-16 and B-17 provide the background reference area data and sub-surface borehole background data.

For pad/building structural survey units, the mean activity and variability was estimated for Class 2 and 3 structures prior to the implementation of the scoping survey. These estimates were used to determine the number of direct measurements required to satisfy FSS requirements. Collection of remedial action support data, in conjunction with already acquired scoping/characterization survey data, will be required for determining the data needs for Class 1 structural survey units.

3.6.2 Determining Measurement/Sampling Locations

Measurement/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 determinations 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:

$$L = [(\text{Survey Unit Area})/(0.866 \times \text{number of data points})]^{1/2}$$

The spacing between rows is calculated as: $0.866 \times L$

For land areas, a unique GPS coordinate location will be generated for each sample location.

4.0 INTEGRATED SURVEY STRATEGY

FSS data collected for structural surfaces consist of gamma and alpha plus beta or beta scans to identify locations of residual contamination and direct measurements of beta surface activity. Smear samples, although not used in the final data quality assessment, will be collected from judgmental locations to measure removable alpha and beta surface activity. Final status surveys of open land areas will consist of gamma scans to identify locations of residual contamination and samples of soil, analyzed for potential contaminants. Additional judgmental measurements and samples will be obtained, as necessary, from locations where scans indicate potential residual contamination. Tables B-2 and B-3 provide survey unit information for land areas and pads/buildings, respectively.

4.1 SURFACE SCANS

Surface scans have been or will be performed using NaI scintillation detectors for direct gamma radiation over land areas and structures and also gas proportional detectors for direct alpha plus beta or beta radiation for structures. Detectors are coupled to ratemeters or ratemeter-scalers with audible indicators. Characterization gamma surface scan data of land areas that will not require remediation were also intended as FSS data. These data were collected using a GPS system that enabled real time gamma count rate and position data capture under a subcontract with the Environmental Restoration Group, Inc. Table 4-1 shows the recommended surface scan coverage discussed in MARSSIM.

Table 4-1: MARSSIM-Recommended FSS Survey 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

4.1.1 Class 1 Land Area Survey Units

All Class 1 land survey areas were 100% scanned during characterization. These areas will be subdivided into survey units and scanned 100% following the completion of the remediation and satisfactory remedial action support surveys. Overburden soil removed from the former radiological waste disposal area will be consolidated into survey units independent of the underlying land areas and scanned 100%.

4.1.2 Class 2 and 3 Land Area Survey Units

Class 2 land areas received medium to high density gamma surface scans during the characterization survey. Class 2 scan coverage density began as 100% coverage near roadways, railroads, and around pads/buildings and then was gradually decreased in outlying areas. The overall gamma radiation scan coverage was 50 to 75% of the Class 2 land areas. Class 3 land area survey units received low to medium density gamma scans during characterization. Gamma radiation scans were performed over 30 to 50% of the Class 3 land areas with areas near roads, railroads, and structures receiving the highest coverage. These data were collected and presented in the characterization survey report and will also satisfy the FSS requirements (ORISE 2006c). Additional FSS gamma surface scans will be performed in those Class 2 or 3 survey units that are contiguous with remediated Class 1 survey units.

4.1.3 Class 1 Pad/Building Survey Units

All Class 1 pad/building surfaces were 100% scanned during characterization. These areas will be subdivided into survey units and scanned 100% for alpha plus beta or beta radiation following the completion of the remediation and satisfactory remedial action support surveys.

4.1.4 Class 2 and 3 Pad/Building Survey Units

Pads/building floors and lower walls were scanned for alpha plus beta, or beta, and gamma radiation during either the Phase 1 or 2 scoping surveys. These scans were conducted such that FSS scanning requirements were satisfied in all cases.

Up to 50% of the accessible Phase 1, Class 2 scoping survey structure surfaces were scanned and in the case of Building B-913, 100% of the floor was scanned. Professional judgment was combined with a systematic approach during the Phase 1 surveys to select scan areas dependent upon visual inspections, historical records of spills or cleanups, and findings as the survey progressed. In buildings, upper walls and overhead structures were also scanned with emphasis on horizontal surfaces where residual contamination may have settled and accumulated when access could be achieved and if elevated radiation was identified on the floor.

Class 2 survey units within Buildings B-912, B-913, and F-731 will be re-scanned over 10 to 50% of the surfaces following remediation of the Class 1 contaminated areas.

Phase 2 scan surveys of the Class 2 deconstructed buildings with concrete floors (F Line) involved scanning up to 100% of the building floor section made accessible by the deconstruction contractor. The amount of the total floor area available for each of these deconstructed buildings ranged from 30 to 60%. The wooden floors were required to be removed and staged in debris piles for all but one (H-711) of the H Line buildings. Scans were conducted on approximately 75% of the accessible floor area of building H-711 and on 10 to 20% of the individual floor planks for the remaining H Line buildings. The floor of building H-715 had degraded to such an extent that it could not be removed intact and in fact had collapsed into the crawl space of the building. Therefore, the number of planks available for scan surveys was minimal. Deconstructed wall debris from the F and

H Line buildings were also staged in piles and scanning covered 10 to 50% of the accessible wall debris surfaces.

Up to 25% of the accessible Phase 1, Class 3 surfaces were scanned. Pads/floors and lower walls were judgmentally scanned for alpha plus beta, or beta, and gamma radiation.

Phase 2 scoping survey surface scans of the Class 3 deconstructed buildings with concrete floors (D, E, F and G Lines) involved scanning up to 100% of the building floor section made accessible by the deconstruction contractor. The amount of floor area available for each of these deconstructed buildings ranged from 15 to 40%. The wooden floors were removed and staged in debris piles for I Line buildings and the deconstructed walls also staged in separate debris piles for all deconstructed buildings. Scans were conducted on approximately 10 to 20% of the individual floor planks for the I Line buildings and 10 to 20% of the accessible surfaces in each of the deconstructed wall debris piles.

4.2 SOIL SAMPLING AND SURFACE ACTIVITY MEASUREMENTS

FSS surface soil samples (0 to 0.15 m) have been or will be collected from pre-determined random-start/systematic or random locations as applicable. Additionally, judgmental samples have been or will be collected from locations where elevated direct gamma radiation is detected by surface scans. Soil samples are maintained under formal chain-of-custody procedures then analyzed in the IEAV laboratory by gamma spectroscopy and results reported in units of pCi/g. The health and safety plan discusses the procedure for collecting samples within MEC areas (ORISE 2006g).

FSS direct measurements to quantify total beta activity levels have been or will be performed at pre-determined random start/systematic or random locations as applicable. Additional judgmental measurements have been or will be made within any areas of residual contamination identified by surface scans and at contiguous locations to delineate contamination boundaries. Measurements will be made using gas proportional detectors coupled to ratemeter-scalers. Surface activity data will be converted to units of dpm/100 cm^2.

4.2.1 Class 1 Land Area Survey Units

The number of and specific locations for FSS soil samples in Class 1 land area survey units will be determined in accordance with Sections 3.6.1 and 3.6.2. The specific DQO inputs will be derived from the remedial action support survey sample results. It is anticipated that a minimum of five soil samples will be collected from within each survey unit during remediation from which the mean concentration and variability will be determined. The 18 Class 1 survey units are shown on Figure A-3. Currently, the floor of Building B-911 is being considered as a structural survey unit. However, remediation may result in the removal of the entire floor and the sub-floor soil ultimately being addressed for FSS as a land area survey unit. Table B-18 provides the planning DQOs for soil overburden from the former radiological waste disposal area.

4.2.2 Class 2 Land Area Survey Units

The number of FSS soil samples required for each Class 2 survey unit is provided in Tables B-4 through B-14. As previously discussed, the characterization survey sample results were used for generating the DQO inputs for those survey units that lay within each of the 11 respective planning areas. The number of samples required and location is generated in accordance with Sections 3.6.1 and 3.6.2. Planning areas and survey units are shown on Figure A-3.

4.2.3 Class 3 Land Area Survey Units

FSS soil sampling of the five Class 3 survey units was completed during the characterization survey. The planning inputs were developed from scoping survey soil samples results and are shown in Table B-15. The sampling locations were determined by randomly generating GPS coordinates within each survey unit. Survey units are shown on Figure A-3.

4.2.4 Class 1 Pad/Building Survey Units

Class 1 structural survey units are associated with Buildings B-911, B-912, B-913, F-731, F-737, and G-723. The DQO inputs will be derived from the remedial action support survey measurement results.

4.2.5 Class 2 Pad/Building Survey Units

FSS direct measurements of most Class 2 structural survey units were completed during the scoping survey phase. The DQO mean concentration and variability inputs for determining the number of direct measurements to satisfy FSS requirements were prospectively estimated. The actual data results were retrospectively reviewed to determine the adequacy of the estimated surface activity concentration. This planning followed the procedure described in Sections 3.6.1 and 3.6.2. The planning and retrospective values are provided in Tables B-19 and B-21. The results of the Sign test for these survey units will be provided in the FSS report.

The exception to the above is for those Class 2 survey units that are within the Class 1 structures that will be remediated. For these survey units, characterization data will be used to determine the required measurements.

4.2.6 Class 3 Pad/Building Survey Units

FSS direct measurements for all Class 3 structural survey units were completed during the scoping survey phase. The DQO mean concentration and variability inputs for determining the number of direct measurements to satisfy FSS requirements were prospectively estimated. The actual data results were retrospectively reviewed to determine the adequacy of the estimated surface activity concentration. This planning followed the procedure described in Sections 3.6.1 and 3.6.2. The planning and retrospective values are provided in Tables B-20 and B-22. The Sign test results for these survey units will be provided in the FSS report.

5.0 INSTRUMENTATION AND CALIBRATION

Calibration of all field and laboratory instrumentation will be based on standards/sources, traceable to NIST. Specific field and laboratory instrumentation parameters are discussed below.

5.1 FIELD INSTRUMENTATION

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

5.1.2 Scanning Instrument/Detector Combinations

Alpha plus Beta

Ludlum Floor Monitor Model 239-1 combined with Ludlum Ratemeter-Scaler Model 2221 coupled to Ludlum Gas Proportional Detector Model 43-37, Physical Area: 550 cm^2 (Ludlum Measurements, Inc., Sweetwater, TX), Minimum Detectable Concentration (MDC) = 300 dpm/100 cm^2 Th-232, based on a scanning total efficiency for the Th-232 decay series of approximately 1.50.

