Radiological Historical Site Assessment –

Defense National Stockpile Center; Somerville Depot, Hillsborough, NJ

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Glossary of Terms, Acronyms and Abbreviations

αdm	alpha decays per minute
CEDE	Committed Effective Dose Equivalent
cm^2	square centimeter
cpm	counts per minute
DandD	NRC Dose Modeling Code, Version 2.1.
DCGL	Derived Concentration Guideline Level
DLA	Defense Logistic Agency
DNSC	Defense National Stockpile Center
DoD	Department of Defense
dpm	disintegrations per minute
DQO	data quality objective
EPA	Environmental Protection Agency
FSS	final status survey
ft^2	square feet
GSA	General Services Administration
HSA	historical site assessment
in^2	square inches
LBGR	lower bound of the gray region
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MDC	minimum detectable count
MDCR	minimum detectable count rate
mrem/yr	millirem per year
NRC	Nuclear Regulatory Commission
NUREG	NRC nuclear regulation document
ORPP	Occupational Radiation Protection Program
SU	survey unit
Th	thorium
U	uranium
WRS	Wilcoxon Rank Sum
ZnS(Ag)	Zinc Sulfide with silver doping, a scintillator

Executive Summary

This Historical Site Assessment (HSA) of the Defense National Stockpile Center (DNSC) Somerville Depot, Hillsborough, NJ, was performed in accordance with the requirements of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG 1575, EPA 402-R-97-016. The HSA provides input to the design of Final Status Surveys, which in turn determine if the storage and use areas are suitable for unrestricted release as specified by the Nuclear Regulatory Commission (NRC).

All bulk NRC-licensed material has been removed from the Somerville Depot. Radiological operations at the Depot are authorized under NRC license STC-133, issued to the DNSC, and which expires on February 28, 2010. The license authorizes the storage, sampling, repackaging, and transfer of natural uranium and thorium ores, concentrates, and solids. The total authorized quantity is 2,000,000 kilograms (~4,410,000 pounds). A review of the chemical/isotopic analysis and storage time (50 years plus) indicates that any residual quantities of natural uranium and thorium would be in equilibrium with their progeny.

Impacted warehouses from storage of radioactive materials at the depot consisted of Warehouses 1, 3 and 4. The Decon Trailer was also identified as potentially impacted as samples were tested there. Sampling and repackaging appear to be the only operations which would provide any opportunity for building surface contamination. Since this process was performed under well-documented, controlled conditions, the likelihood of residual contamination, if any, is minimal. Records of storage throughout the years were defined by lots in specific Warehouses and Bays. Non-impacted areas would include any areas not used for sampling or storage.

Findings from the HSA document review and results of characterization surveys indicate that the only Class 1 area is the remediated area in Warehouse 3 Section A. All remaining impacted areas, as identified in the table below, are considered MARSSIM Class 3.

Warehouse	Section	Bays	Purpose
1	C	9,10,17,18	Sampling
1	D	12,15,21	Storage
3	A	1,2,3,4,5,6,7,11, 12,13,14,15,19	Storage
3	E-1	All	Storage
3	E-4	All	Sampling
4	A	20	Storage
4	C	31, 32	Storage
Decon Trailer			Sampling

The development of the site-specific DCGL's has been based on the application of the NRC's DandD computer code with the incorporation of updated dosimetric modeling, as reflected in the dose conversion factors in Federal Guidance Report #13. These DCGL represent residual contamination levels acceptable for unconditional release of the site and license termination. The use of the FGR #13 dose conversion factors has been determined acceptable by NRC for application in deriving site-specific DCGL's. A specific request has been submitted to NRC requesting approval for application for the Somerville facility.

The results for smear (non-fixed) radioactive contamination levels between the reference areas and impacted survey units were not significantly different being within one standard deviation of each other. The residual contamination on walls, if any, should be less than these measured values due to the control over the limited operations which took place.

Warehouses 1 and 4 are currently used for storage of various non-licensed items; the following areas will need to be emptied of all material at time of FSS. All areas of concern in Warehouse 2 and 3 appear to be unused. For the areas identified below, access to wall areas extending to 10 feet on both sides will also be required.

- Warehouse 1 Section C Bays 9, 10, 17, 18.
- Warehouse 1 Section D Bays 12, 15, 21 and 30.
- Warehouse 4 Section A Bay 20
- Warehouse 4 Section C Bays 31 and 32

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1.0 PURPOSE

As a result of the recent removal of all Nuclear Regulatory Commission (NRC) licensed radioactive material, the Defense National Stockpile Center (DNSC) has directed that an investigation be performed at the Somerville Depot to ensure that former storage locations are suitable for unrestricted release as specified by the NRC.