Beta

Ludlum Ratemeter-Scaler Model 2221 coupled to Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2 equipped with a 3.8 mg/cm^2 Mylar window (Ludlum Measurements, Inc., Sweetwater, TX) MDC = 800 dpm/100 cm^2 Th-232, based on a scanning total efficiency for the beta-only component of the Th-232 decay series of approximately 0.40.

The actual scanning MDC for the instrumentation will be compared with required scanning MDC determined at the time of the Class 1 final status survey DQO development. Sample spacing will be adjusted if necessary to ensure that the actual scan MDC is less than the required scan MDC for each Class 1 survey unit. A review of the area factors presented in Table B-24 demonstrates that a sample spacing of less than 100 m^2 will ensure that the required scan MDC is satisfied.

Gamma

Ludlum Pulse Ratemeter Model 12 (Ludlum Measurements, Inc., Sweetwater, TX) coupled to Victoreen sodium iodide (NaI) Scintillation Detector Model 489-55, Crystal: 3.2 cm x 3.8 cm (Victoreen, Cleveland, OH). MDC = 2.8 pCi/g Th-232 (assumes secular equilibrium with progeny in the decay series) and MDC = 4.5 pCi/g for U-238 (assumes secular equilibrium with the decay series).

Based on characterization data demonstrating that U-238 concentrations from licensed material contamination exists as a mixture with Th-232 in virtually every case, a combined scan MDC for the mixture may be calculated from the observed fractional amounts. The observed Th-232:U-238 ratio ranged from approximately 10:1 to 20:1. The calculated scan MDC for the 10:1 activity ratio is calculated to be 2.9 pCi/g total activity and can be compared with the similarly calculated total activity DCGL of 2.81 pCi/g for the CBD. The actual scanning MDC for the instrumentation will be compared with required scanning MDC for Class 1 survey units in the same manner as described above for structure surface scans. Sample spacing will be adjusted if necessary to ensure that the actual scan MDC is less than the required scan MDC for each Class 1 survey unit.

5.1.3 Direct Measurement Instrument/Detector Combinations

Beta

Ludlum Ratemeter-Scaler Model 2221 coupled to Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2 (Ludlum Measurements, Inc., Sweetwater, TX). MDC = 200 dpm/100 cm^2 Th-232, based on the beta-only efficiency of approximately 0.42.

Use of only the more restrictive Th-232 surface activity $DCGL_W$, rather than modifying the $DCGL_W$ to also account for any small percentage of natural uranium activity that may be present, will allow for simplification of the survey process yet provide an overall more conservative approach for assessing surface activity levels. Therefore, the calibration of detectors used for assessing surface activity will be calibrated only for the Th-232 decay series. The calibration procedure will be in accordance with ISO-7503[1] recommendations. Total beta efficiencies (ε_{total}) will be determined for each instrument/detector combination and consist of the product of the 2π instrument efficiency (ε_i) and surface efficiency (ε_s): $\varepsilon_{total} = \varepsilon_i \times \varepsilon_s$. Beta total efficiencies will be determined based on a beta energy multi-point calibration, development of instrument efficiency to beta energy calibration curves, and the calculation of the weighted efficiency representing the Th-232 decay series. Included in the weighted efficiency will be an empirically determined correction for disequilibrium in the decay series that results from Rn-220 loss. A 3.8 mg/cm^2 density thickness Mylar window will be used on the beta detectors to block detector response contributions from alpha radiation.

[1] International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.

ISO-7503 recommends an ε_s of 0.25 for beta emitters with a maximum energy of less than 0.4 MeV and an ε_s of 0.5 for maximum beta energies greater than 0.4 MeV. Figure A-4 illustrates an example multi-point calibration efficiency determination.

Direct measurement results will be reported in units of dpm/100 cm^2.

5.2 Laboratory Instrumentation

FSS samples will be analyzed in accordance with the ORISE Laboratory Procedures Manual (ORISE 2006h). Smear samples will be analyzed using a low-background proportional counter and results reported in units of dpm/100 cm^2. Soil samples will be analyzed by gamma spectroscopy and results reported in units of picocuries per gram (pCi/g).

5.2.1 Gross Alpha/Beta (Removable Activity)

Smear samples will be analyzed using the following equipment:

Low Background Gas Proportional Counter Model LB-5100-W (Tennelec/Canberra, Meriden, CT). MDCs = 9 dpm/100 cm^2 for alpha and 15 dpm/100 cm^2 for beta with a two-minute count time.

5.2.2 Gamma Spectroscopy

Soil samples will be analyzed by gamma spectroscopy using the following equipment:

High Purity Extended Range Intrinsic Detector CANBERRA/Tennelec Model No: ERVDS30-25195 (Canberra, Meriden, CT) used in conjunction with Lead Shield Model G-11 (Nuclear Lead, Oak Ridge, TN) and Multichannel Analyzer DEC ALPHA Workstation (Canberra, Meriden, CT).

High Purity Extended Range Intrinsic Detector Model No. GMX-45200-5 (AMETEK/ORTEC, Oak Ridge, TN) used in conjunction with Lead Shield Model SPG-16-K8 (Nuclear Data) Multichannel Analyzer DEC ALPHA Workstation (Canberra, Meriden, CT).

High-Purity Germanium Detector Model GMX-30-P4, 30% Eff. (AMETEK/ORTEC, Oak Ridge, TN) used in conjunction with Lead Shield Model G-16 (Gamma Products, Palos Hills, IL) and Multichannel Analyzer DEC ALPHA Workstation (Canberra, Meriden, CT).

Gamma Spectroscopy MDC = 0.11 pCi/g for Th-232 (based on the 0.911 MeV photopeak from Ac-228) and 0.70 pCi/g for U-238 (based on the 0.063 MeV photopeak from Th-234) based on a 60-minute count time.

6.0 DATA REVIEW AND INVESTIGATION THRESHOLDS

Data will be reviewed to assure that the type, quantity, and quality are consistent with the survey plan and design assumptions. Data standard deviations will be compared with the assumptions made in establishing the number of data points. Individual and average data values will be compared with guideline values and proper survey area classifications will be confirmed. Individual measurements in excess of the guideline level for Class 1 and 2 areas have been or will be investigated. For Class 3 survey units, although less conservative than the recommendation provided in MARSSIM, measurements in excess of 75 percent of the guideline for Class 3 areas have or will prompt investigation. The requirement for increasing the investigation threshold is due to the low DCGLs relative to background. Should a survey unit require investigation, reclassification, remediation, and/or resurvey, a determination of the cause will be initiated and the data conversion and assessment process repeated for new data sets. Additional information regarding the evaluation of measurement results in excess of the DCGLs is provided in Section 7.3.

7.0 DETERMINING COMPLIANCE WITH DCGLs

As discussed in Section 3.1 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 below.

7.1 LAND AREA SURVEY UNITS

Land area survey units will be evaluated using the Wilcoxon Rank Sum test. Survey unit and background reference area soil sample results collected from the random or random-start/systematic locations will be converted to unity in accordance with the equation in Section 3.1. 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:

- 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.
- If several measurements have the same value, assign them the average ranking of the group of tied measurements.
- Sum the ranks of the adjusted reference area measurements; this value is the test statistic, W_R.
- 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, the survey unit will always pass a complete application of the WRS test. No further evaluation is necessary as the survey unit will always pass the WRS test and the null hypothesis rejected. Otherwise, W_R must be calculated. If W_R is greater than the critical value, H_0 is rejected, and the survey unit meets the established criteria. If W_R is less than or equal to the critical value, H_0 is not rejected, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or resurvey should be performed as appropriate.

7.2 PAD/BUILDING SURVEY UNITS

Structural survey units will be evaluated using the Sign test. Individual activity values and the average activity value will be calculated.

If all values from the random or random-start/systematic locations for a survey unit are less than the guideline level, 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 resurvey is required.

If the average activity value is less than the guideline level, but some individual values are greater than the guideline, data evaluation by the Sign test proceeds, as follows:

- List each of the survey unit measurements.
- Subtract each measurement from the guideline level.
- Discard all differences which are "0"; determine a revised sample size.
- Count the number of positive differences; this value is the test statistic, S+.
- 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, H_0 is rejected, and the survey unit meets the established criteria. If S+ is less than or equal to the critical value, H_0 is not rejected, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or resurvey should be performed, as appropriate.

7.3 Elevated Measurement Comparison

Soil samples or direct measurement results that exceed the $DCGL_W$ must also be evaluated for compliance with a $DCGL_{EMC}$. The remediation scope of work requires that contamination be reduced to levels that are below the $DCGL_W$ and remedial action support surveys will be performed as assurance that this requirement is met (ORNL 2006). However because contamination is present prior to remediation in a Class 1 survey unit, the potential also exists that isolated locations of residual soil concentrations or surface activity may be identified during the FSS that exceed the $DCGL_W$. The statistical tests for demonstrating compliance are such that some samples/measurements may exceed the $DCGL_W$, yet still reject the null hypothesis. Therefore, both the statistically-based and judgmental 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 $DCGL_W \times$ Area Factor. The concentration threshold for soil samples from Class 1 survey units that would require an EMC comparison will be defined as either the Th-232 or U-238 $DCGL_W$ plus the sum of the respective mean background concentration and two standard deviations. For Class 1 surfaces, the corresponding threshold would be the surface activity $DCGL_W$, in terms of counts per minute, plus the sum of the mean construction material-specific background count rate and two standard deviations. Tables B-23 and B-24 provide area factors for both soil concentrations and surface activity. Area factors were developed using the identical inputs used in generating the site-specific $DCGL_W$s with only the size of the area of contamination changed and for soil, the length parallel to the aquifer flow. When individual samples/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 equation 8-2 in MARSSIM. Any measurement that exceeds the $DCGL_W$ within a Class 2 or 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 that will be submitted to the NRC for review. The contents of the report will provide all applicable data and documentation necessary to support the request for removal of the Curtis Bay Depot from the DNSC's NRC license

9.0 TENTATIVE SCHEDULE

The FSS schedule will be dependent upon the progress and schedule of the remediation contractor. The current anticipated schedule is as follows:

Measurement and Sampling	April through July 2007
Sample Analysis	April through August 2007
Draft Report	Within six weeks of completing the sample analyses

APPENDIX A:

FIGURES

431-001b (2)

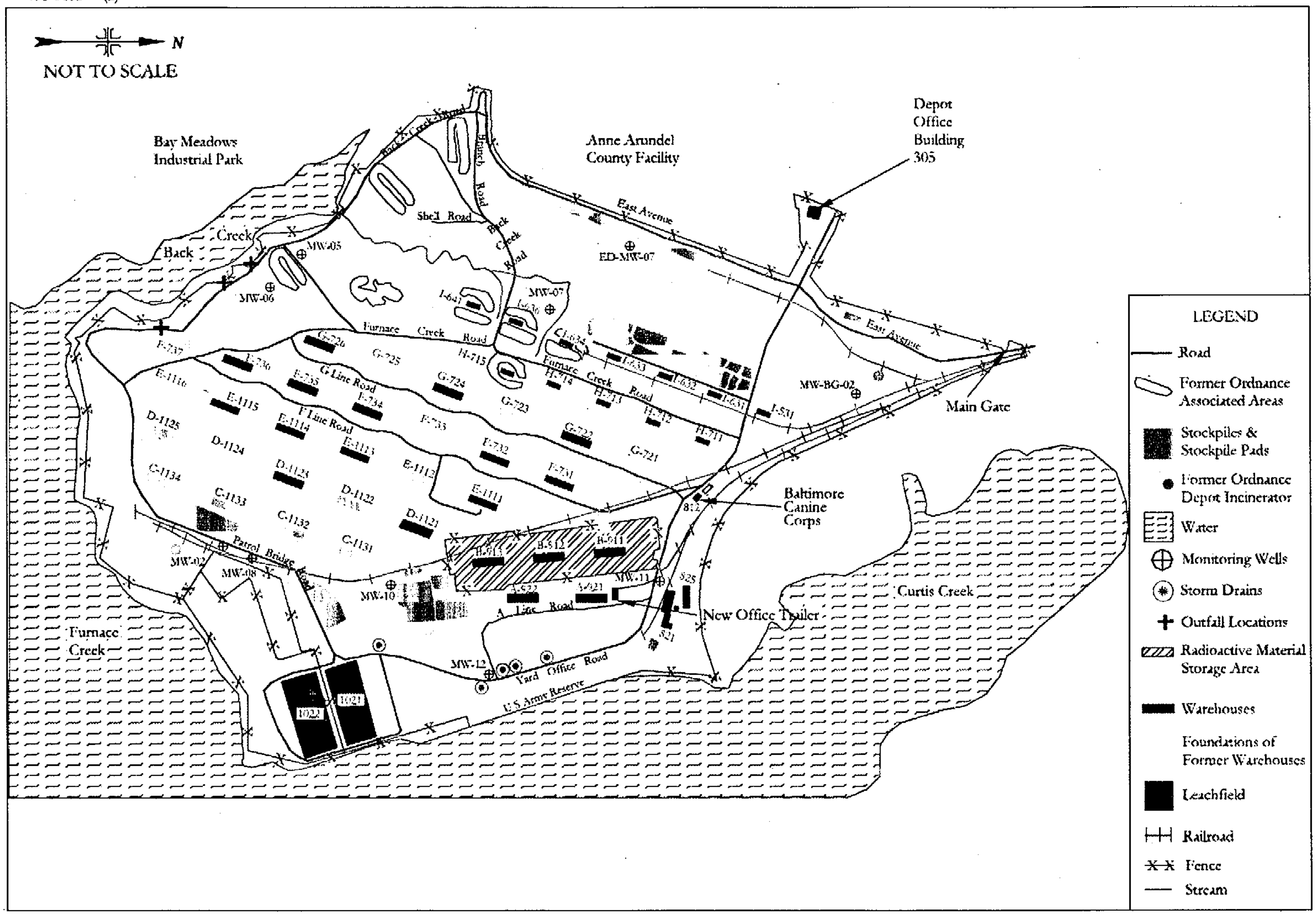


Figure A-1: Curtis Bay Depot, Curtis Bay, Maryland—Plot Plan

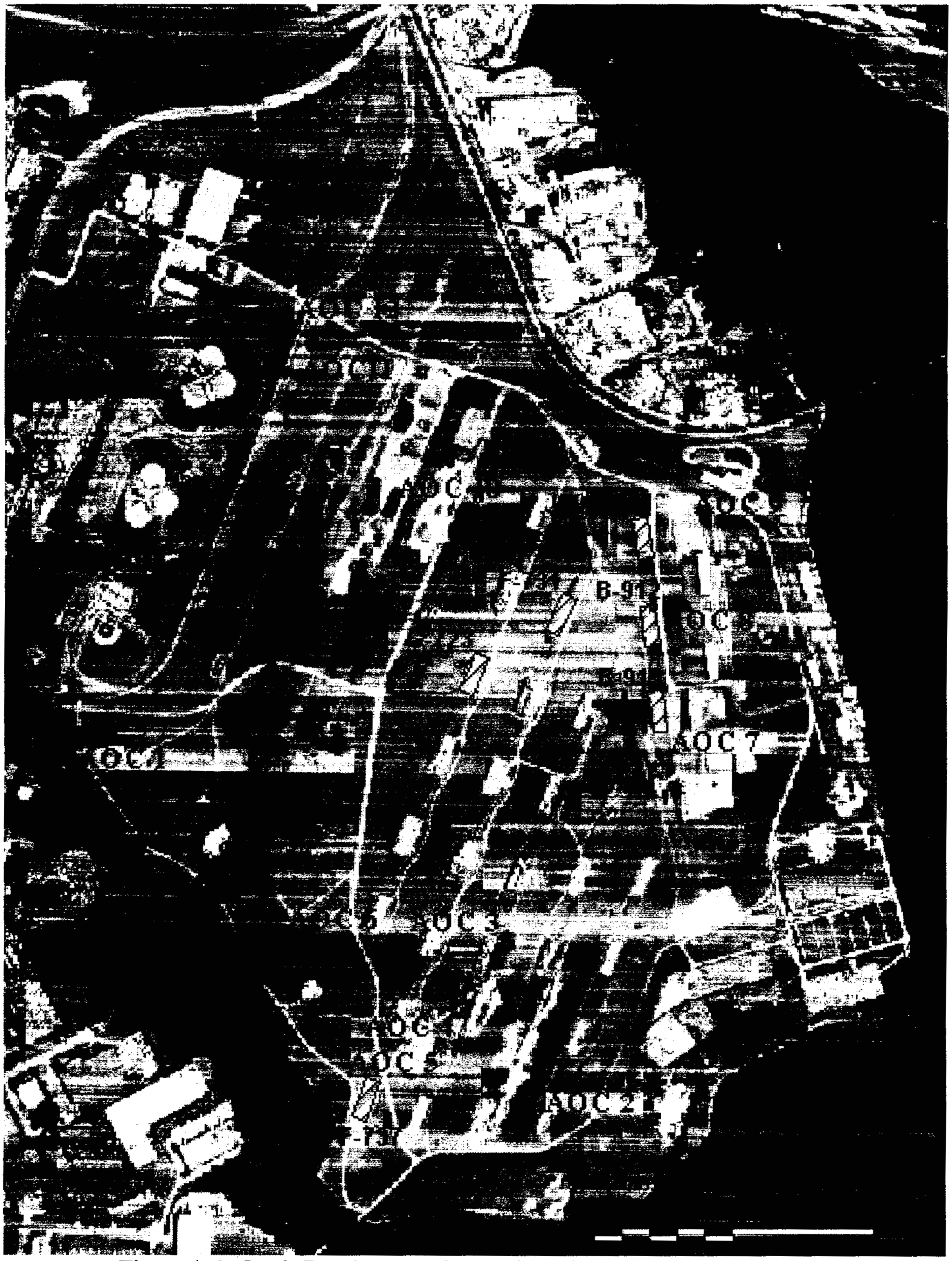


Figure A-2: Curtis Bay Depot—Contaminated Buildings and Soil AOCs

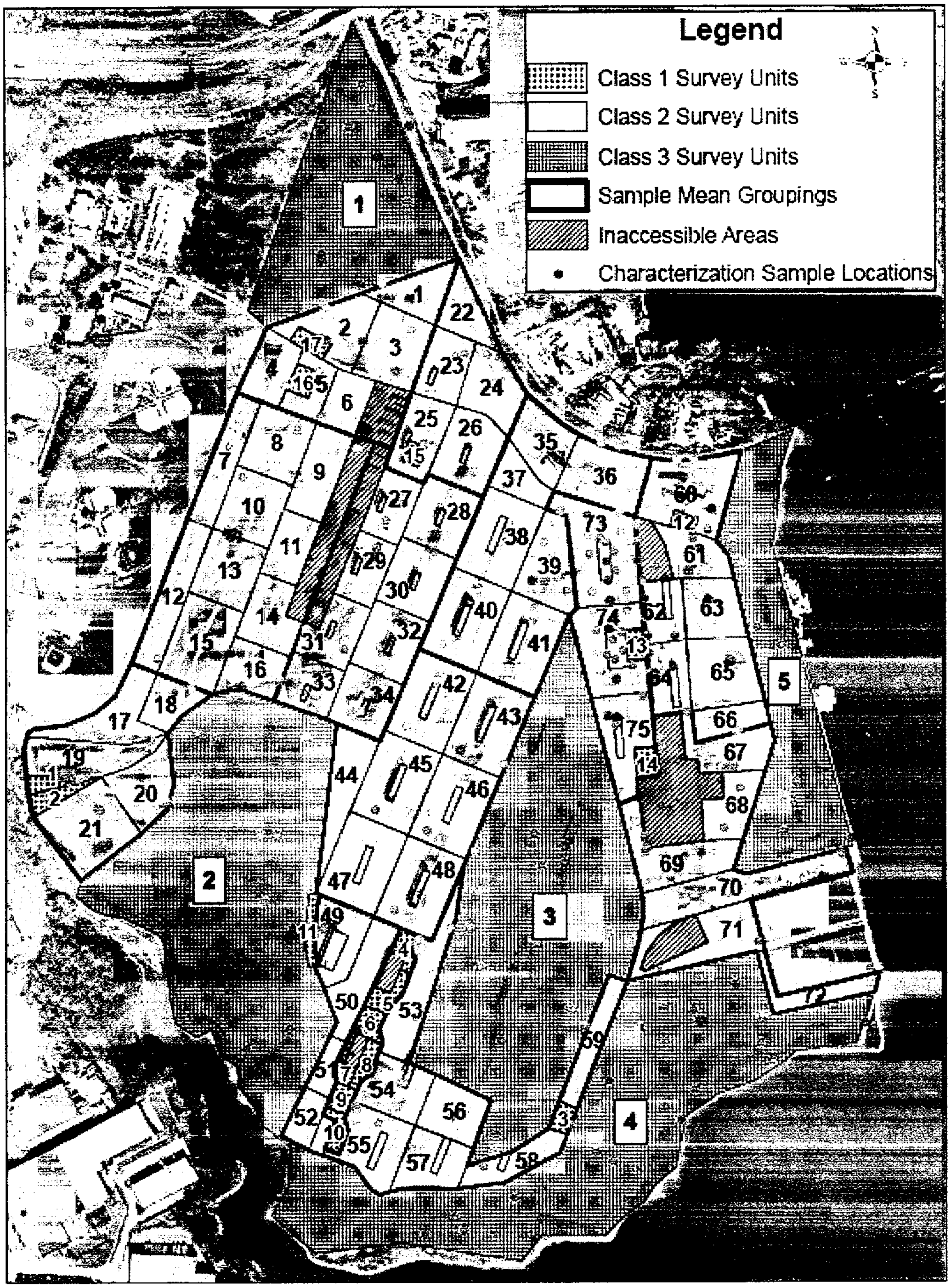


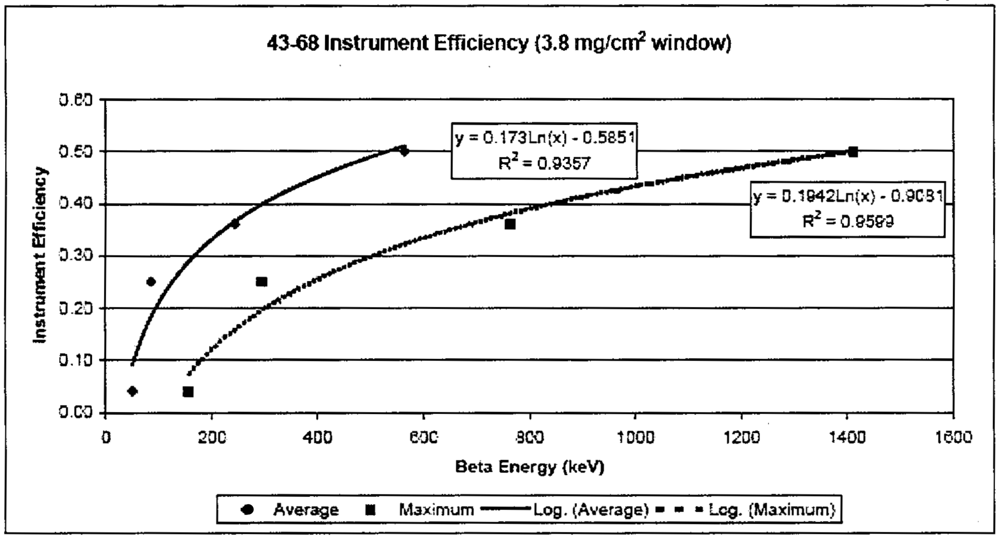
Figure A-3: Curtis Bay Depot—FSS Survey Units (#Survey Unit ID), Class 2 Sample Mean Planning Boundaries, Characterization Sample Locations

Th-232 Decay Series Gas Proportional Detector Calibration Worksheet

Task Number: 431 Curtis Bay Depot Characterization | Data Entry

Instrument:	2221 #16	
Detector:	43-68 #16	(3.8 mg/cm² window)
Cal. BKG Avg (cpm):	372	

Calibration Data			
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency
C-14	49.74	156.5	0.04
Tc-99	84.6	293.5	0.25
Tl-204	244.03	763.4	0.36
Sr/Y-90	564.75	1413.05	0.50



Th-232 Decay Series Calculation[2]					
Radionuclide	Average Beta Energy (keV)[1]	Fraction	Instrument Efficiency[3]	Surface Efficiency	Weighted Efficiency
Th-232	alpha	1	0.00	0.25	0.00
Ra-228	7.2	1	0.00	0.00	0.00
Ac-228	377	0.93	0.44	0.50	0.20
Th-228	alpha	1	0.00	0.25	0.00
Ra-224	alpha	1	0.00	0.25	0.00
Rn-220	alpha	0.75	0.00	0.25	0.00
Po-216	alpha	0.75	0.00	0.25	0.00
Pb-212	102	0.751	0.22	0.25	0.04
Bi-212	770	0.307	0.56	0.50	0.09
Bi-212	alpha	0.27	0.00	0.25	0.00
Po-212	alpha	0.48	0.00	0.25	0.00
Tl-208	557	0.268	0.51	0.50	0.07
				Total Efficiency:	0.40
				Static MDC (dpm/100 cm²):	184

[1] http://atom.kaeri.re.kr/ton/
[2] Refer to Table 14.2 of *Decommissioning Health Physics: A Handbook for MARSSIM Users*. E W Abelquist. 2001. Fractions adjusted to account for Rn-220 loss.
[3] Calculated using exponential curve shown above for average beta energy

Figure A-4: Example Instrument Calibration Efficiency Determination

APPENDIX B:

TABLES

Table B-1: Building Information, Curtis Bay Depot, Maryland				
Building Line Designation	**Building ID**	**History of Radioactive Material Use**	**Radioactive Material[a]**	**Initial HSA Building Classification**
Warehouses 73 m × 183 m	1021	No		3
	1022	Yes	Th	2
A Line 15 m × 67 m	A-921	Yes	Th, MS	2
	A-922	No		3
B Line 15 m × 67 m	B-911	Yes	Th, SS	1
	B-912	Yes	Th	1
	B-913	Yes	Th	2
C Line 15 m × 67 m	C-1131	No		3
	C-1132	No		3
	C-1133	No		3
	C-1134	No		3
D Line 15 m × 67 m	D-1121	No		3
	D-1122	No		3
	D-1123	No		3