The primary purpose of this Historical Site Assessment (HSA) is to collect existing information concerning the site and its surroundings regarding the use of NRC licensed radioactive materials. This HSA includes those physical measurements and surveys necessary for background reference areas, scoping, and characterization. The gathered information and survey data are designed for use in support of a Final Status Survey.

2.0 PROPERTY DESCRIPTION

2.1 Physical Characteristics

2.1.1 Owner and Operator's Address

The facility is owned by the Federal Government (GSA) and operated by the Defense Logistic Agency, Defense National Stockpile Center, 8725 John J. Kingman Road, Suite 3221, Fort Belvoir, VA 22060-6223.

2.1.2 Facility Location

The address of the DNSC Somerville Depot is 152 US Highway 206 South, Hillsborough, NJ 08844-4135. The Somerville Depot is located on the west side of Route 206, approximately 2.5 miles south of Somerville, NJ. The geographic coordinates are approximately 40º 32'15" north latitude and 74º 38'00" west longitude.

2.1.3 Topography

Figure 1 illustrates the facility location and it relationship to the immediate surrounding communities.

Figure 1 – Satellite Photo of Local Region

2.2 Environmental Setting

The primary references for the environmental setting data are Reference 8.1 and 8.2**.** Much of this data is not pertinent due to the limited use and operations with radioactive materials.

2.2.1 Surface Features

Hydrology flow patterns at the Depot indicate that lands to the east and west of the Depot drain toward the Depot property. Drainage swales located north and south of the Depot provide potential migration routes for the release of contaminates from the site. Ditches to the north of the site drain towards Dukes Brooke while ditches to the south drain toward Royce Brook. Reference 8.1 discusses the environmentally sensitive areas of both Dukes Brook and Royce Brook.

2.2.2 Physical Characteristics

The Depot consists of buildings, paved areas, and maintained grassy areas. The storm water drainage system is controlled by a system of nearly level ditches. As the slope of the ditches is nearly level, the velocity of storm water runoff is slowed and contributes to groundwater recharge on site.

3.0 Historical Site Assessment Methodology

3.1 Approach and Rationale

The primary purpose of the Historical Site Assessment (HSA) is to collect existing information concerning the site and its surroundings.

Further, the primary objectives of the HSA are to:

- identify potential sources of contamination
- determine whether or not sites pose a threat to human health and the environment
- differentiate impacted from non-impacted areas
- provide input to scoping and characterization survey designs
- provide an assessment of the likelihood of contaminant migration
- identify additional potential radiation sites related to the site being investigated.

Scoping and characterization surveys were performed for certain reference areas and related potential survey units identified during the HSA investigation and are documented herein.

3.2 Boundaries of the Site

Currently, the Somerville Depot consists of approximately 77 acres of land. The entrance to the Depot is through Veterans Administration property on the western side of Route 206, approximately two and one half miles (4.0 km) south of Somerville, New Jersey. The Depot can be reached by following Interstate 287 to the Route 206 exit, and by following Route 206 South to the main Depot entrance west of the highway. Entrance is through the main gate through the portion of the former Depot which is owned by the Veterans Administration (VA). The current Depot is located approximately 0.75 miles west of the main gate.

Warehouse storage at the Depot consists of four ground-level concrete-block buildings as shown in Figure 2. Outdoor open storage areas cover approximately 455,000 square feet. The facility also includes the following support buildings: administration building, maintenance building, decontamination trailer, pump house, scale house, switch gear house, and vault.

Security at the facility is provided by a ten-foot chain-link fence surrounding the current Depot property, VA Depot, and US Postal Service (USPS) facility There are six entrance gates and two railroad entrances which are kept locked when not in use. The main gate is open but controlled during working hours.

3.3 Documents Reviewed

Following is a listing of the type and kinds of documents which are maintained by the Depot. In many cases, records dating into the 1950’s were reviewed.

- Transfer Records
- Bill of Ladings
- Receiving Reports
- Visitor and Vehicle Passes
- Inventory Record Cards
- Occupational Radiation Protection Program, Nov. 2002
- Radiation Inspection Reports (NRC and CHPPM)
- NRC STC-133 License and Associated Files
- Sampling Records (1996-2001)

3.4 Property Inspections

A partial tour of the facility was conducted on August 9, 2005 during the pre-bid conference. Each potentially impacted building was observed during the week of November 14-16, 2005,

3.5 Personal Interviews

The following individuals were contacted or interviewed during this HSA.