	D-1124	No		3
	D-1125	No		3
E Line 15 m × 67 m	E-1111	No		3
	E-1112	No		3
	E-1113	No		3
	E-1114	No		3
	E-1115	No		3
	E-1116	No		3
F Line 15 m × 67 m	F-731	Yes	Th	1
	F-732	No		3
	F-733	No		3
	F-734	Yes	Th	2
	F-735	Yes	MS	2
	F-736	Yes	MS	2
	F-737	Yes	MS	1

Table B-1 (cont.): Building Information, Curtis Bay Depot, Maryland				
Building Line Designation	**Building ID**	**History of Radioactive Material Use**	**Radioactive Material[a]**	**Initial HSA Building Classification**
G Line 15 m × 67 m	G-721	Yes	SS	2
	G-722	No		3
	G-723	No		3
	G-724	No		3
	G-725	No		3
	G-726	No		3
H Line 10 m × 29 m	H-711	Yes	SS	2
	H-712	Yes	SS	2
	H-713	Yes	SS	2
	H-714	Yes	SS	2
	H-715	Yes	SS	2
I Line 10 m × 29 m	I-531	No		3
	I-631	No	Designation changed	2
	I-632	No		3
	I-633	No		3
	I-634 Igloo	No		3
	I-634	No		3
	I-636	No		3
	I-641	No		3
800 series	821	No		3
	825	No		3

[a]Th = thorium nitrate, oxide, or hydroxide, MS = monazite sand, SS = sodium sulfate.

Table B-2: Land Area Survey Unit Identification			
SURVEY UNIT	CLASS	AREA	REMARKS
Class 1 Survey Units (C1 SU#)			
C1 SU 1	1	2,271 m^2	AOC 1
C1 SU 1a	1	TBD	AOC 1 overburden
C1 SU 1b	1	TBD	AOC 1 overburden
C1 SU 1c…n	1	TBD	AOC 1 overburden
C1 SU 2	1	2,671 m^2	AOC 1
C1 SU 3	1	1,743 m^2	AOC 2
C1 SU 4	1	2,115 m^2	AOC 3
C1 SU 5	1	2,601 m^2	AOC 4
C1 SU 6	1	2,513 m^2	AOC 4
C1 SU 7	1	1,575 m^2	AOC 4
C1 SU 8	1	2,148 m^2	AOC 4
C1 SU 9	1	1,832 m^2	AOC 5
C1 SU 10[a]	1	2,030 m^2	AOC 5
C1 SU 11	1	2,220 m^2	AOC 6
C1 SU 12	1	1,263 m^2	AOC 9
C1 SU 13	1	1,770 m^2	AOC 8
C1 SU 14	1	1,964 m^2	AOC 7
C1 SU 15	1	1,158 m^2	AOC 10
C1 SU 16	1	1,993 m^2	AOC 11
C1 SU 17	1	1,987 m^2	AOC 12
C1 SU 18	1	TBD	B-911 loading dock
Class 2 Survey Units (C2 SU#)			
C2 SU 1	2	9,188 m^2	Planning Area 1
C2 SU 2	2	12,164 m^2	Planning Area 1
C2 SU 3	2	14,189 m^2	Planning Area 1
C2 SU 4	2	9,232 m^2	Planning Area 1
C2 SU 5	2	5,653 m^2	Planning Area 1
C2 SU 6	2	7,435 m^2	Planning Area 1
C2 SU 7	2	11,323 m^2	Planning Area 2
C2 SU 8	2	12,602 m^2	Planning Area 2
C2 SU 9	2	11,714 m^2	Planning Area 2
C2 SU 10	2	12,602 m^2	Planning Area 2
C2 SU 11	2	8,536 m^2	Planning Area 2
C2 SU 12	2	13,047 m^2	Planning Area 2
C2 SU 13	2	12,602 m^2	Planning Area 2
C2 SU 14	2	10,706 m^2	Planning Area 2
C2 SU 15	2	16,177 m^2	Planning Area 2
C2 SU 16	2	9,287 m^2	Planning Area 2
C2 SU 17	2	13,330 m^2	Planning Area 3
C2 SU 18	2	7,018 m^2	Planning Area 3