- F. Kevin Reilly*, Director, Directorate of Environmental Management; Manager Occupational Radiation Protection Program
- Michael Pecullan, Deputy Manager Occupational Radiation Protection Program**
- James M. Farley, Depot Manager, Somerville Depot
- Mary Davidson, Radiation Safety Officer-Somerville Depot and Binghamton Depot**
- Donald Reed, EEO Supervisor, Somerville Depot

- Deborah Eichfeld, Administrative Assistant, Somerville Depot

* Conducted the pre-bid site walk down on August 10, 2005.

** Participated in discussions at the Binghamton Depot, November 7-10, 2005.

4.0 HISTORY AND CURRENT USAGE

4.1 History

The Depot was originally constructed in 1942 and 1943 as a Jersey City Sub-Quartermaster Depot and was responsible for supplying food, clothing, and armor to support the World War II effort. The Depot was also used as a prisoner of war camp for Italian prisoners. In 1946, the Quartermaster operation was relocated to Belle Meade, NJ and the Veterans Administration assumed responsibility and occupied the Depot. The Somerville Depot occupies 77 acres. The VA and the U.S. Postal Service now occupy the balance of the 353 acres available on the Somerville facility. The General Services Administration (GSA) assumed responsibility for the area presently occupied by the Defense National Stockpile Center in March 1952, and in July 1988, the Defense Logistics Agency assumed responsibility for the Depot.

The Somerville Depot is currently operated by the Department of Defense (DoD), Defense Logistics Agency (DLA). The Somerville Depot stored columbium/tantalum and tungsten in various forms (ores and concentrates, metal scrap, natural minerals) which contain naturally occurring radioactive materials in the form of uranium and thorium. Some of these commodities contained sufficient quantities of these two naturally occurring radionuclides as to require licensing by the Nuclear Regulatory Commission (NRC).

4.1.1 Warehouses Used for Storage

Warehouse storage of licensed radioactive material at the depot consisted of three of the four ground-level concrete block buildings (Warehouses 1, 3, and 4) with open steel roof trusses supporting a concrete plank roof deck. The size of each warehouse is 200 feet by 1000 feet. The warehouses are subdivided into five (A through E) equal sections (Section E in Warehouse 3 is further divided into four sub-sections). Each section is accessed through four overhead roll-up metal doors; the subsections in 3E have only two doors each. Figure 2 provides a view of the site layout.

Various sections of the warehouses at the DNSC Somerville contained packaged (wood boxes and steel drums) tungsten ores and concentrates, tantalum/columbium concentrates, tungsten metal scrap, and other materials, some of which contained licensable quantities of thorium and uranium, and were controlled under the DNSC NRC license STC-133.