Table B-2 (cont.): Land Area Survey Unit Identification			
SURVEY UNIT	CLASS	AREA	REMARKS
C2 SU 19	2	12,873 m^2	Planning Area 3
C2 SU 20	2	11,216 m^2	Planning Area 3
C2 SU 21	2	18,018 m^2	Planning Area 3
C2 SU 22	2	7,948 m^2	Planning Area 4
C2 SU 23	2	9,351 m^2	Planning Area 4
C2 SU 24	2	11,601 m^2	Planning Area 4
C2 SU 25	2	9,952 m^2	Planning Area 4
C2 SU 26	2	13,388 m^2	Planning Area 4
C2 SU 27	2	8,596 m^2	Planning Area 5
C2 SU 28	2	12,305 m^2	Planning Area 5
C2 SU 29	2	8,473 m^2	Planning Area 5
C2 SU 30	2	12,305 m^2	Planning Area 5
C2 SU 31	2	10,000 m^2	Planning Area 5
C2 SU 32	2	12,305 m^2	Planning Area 5
C2 SU 33	2	8,850 m^2	Planning Area 5
C2 SU 34	2	10,855 m^2	Planning Area 5
C2 SU 35	2	11,225 m^2	Planning Area 6
C2 SU 36	2	15,104 m^2	Planning Area 6
C2 SU 37	2	6,677 m^2	Planning Area 6
C2 SU 38	2	16,473 m^2	Planning Area 6
C2 SU 39	2	13,056 m^2	Planning Area 6
C2 SU 40	2	16,473 m^2	Planning Area 6
C2 SU 41	2	16,473 m^2	Planning Area 6
C2 SU 42	2	16,473 m^2	Planning Area 7
C2 SU 43	2	16,473 m^2	Planning Area 7
C2 SU 44	2	12,103 m^2	Planning Area 7
C2 SU 45	2	16,473 m^2	Planning Area 7
C2 SU 46	2	16,473 m^2	Planning Area 7
C2 SU 47	2	16,473 m^2	Planning Area 7
C2 SU 48	2	16,473 m^2	Planning Area 7
C2 SU 49	2	7,222 m^2	Planning Area 8
C2 SU 50	2	11,134 m^2	Planning Area 8
C2 SU 51	2	3,828 m^2	Planning Area 8
C2 SU 52	2	5,052 m^2	Planning Area 8
C2 SU 53	2	15,175 m^2	Planning Area 8
C2 SU 54	2	10,514 m^2	Planning Area 8
C2 SU 55	2	12,778 m^2	Planning Area 8
C2 SU 56	2	10,264 m^2	Planning Area 8
C2 SU 57	2	10,128 m^2	Planning Area 8
C2 SU 58	2	8,063 m^2	Planning Area 8
C2 SU 59	2	8,507 m^2	Planning Area 8
C2 SU 60	2	19,429 m^2	Planning Area 9
C2 SU 61	2	8,830 m^2	Planning Area 9

Table B-2 (cont.): Land Area Survey Unit Identification			
SURVEY UNIT	**CLASS**	**AREA**	**REMARKS**
C2 SU 62	2	7,090 m^2	Planning Area 9
C2 SU 63	2	10,649 m^2	Planning Area 9
C2 SU 64	2	8,142 m^2	Planning Area 9
C2 SU 65	2	14,551 m^2	Planning Area 9
C2 SU 66	2	6,518 m^2	Planning Area 9
C2 SU 67	2	10,691 m^2	Planning Area 10
C2 SU 68	2	9,232 m^2	Planning Area 10
C2 SU 69	2	14,991 m^2	Planning Area 10
C2 SU 70	2	19,889 m^2	Planning Area 10
C2 SU 71	2	14,038 m^2	Planning Area 10
C2 SU 72	2	7,258 m^2	Planning Area 10
C2 SU 73	2	20,505 m^2	Planning Area 11
C2 SU 74	2	14,569 m^2	Planning Area 11
C2 SU 75	2	12,711 m^2	Planning Area 11
Class 3 Survey Units (C3 SU#)			
C3 SU 1	3	94,266 m^2	FSS Completed
C3 SU 2	3	200,571 m^2	FSS Completed
C3 SU 3	3	201,931 m^2	FSS Completed
C3 SU 4	3	184,966 m^2	FSS Completed
C3 SU 5	3	77,293 m^2	FSS Completed

[a]Survey Unit will include the area beneath the Building F-737 pad.

Table B-3: Pad/Building Survey Unit Identification			
Pad/Building/Survey Unit	CLASS	AREA	REMARKS
Structures With Class 1 Survey Units			
Building B-911			
C1 SU 1	1	93 m^2	Floor
C1 SU 2	1	93 m^2	Floor
C1 SU 3	1	93 m^2	Floor
C1 SU 4	1	93 m^2	Floor
C1 SU 5	1	93 m^2	Floor
C1 SU 6	1	93 m^2	Floor
C1 SU 7	1	93 m^2	Floor
C1 SU 8	1	93 m^2	Floor
C1 SU 9	1	93 m^2	Floor
C1 SU 10	1	93 m^2	Floor
C1 SU 11	1	93 m^2	Floor
C1 SU 12	1	69 m^2	South Wall
C1 SU 13	1	100 m^2	S. West Wall
C1 SU 14	1	100 m^2	C. West Wall
C1 SU 15	1	100 m^2	N. West Wall
C1 SU 16	1	69 m^2	North Wall
C1 SU 17	1	100 m^2	N. East Wall
C1 SU 18	1	100 m^2	C. East Wall
C1 SU 19	1	100 m^2	S. East Wall
C1 SU 20	1	83 m^2	Overhead Trusses
C1 SU 21	1	114 m^2	Loading Dock
Building B-912			
C1 SU 22	1	93 m^2	Floor
C1 SU 23	1	93 m^2	Floor
C1 SU 24	1	93 m^2	Floor
C1 SU 25	1	93 m^2	Floor
C1 SU 26	1	93 m^2	Floor
C1 SU 27	1	93 m^2	Floor
C1 SU 28	1	93 m^2	Floor
C1 SU 29	1	93 m^2	Floor
C1 SU 30	1	93 m^2	Floor
C1 SU 31	1	93 m^2	Floor
C1 SU 32	1	93 m^2	Floor
C1 SU 33	1	69 m^2	South Wall
C1 SU 34	1	100 m^2	S. West Wall
C1 SU 35	1	100 m^2	C. West Wall
C1 SU 36	1	100 m^2	N. West Wall
C1 SU 37	1	69 m^2	North Wall

Table B-3 (cont.): Pad/Building Survey Unit Identification			
Pad/Building/Survey Unit	**CLASS**	**AREA**	**REMARKS**
Building B-912 (cont.)			
C1 SU 38	1	100 m^2	N. East Wall
C1 SU 39	1	100 m^2	C. East Wall
C1 SU 40	1	100 m^2	S. East Wall
C1 SU 41	1	83 m^2	Overhead Trusses
Building B-913			
C1 SU 42	1	93 m^2	Floor
C2 SU 43	2	495 m^2	Floor
C2 SU 44	2	495 m^2	Floor
C2 SU 45	2	69 m^2	South Wall
C2 SU 46	2	300 m^2	West Wall
C2 SU 47	2	69 m^2	North Wall
C2 SU 48	2	300 m^2	East Wall
C3 SU 49	3	83 m^2	Overhead Trusses
Building F-731			
C1 SU 50	1	93 m^2	Floor
C1 SU 51	1	93 m^2	Floor
C1 SU 52	1	93 m^2	Floor
C1 SU 53	1	93 m^2	Floor
C1 SU 54	1	93 m^2	Floor
C1 SU 55	1	93 m^2	Floor
C1 SU 56	1	93 m^2	Floor
C1 SU 57	1	93 m^2	Floor
C1 SU 58	1	93 m^2	Floor
C1 SU 59	1	93 m^2	Floor
C1 SU 60	1	93 m^2	Floor
C1 SU 61	1	134 m^2	Lower West Wall
C2 SU 62	2	69 m^2	South Wall
C2 SU 63	2	168 m^2	Upper West Wall
C2 SU 64	2	69 m^2	North Wall
C2 SU 65	2	300 m^2	East Wall
C2 SU 66	2	83 m^2	Overhead Trusses
Building F-737			
C1SU 67	1	153 m^2	Pad
C1 SU 68	1	153 m^2	Pad
C1 SU 69	1	153 m^2	Pad
C1 SU 70	1	153 m^2	Pad
C1 SU 71	1	153 m^2	Pad
C1 SU 72	1	153 m^2	Pad
C1 SU 73	1	153 m^2	Pad
C1 SU 74	1	153 m^2	Pad

Table B-3 (cont.): Pad/Building Survey Unit Identification			
Pad/Building/Survey Unit	**CLASS**	**AREA**	**REMARKS**
Building F-737 (cont.)			
C1 SU 75	1	153 m^2	Pad
C1 SU 76	1	107 m^2	Pad
Building G-723			
C1 SU 77	1	112 m^2	N. 1/3 Loading Dock
C2 SU 78	2	224 m^2	S. 2/3 Loading Dock
C3 SU 79	3	1,022 m^2	Pad
Class 2 Structures			
A-921/C2 SU 80	2	1,351 m^2 (F and LW[a])	FSS Completed
F-734/ C2 SU 81	2	1,022 m^2 (F and DP[b])	FSS Completed
F-735/ C2 SU 82	2	1,022 m^2 (F and DP)	FSS Completed
F-736/ C2 SU 83	2	1,022 m^2 (F and DP)	FSS Completed
G-721/ C2 SU 84	2	1,022 m^2 (pad)	FSS Completed
H-711/ C2 SU 85	2	293 m^2 (F and DP)	FSS Completed
H-712/ C2 SU 86	2	293 m^2 (debris piles)	FSS Completed
H-713/ C2 SU 87	2	293 m^2 (debris piles)	FSS Completed
H-714/ C2 SU 88	2	293 m^2 (debris piles)	FSS Completed
H-715/ C2 SU 89	2	293 m^2 (debris piles)	FSS Completed
1022/ C2 SU 90a	2	4,462 m^2 (south floor/ LW)	FSS Completed
1022/ C2 SU 90b	2	4,462 m^2 (south floor/ LW)	FSS Completed
1022/ C2 SU 90c	2	4,462 m^2 (south floor/ LW)	FSS Completed
Class 3 Structures			
A-922/C3 SU 91	3	1,351 m^2 (F and LW)	FSS Completed
C-1131/C3 SU 92	3	1,022 m^2 (pad)	FSS Completed
C-1132/C3 SU 93	3	1,022 m^2 (pad)	FSS Completed
C-1133/C3 SU 94	3	1,022 m^2 (pad)	FSS Completed
C-1134/C3 SU 95	3	1,022 m^2 (pad)	FSS Completed
D-1121/C3 SU 96	3	1,022 m^2 (F and DP)	FSS Completed
D-1122/C3 SU 97	3	1,022 m^2 (pad)	FSS Completed
D-1123/C3 SU 98	3	1,022 m^2 (F and DP)	FSS Completed
D-1124/C3 SU 99	3	1,022 m^2 (pad)	FSS Completed
D-1125/C3 SU 100	3	1,022 m^2 (pad)	FSS Completed
E-1111/C3 SU 101	3	1,022 m^2 (F and DP)	FSS Completed
E-1112/C3 SU 102	3	1,022 m^2 (pad)	FSS Completed
E-1113/C3 SU 103	3	1,022 m^2 (F and DP)	FSS Completed
E-1114/C3 SU 104	3	1,022 m^2 (F and DP)	FSS Completed