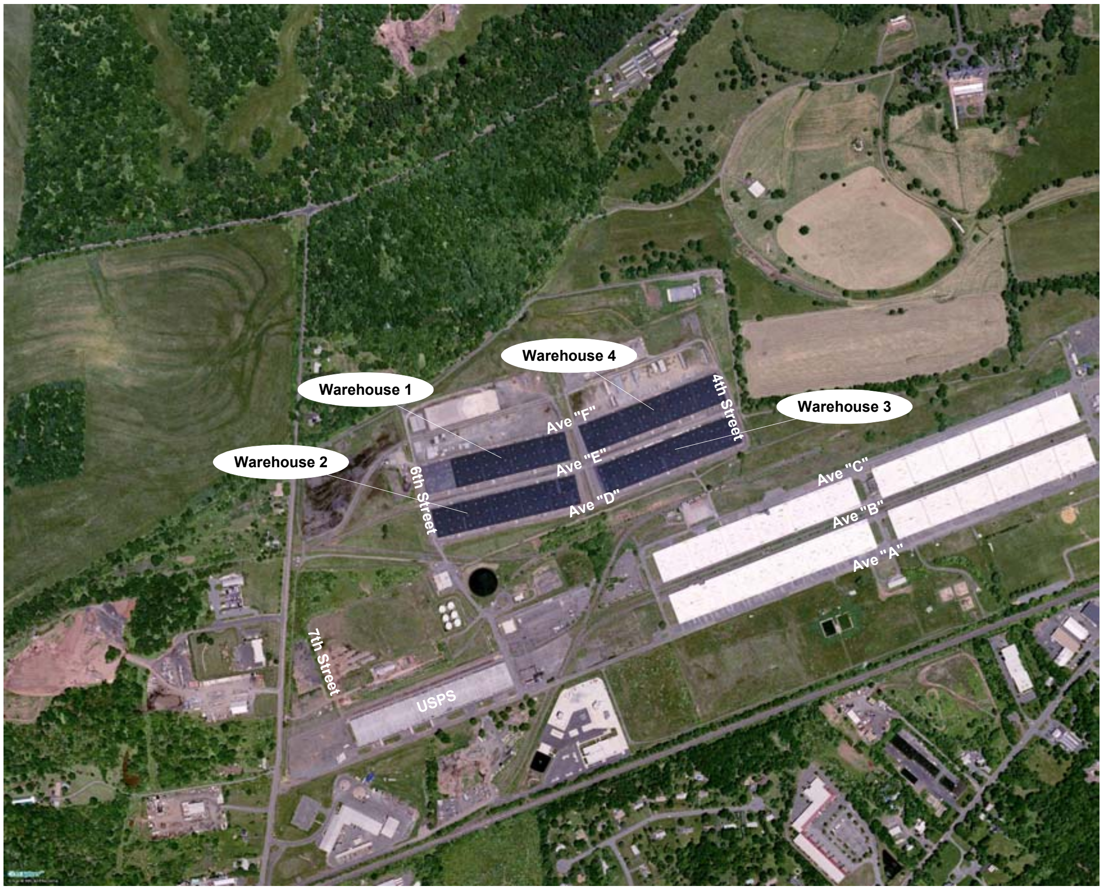


Figure 2 - Somerville Depot Site Layout

4.1.2 Decontamination Trailer

A facility Commodity Inspection Report indicated that four ore samples were opened and limited magnetic testing performed inside the Decontamination Trailer in January 1991. The material was Tantalum Natural Minerals from lots A, B, C, and D. This is the only identified use of the Decontamination Trailer for radioactive materials.

4.1.3 Closed Out Storage Buildings

- **Building T-20**

Part of Building T-20, Section E, was identified as a previous storage area but now operated by the U.S. Postal Service for nearly 30 years. An NRC inspection report dated Jan. 10, 1979, indicated that this building was released to the U.S. Postal Service 3 or more years earlier; no items of non-compliance were observed during the inspection. Building T-20 is bounded by 6th Street on the East, Avenue A on the South, 7th Street on the West, and Avenue B on the North. No characterization survey is deemed required.

- **Building T-57**

Before storage at Building T-20, the initial storage of licensed materials was in Building T-57. This building was razed including the foundation several years ago (pre-1981) and is now a vacant lot. It was located about 550 feet south of the current Depot Administrative Building. The property was deeded to the County of Summerset in June 1981. No characterization survey is deemed required.

4.2 Current Usage

In 2004, the last of the NRC-licensed materials were transferred. The tungsten metal scrap was shipped for burial to Envirocare, UT in September 2004. Shipment of the tantalum concentrates was made to Cabot Performance Materials, Boyertown, PA, earlier in November 2000.

4.3 Adjacent Land Usage

The current Depot property is situated in the western portion of the original 355-acre Depot. The adjacent land to the east is part of the original depot now being used by the Veterans Administration. To the north is the Duke Estate, a tract of approximately 3,000 acres which is largely undeveloped, and a parcel which was once part of the Depot and is currently being used as a firing range. To the west, land use reflects a mixture of residences and commercial businesses along Roycefield Road. Land use to the south is primarily residential, with some commercial businesses. A park and recreational area is also present on land to the southeast which was formerly part of the VA Depot.

5.0 FINDINGS

Radiological operations at the Somerville Depot are authorized under NRC license STC-133 issued to the Defense National Stockpile Center (DNSC) which expires on February 28, 2010. The license authorizes the storage, sampling, repackaging, and transfer of natural uranium and thorium ores, concentrates and solids. The total authorized quantity is 2,000,000 kilograms (~4,410,000 pounds).

Between 1996 and 2001, DLA established a special project to sample the tungsten material in order to determine the percent abundance of uranium and thorium in the ore to establish which required licensing under the NRC. The program did not include columbium/tantalum; however, 314 lots of tungsten ores and concentrates were analyzed and none were found licensable. The analysis for tantalum natural minerals (7 lots) was accomplished during acquisition; all were licensable. Tungsten metal scrap (10 codes) were analyzed via gamma spectroscopy; three were licensable. At the Somerville Depot, the project took place in two separate warehouse sections:

- Warehouse 1 Section C Bays 9, 10, 17 and 18 for tungsten metal scrap.
- Warehouse 3 Section E Cubicle 4 for tungsten ores and concentrates (non-licensable)

The sampling followed a well-defined procedure to minimize the potential for the spread of contamination. The sampling occurred in an area that was covered to protect the floor surface from contamination and with localized ventilation systems to preclude airborne radioactivity. Contamination controls included covering the floor area with plastic and cardboard. Surveys performed following the project did not indicate the presence of residual radioactivity.