Table B-3 (cont.): Pad/Building Survey Unit Identification			
Pad/Building/Survey Unit	**CLASS**	**AREA**	**REMARKS**
Class 3 Structures (cont.)			
E-1115/C3 SU 105	3	1022 m^2 (F and DP)	FSS Completed
E-1116/C3 SU 106	3	1022 m^2 (pad)	FSS Completed
F-732/C3 SU 107	3	1022 m^2 (F and DP)	FSS Completed
F-733/C3 SU 108	3	1022 m^2 (pad)	FSS Completed
G-722/C3 SU 109	3	1022 m^2 (F and DP)	FSS Completed
G-724/C3 SU 110	3	1022 m^2 (F and DP)	FSS Completed
G-725/C3 SU 111	3	1022 m^2 (pad)	FSS Completed
G-726/C3 SU 112	3	1022 m^2 (F and DP)	FSS Completed
I-531/C3 SU 113	3	293 m^2 (debris piles)	FSS Completed
I-631/C3 SU 114	3	293 m^2 (debris piles)	FSS Completed
I-632/C3 SU 115	3	293 m^2 (debris piles)	FSS Completed
I-633/C3 SU 116	3	293 m^2 (debris piles)	FSS Completed
I-634/C3 SU 117	3	293 m^2 (debris piles)	FSS Completed
I-636/C3 SU 118	3	293 m^2 (debris piles)	FSS Completed
I-641/C3 SU 119	3	293 m^2 (debris piles)	FSS Completed
I-634 Igloo/C3 SU 120	3	274 m^2 (F and LW)	FSS Completed
821/C3 SU 121	3	655 m^2 (F and LW)	FSS Completed
825/C3 SU 122	3	512 m^2 (F and LW)	FSS Completed
1021/C3 SU 123	3	13,386 m^2 (F and LW)	FSS Completed

[a]F and LW = Floor and Lower Walls.
[b]F and DP = Floor and Debris Pile.

Table B-4: Class 2, Land Area 1 Planning Inputs

Class 2, Area 1 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0319	0.81	0.00	1.19	0.36	0.16
0431S0330	0.76	-0.05	0.57	-0.26	-0.14
0431S0331	1.16	0.35	1.56	0.73	0.45
0431S0332	1.12	0.31	1.70	0.87	0.50
0431S0333	1.04	0.23	1.06	0.23	0.18
0431S0334	1.14	0.33	1.58	0.75	0.45
0431S0335	1.18	0.37	1.47	0.64	0.42
0431S0336	0.57	-0.24	1.01	0.18	0.00
0431S0393	2.46	1.65	2.52	1.69	1.34
0431S0411	2.20	1.39	2.04	1.21	1.03
0431S0412	2.29	1.48	1.92	1.09	1.01
DCGLs	2.90		2.20		
Mean	1.47	0.53	1.51	0.68	0.49
Sigma	0.66	0.66	0.54	0.54	0.34

Δ/σ = 1.5 α = 0.05 β = 0.10 N/2 = 15

Table B-5: Class 2, Land Area 2 Planning Inputs

Class 2, Area 2 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0173	0.52	-0.29	1.06	0.23	0.00
0431S0174	0.63	-0.18	0.73	-0.10	-0.11
0431S0177	0.73	-0.08	1	0.17	0.05
0431S0190	0.84	0.03	1.11	0.28	0.14
0431S0191	0.68	-0.13	0.68	-0.15	-0.11
0431S0192	0.79	-0.02	1.00	0.17	0.07
0431S0194	0.57	-0.24	0.64	-0.19	-0.17
0431S0297	2.09	1.28	1.21	0.38	0.61
0431S0298	2.32	1.51	0.99	0.16	0.59
0431S0318	0.95	0.14	0.94	0.11	0.10
0431S0320	0.94	0.13	0.98	0.15	0.11
0431S0321	1.04	0.23	1.36	0.53	0.32
0431S0337	1.21	0.40	1.24	0.41	0.32
0431S0338	0.42	-0.39	0.42	-0.41	-0.32
DCGLs	2.90		2.20		
Mean	0.98	0.17	0.95	0.12	0.12[a]
Sigma	0.56	0.56	0.26	0.26	0.23

Δ/σ = 2.83 α = 0.05 β = 0.05 N/2 = 10

[a]LBGR increased to 0.35 to obtain a relative shift between 1 and 3

Table B-6: Class 2, Land Area 3 Planning Inputs					
Class 2 Area 3 FSS Planning					
Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0194	0.57	-0.24	0.64	-0.19	-0.17
0431S0196	1.32	0.51	0.5	-0.33	0.03
0431S0197	1.35	0.54	1.31	0.48	0.40
0431S0198	1.09	0.28	1.70	0.87	0.49
0431S0199	0.54	-0.27	0.64	-0.19	-0.18
0431S0295	0.53	-0.28	0.79	-0.04	-0.11
0431S0296	0.82	0.01	1.50	0.67	0.31
DCGLs	2.90		2.20		
Mean	0.89	0.08	1.01	0.18	0.11[a]
Sigma	0.36	0.36	0.48	0.48	0.25
Δ/σ = 3	α = 0.05 β = 0.05		N/2 = 10		

[a] LBGR increased to 0.25 to obtain a relative shift between 1 and 3

Table B-7: Class 2, Land Area 4 Planning Inputs					
Class 2 Area 4 FSS Planning					
Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0323	2.04	1.23	2.09	1.26	1.00
0431S0324	1.01	0.20	1.43	0.60	0.34
0431S0325	0.87	0.06	1.03	0.20	0.11
0431S0327	0.74	-0.07	1.22	0.39	0.15
0431S0328	1.06	0.25	0.98	0.15	0.15
0431S0329	0.91	0.10	1.27	0.44	0.23
0431S0374	0.90	0.09	0.98	0.15	0.10
0431S0392	2.33	1.52	2.55	1.72	1.31
0431S0394	1.78	0.97	1.75	0.92	0.75
DCGLs	2.90		2.20		
Mean	1.29	0.48	1.48	0.65	0.46
Sigma	0.59	0.59	0.55	0.55	0.32
Δ/σ = 1.69	α = 0.05 β = 0.10		N/2 = 13		

Table B-8: Class 2, Land Area 5 Planning Inputs

Class 2 Area 5 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0174	0.63	-0.18	0.73	-0.10	-0.11
0431S0175	0.55	-0.26	0.73	-0.10	-0.14
0431S0176	0.94	0.13	1.23	0.40	0.23
0431S0185	0.76	-0.05	1.82	0.99	0.43
0431S0187	1.28	0.47	1.58	0.75	0.50
0431S0189	1.20	0.39	1.31	0.48	0.35
0431S0192	0.79	-0.02	1.00	0.17	0.07
0431S0193	1.56	0.75	1.11	0.28	0.39
0431S0322	1.24	0.43	1.42	0.59	0.42
0431S0338	0.42	-0.39	0.42	-0.41	-0.32
DCGLs	2.90		2.20		
Mean	0.94	0.13	1.14	0.31	0.18[a]
Sigma	0.37	0.37	0.43	0.43	0.23

$\Delta/\sigma = 2.83$ $\alpha = 0.05$ $\beta = 0.05$ N/2 = 10

[a] LBGR increased to 0.35 to obtain a relative shift between 1 and 3

Table B-9: Class 2, Land Area 6 Planning Inputs

Class 2 Area 6 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0182	0.46	-0.35	0.61	-0.22	-0.22
0431S0183	0.87	0.06	0.84	0.01	0.03
0431S0184	1.12	0.31	1.21	0.38	0.28
0431S0185	0.76	-0.05	1.82	0.99	0.43
0431S0186	1.38	0.57	1.98	1.15	0.72
0431S0325	0.87	0.06	1.03	0.20	0.11
0431S0326	0.86	0.05	1.27	0.44	0.22
0431S0339	0.91	0.10	1.50	0.67	0.34
0431S0340	0.62	-0.19	1.02	0.19	0.02
0431S0371	0.65	-0.16	0.37	-0.46	-0.26
DCGLs	2.90		2.20		
Mean	0.85	0.04	1.17	0.34	0.17[a]
Sigma	0.26	0.26	0.51	0.51	0.25

$\Delta/\sigma = 3$ $\alpha = 0.05$ $\beta = 0.05$ N/2= 10

[a] LBGR increased to 0.25 to obtain a relative shift between 1 and 3

Table B-10: Class 2, Land Area 7 Planning Inputs

Class 2 Area 7 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0169	1.52	0.71	2.10	1.27	0.82
0431S0170	0.78	-0.03	1.6	0.77	0.34
0431S0171	1.31	0.50	1.48	0.65	0.47
0431S0172	0.85	0.04	1.01	0.18	0.10
0431S0178	1.08	0.27	1.60	0.77	0.44
0431S0179	0.45	-0.36	0.52	-0.31	-0.27
0431S0180	1.45	0.64	2.30	1.47	0.89
0431S0181	0.62	-0.19	0.83	0.00	-0.07
0431S0186	1.38	0.57	1.98	1.15	0.72
DCGLs	2.90		2.20		
Mean	1.05	0.24	1.49	0.66	0.38
Sigma	0.39	0.39	0.60	0.60	0.30

$\Delta/\sigma = 2.07$ $\alpha = 0.05$ $\beta = 0.05$ N/2 = 13

Table B-11: Class 2, Land Area 8 Planning Inputs

Class 2 Area 8 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0161	0.68	-0.13	0.96	0.13	0.01
0431S0162	0.77	-0.04	0.65	-0.18	-0.10
0431S0163	0.68	-0.13	0.73	-0.10	-0.09
0431S0164	0.70	-0.11	0.83	0.00	-0.04
0431S0165	0.46	-0.35	0.45	-0.38	-0.29
0431S0166	1.18	0.37	1.24	0.41	0.31
0431S0167	1.44	0.63	1.17	0.34	0.37
0431S0168	1.30	0.49	1.40	0.57	0.43
0431S0172	0.85	0.04	1.01	0.18	0.10
DCGLs	2.90		2.20		
Mean	0.90	0.09	0.94	0.11	0.08[a]
Sigma	0.33	0.33	0.30	0.30	0.18

$\Delta/\sigma = 2.78$ $\alpha = 0.05$ $\beta = 0.05$ N/2 = 10

[a] LBGR increased to 0.50 to obtain a relative shift between 1 and 3

Table B-12: Class 2, Land Area 9 Planning Inputs

Class 2 Area 9 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0306	0.98	0.17	0.95	0.12	0.11
0431S0307	1.29	0.48	1.32	0.49	0.39
0431S0309	1.05	0.24	0.74	-0.09	0.04
0431S0360	0.23	-0.58	0.08	-0.75	-0.54
0431S0362	0.46	-0.35	0.57	-0.26	-0.24
0431S0365	1.21	0.40	1.79	0.96	0.57
0431S0366	0.74	-0.07	1.08	0.25	0.09
0431S0368	0.68	-0.13	0.75	-0.08	-0.08
0431S0369	1.21	0.40	1.04	0.21	0.23
0431S0370	0.55	-0.26	1.10	0.27	0.03
0431S0395	2.48	1.67	2.75	1.92	1.45
0431S0396	1.37	0.56	1.00	0.17	0.27
DCGLs	2.90		2.20		
Mean	1.02	0.21	1.10	0.27	0.19
Sigma	0.58	0.58	0.66	0.66	0.36

Δ/σ = 2.25 α = 0.05 β = 0.05 N/2 = 11

Table B-13: Class 2, Land Area 10 Planning Inputs

Class 2 Area 10 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0310	0.53	-0.28	0.70	-0.13	-0.16
0431S0311	0.43	-0.38	0.33	-0.50	-0.36
0431S0313	0.27	-0.54	0.33	-0.50	-0.41
0431S0314	0.61	-0.20	0.97	0.14	-0.01
0431S0315	0.90	0.09	1.04	0.21	0.13
0431S0316	0.55	-0.26	0.42	-0.41	-0.28
0431S0317	0.93	0.12	1.51	0.68	0.35
0431S0356	0.67	-0.14	0.74	-0.09	-0.09
0431S0359	0.74	-0.07	0.97	0.14	0.04
0431S0360	0.23	-0.58	0.08	-0.75	-0.54
0431S0361	0.80	-0.01	1.07	0.24	0.11
0431S0385	2.28	1.47	1.91	1.08	1.00
0431S0386	2.33	1.52	1.81	0.98	0.97
DCGLs	2.90		2.20		
Mean	0.87	0.06	0.91	0.08	0.06
Sigma	0.67	0.67	0.57	0.57	0.35

Δ/σ = 2.69 α = 0.05 β = 0.05 N/2 = 11

Table B-14: Class 2, Land Area 11 Planning Inputs

Class 2 Area 11 FSS Planning

Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0068	0.83	0.02	0.38	-0.45	-0.20
0431S0069	0.72	-0.09	0.86	0.03	-0.02
0431S0070	0.42	-0.39	0.34	-0.49	-0.36
0431S0071	0.33	-0.48	0.28	-0.55	-0.42
0431S0072	0.63	-0.18	0.50	-0.33	-0.21
0431S0073	0.98	0.17	0.94	0.11	0.11
0431S0074	1.54	0.73	1.90	1.07	0.74
0431S0075	0.68	-0.13	0.42	-0.41	-0.23
0431S0076	1.56	0.75	1.61	0.78	0.61
0431S0077	0.76	-0.05	0.88	0.05	0.01
0431S0078	1.01	0.20	1.58	0.75	0.41
0431S0079	1.15	0.34	1.28	0.45	0.32
0431S0080	0.93	0.12	1.38	0.55	0.29
0431S0081	0.85	0.04	1.20	0.37	0.18
0431S0082	0.74	-0.07	0.46	-0.37	-0.19
0431S0083	0.82	0.01	0.62	-0.21	-0.09
0431S0084	0.76	-0.05	1.02	0.19	0.07
0431S0085	0.70	-0.11	0.93	0.10	0.01
0431S0086	1.01	0.20	1.23	0.40	0.25
0431S0087	1.09	0.28	1.19	0.36	0.26
0431S0088	1.26	0.45	1.25	0.42	0.35
0431S0089	0.89	0.08	0.70	-0.13	-0.03
0431S0090	0.64	-0.17	0.78	-0.05	-0.08
0431S0091	0.62	-0.19	0.65	-0.18	-0.15
0431S0092	0.92	0.11	1.33	0.50	0.27
0431S0093	1.19	0.38	1.80	0.97	0.57
0431S0094	0.84	0.03	2.14	1.31	0.61
0431S0095	0.73	-0.08	1.39	0.56	0.23
0431S0096	0.98	0.17	1.21	0.38	0.23
0431S0097	0.59	-0.22	1.90	1.07	0.41
0431S0098	0.98	0.17	0.97	0.14	0.12
0431S0099	1.30	0.49	1.24	0.41	0.36
0431S0100	0.75	-0.06	0.67	-0.16	-0.09
0431S0101	0.69	-0.12	1.34	0.51	0.19
0431S0102	1.38	0.57	1.30	0.47	0.41
DCGLs	2.90		2.20		
Mean	0.89	0.08	1.08	0.25	0.14[a]
Sigma	0.28	0.28	0.48	0.48	0.24
$\Delta/\sigma = 2.92$		$\alpha = 0.05$ $\beta = 0.05$		N/2 = 10	

[a] LBGR increased to 0.30 to obtain a relative shift between 1 and 3

Table B-15: Class 3 Land Area Survey Unit Planning

Class 3 FSS Planning

	Th-232	Est Net	U-238	Est Net	Unity
0431S0001	1.81	1.00	1.27	0.44	0.78
0431S0002	1.72	0.91	2.38	1.55	1.23
0431S0003	0.67	-0.14	0.98	0.15	-0.01
0431S0004	1.70	0.89	1.49	0.66	0.82
0431S0005	0.77	-0.04	1.07	0.24	0.09
0431S0006	1.71	0.90	1.39	0.56	0.78
0431S0022	1.90	1.09	1.80	0.97	1.07
0431S0040	0.72	-0.09	1.12	0.29	0.08
0431S0042	0.77	-0.04	1.14	0.31	0.12
DCGLs	2.90		2.20		
Mean	1.31	0.50	1.40	0.57	0.55
Sigma		0.55		0.44	0.28
$\Delta/\sigma = 1.61$		$\alpha = 0.05$ $\beta = 0.10$		N/2 = 13	

Table B-16: Background Reference Area Data

Background Reference Area

Sample ID	Th-232	U-238	Unity
0431S0043	0.72	0.73	0.58
0431S0044	0.51	0.34	0.33
0431S0045	0.5	0.74	0.51
0431S0046	0.77	0.83	0.64
0431S0047	1.32	0.92	0.87
0431S0048	1.24	1.1	0.93
0431S0049	1.12	0.97	0.83
0431S0050	0.81	1.21	0.83
0431S0051	0.71	0.74	0.58
0431S0052	0.91	1.18	0.85
0431S0053	0.58	0.49	0.42
0431S0054	0.60	0.84	0.59
0431S0055	0.71	0.79	0.60
0431S0056	0.73	0.69	0.57
0431S0057	0.91	0.95	0.75
DCGLs	2.90		2.20
Mean	0.81	0.83	0.66
Sigma	0.25	0.24	0.14

Table B-17: Borehole Background Samples

Borehole Background Samples

Sample ID	Th-232	U-238	Unity
0431S0289	0.72	0.73	0.58
0431S0290	0.51	0.34	0.33
0431S0291	0.5	0.74	0.51
0431S0292	0.77	0.83	0.64
0431S0293	1.32	0.92	0.87
0431S0294	1.24	1.1	0.93
0431S0397	1.12	0.97	0.83
0431S0398	0.81	1.21	0.83
DCGLs	2.90		2.20
Mean	0.87	0.86	0.69
Sigma	0.32	0.27	0.16

Table B-18: Class 1 Former Radiological Waste Disposal Area Overburden Survey Unit Planning					
Rad Waste Disposal Area Overburden FSS Planning					
Sample ID	Th-232	Est Net	U-238	Est Net	Unity
0431S0200	0.51	-0.14	0.72	0.09	-0.01
0431S0201	0.64	-0.01	0.44	-0.19	-0.09
0431S0202	0.76	0.11	0.57	-0.06	0.01
0431S0203	0.54	-0.11	0.56	-0.07	-0.07
0431S0208	0.56	-0.09	0.58	-0.05	-0.05
0431S0209	0.94	0.29	0.86	0.23	0.20
0431S0210	0.74	0.09	0.71	0.08	0.07
0431S0211	0.39	-0.26	0.39	-0.24	-0.20
0431S0216	1.11	0.46	0.83	0.20	0.25
0431S0217	0.32	-0.33	0.29	-0.34	-0.27
0431S0218	0.33	-0.32	0.45	-0.18	-0.19
0431S0222	0.69	0.04	0.54	-0.09	-0.03
0431S0223	0.66	0.01	0.71	0.08	0.04
0431S0224	0.69	0.04	0.80	0.17	0.09
0431S0228	0.57	-0.08	0.72	0.09	0.01
0431S0229	0.51	-0.14	0.46	-0.17	-0.13
0431S0230	1.31	0.66	1.19	0.56	0.48
0431S0235	0.98	0.33	0.92	0.29	0.25
0431S0236	0.86	0.21	0.53	-0.10	0.03
0431S0237	0.45	-0.20	0.72	0.09	-0.03
0431S0245	0.66	0.01	0.50	-0.13	-0.06
0431S0246	0.59	-0.06	0.49	-0.14	-0.08
0431S0250	0.71	0.06	0.70	0.07	0.05
0431S0251	0.48	-0.17	0.60	-0.03	-0.07
0431S0252	2.29	1.64	0.94	0.31	0.71
0431S0260	0.79	0.14	0.56	-0.07	0.02
0431S0268	0.65	0.00	0.92	0.29	0.13
0431S0269	0.59	-0.06	0.50	-0.13	-0.08
0431S0276	0.79	0.14	0.30	-0.33	-0.10
0431S0277	0.73	0.08	0.50	-0.13	-0.03
0431S0284	0.70	0.05	0.70	0.07	0.05
0431S0285	0.63	-0.02	0.26	-0.37	-0.18
DCGLs	2.90		2.20		
Mean	0.72	0.07	0.62	-0.01	0.02
Sigma	0.35	0.35	0.21	0.21	0.16
$\Delta/\sigma = 3^b$	$\alpha = 0.05$ $\beta = 0.05$		N/2 = 10		

[a]Net calculated using borehole background means of 0.65 pCi/g for Th-232 and 0.63 pCi/g for U-238.

[b]LBGR set at 0.52

Table B-19: Class 2 Pad/Building Prospective Survey Unit Planning		
Class 2 Structural Survey Units		
Th-232		
DCGL	400 dpm/100^2	210 cpm
Mean		120 cpm
Sigma		63 cpm
Δ/σ = 1.4	α = 0.05 β = 0.05	N = 20

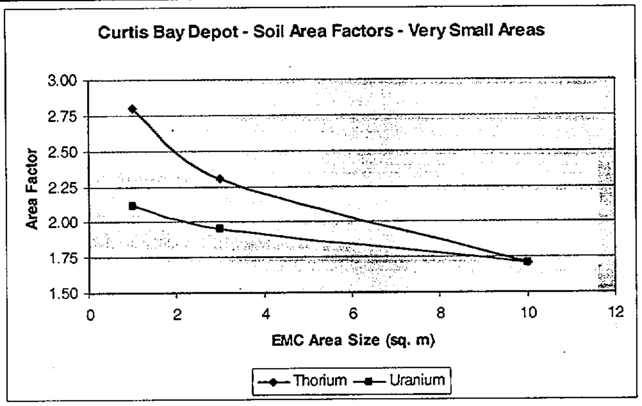
Table B-20: Class 3 Pad/Building Prospective Survey Unit Planning		
Class 3 Structural Survey Units		
Th-232		
DCGLs	400 dpm/100^2	210 cpm
Mean		120 cpm
Sigma		42 cpm
Δ/σ = 3	α = 0.05 β = 0.05	N = 15

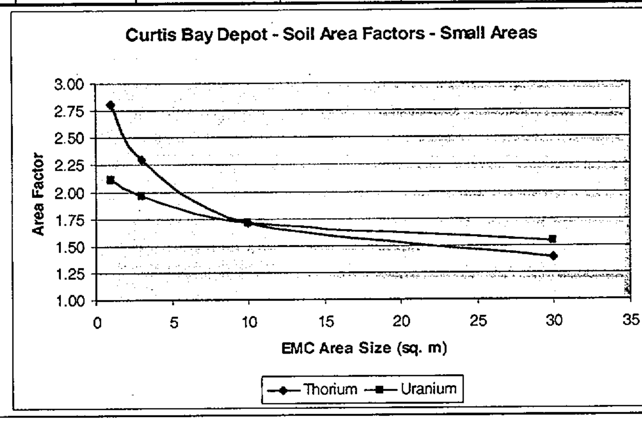
Table B-21: Class 2 Pad/Building Retrospective Survey Unit Planning		
Class 2 Structural Survey Units		
Th-232		
DCGL	400 dpm/100^2	210 cpm
Mean		68 cpm[a]
Sigma		71 cpm[a]
Δ/σ = 2.0	α = 0.05 β = 0.05	N = 15

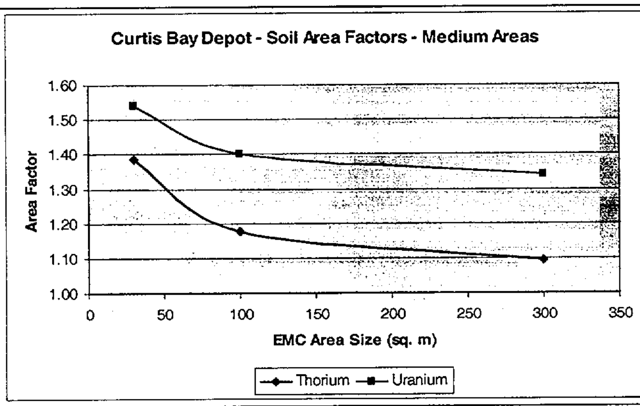
Table B-22: Class 3 Pad/Building Retrospective Survey Unit Planning		
Class 3 Structural Survey Units		
Th-232		
DCGLs	400 dpm/100^2	210 cpm
Mean		40 cpm[a]
Sigma		53 cpm[a]
Δ/σ = 3.2	α = 0.05 β = 0.05	N = 14

[a]Mean and sigma values shown are the maximum retrospective values from Phase 1 scoping survey results for the respective pad/building classification.

Table B-23: Soil Area Factors									
Soil Area Factors	Area Size (square meters)								
	10000	3000	1000	300	100	30	10	3	1
Curtis Bay - Thorium	1.00	1.02	1.03	1.09	1.17	1.39	1.71	2.30	2.80
Curtis Bay - Uranium	1.00	1.01	1.01	1.34	1.40	1.54	1.71	1.96	2.11







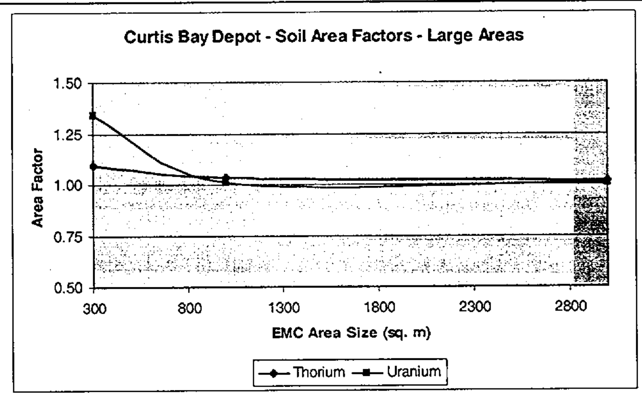
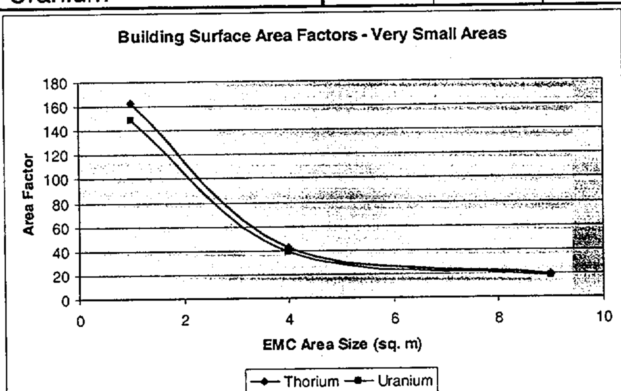
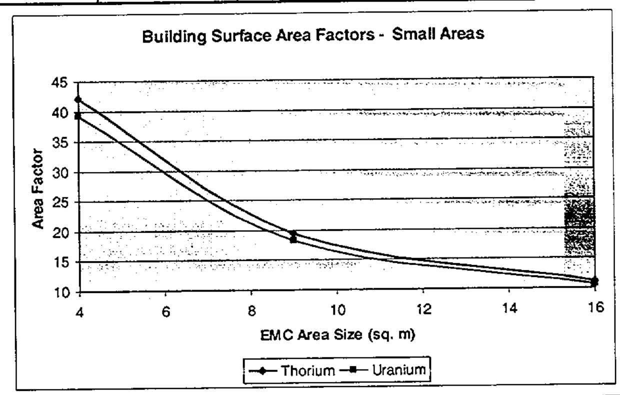
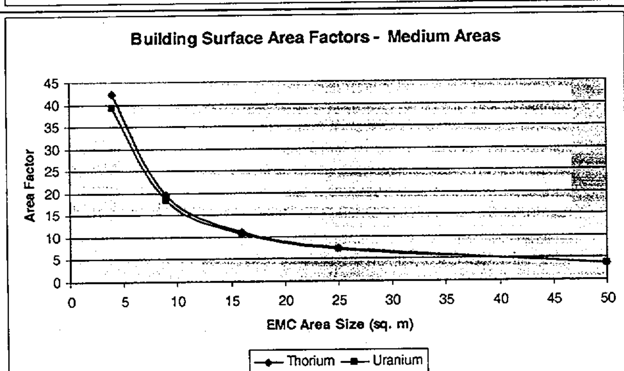


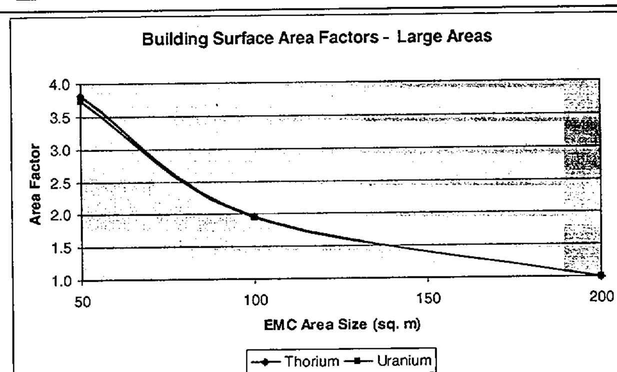
Table B-24: Structural Surface Area Factors

Building Area Factors	Area Size (square meters)							
	200	100	50	25	16	9	4	1
Thorium	1.00	1.96	3.82	7.40	11.24	19.41	42.15	162.56
Uranium	1.00	1.94	3.74	7.15	10.75	18.32	39.19	149.08









APPENDIX C:
REFERENCES

REFERENCES

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