5.1 Potential Contaminants

The licensed radionuclides stored at this facility were thorium and uranium contained as a constituent of tungsten or columbium/tantalum. Table 5-1 contains a listing of the various received material and the lot analysis by weight percent for Th an U. The bulk weight of the material sampled is given as well as the weight percentages of Th and U for averages and the high values of sample lots.

Table 5-1. Th and U Weight Percentages for Commodities

Material	Lot	Weight (lbs)	Weight % U	Weight % Th
Tungsten Metal Scrap	Code 1	6,784	< MDL*	0.300
	Code 2	21,121	< MDL	2.280
	Code 6	1,015	< MDL	2.750
Tantalum Natural Minerals	A	41,600	0.153	0.026
	B	38,400	0.144	0.035
	C	41,600	0.161	0.026
	D	38,400	0.144	0.026
	E	45,528	0.127	0.024
	F	45,528	0.127	0.027
	G	45,528	0.136	0.035

* MDL: Minimum Detection Limit. For calculations this was assumed to be zero.

The Tantalum Natural Minerals were in a granular form; however, the tungsten metal scrap had various physical configurations. Code 1 was a wire material. Code 2 was rods, bits, spring and other various shapes. Code 6 consisted of die cores. Photographs are provided below.

Figure 3- Code 1 Wires

Figure 4- Code 2 Various Shapes

Figure 5- Code 6 Miscellaneous Dies

Several commodities were shipped before the sampling program started and their physical properties may mirror the commodities at the Binghamton Depot. These commodities are further described along with their storage locations in Table 5-4.

5.2 Potential Contaminated Areas

All licensed material at the depot was stored indoors. The licensed radioactive materials for the most part were not removed from their containers except during some sampling and over-packaging programs. With the exception of the special project for sampling the content, the containers were not disturbed or opened while at the depot. The following table summarizes the impacted areas with details provided in the supporting paragraphs.

Table 5-2 Impacted Areas

Warehouse	Section	Bays	Purpose
1	C	9,10,17,18	Sampling
1	D	12,15,21	Storage
3	A	1,2,3,4,5,6,7,11, 12,13,14,15,19	Storage
3	E-1	All	Storage
3	E-4	All	Sampling
4	A	20	Storage
4	C	31,32	Storage
Decon Trailer			Sampling

5.2.1 Impacted Warehouses

Detailed records maintained at the Somerville Depot provided information on warehouse sections and bay locations of the materials. Table 5-3 provides information on the type of material stored, the year the material was received at the Depot, and storage locations over the years.

Table 5-3. Somerville NRC-Licensed Material Storage Locations

Material	Lot No	Weight (lbs)	Date Received	Storage Locations			Shipment Date
				Warehouse	Section	Bay	
Tungsten Metal Scrap	Code 1	6784	Circa 1953	3	A	19	
				4	C	32*	9/16/2004
	Code 2	21121	Circa 1953	3	A	19	
				4	C	32*	9/16/2004
	Code 6	1015	Circa 1953	3	A	19	
				4	C	32*	9/16/2004
Tantalum Natural Minerals	A	41600	4/9/1991	3	E-1	NR	11/15/2000
	B	38400	4/9/1991	3	E-1	NR	11/15/2000
	C	41600	4/9/1991	3	E-1	NR	11/16/2000
	D	38400	4/9/1991	3	E-1	NR	11/16/2000
	E	45528	5/15/1991	3	E-1	NR	11/20/2000
	F	45528	5/15/1991	3	E-1	NR	11/20/2000
	G	45528	5/15/1991	3	E-1	NR	11/17&20/2000

*Interview data also indicated Bay 31.

As part of the ORPP, annual surveys of the radioactive material were performed. These surveys included verification of the integrity of the storage containers, inventory, and dose rate measurements. Surveys for the past 30 years (as early as 1975) were reviewed as part of the historical assessment. Interviews indicated that the facility shipping to the Depot would have taken smears prior to shipment. The historical assessment indicated one spill involving radioactive material at the Somerville Depot.

An approximately 36 square foot floor area in Warehouse 3 Section A Bay 5 was previously found to be contaminated with residual trace amounts of naturally occurring uranium and thorium. This area was subsequently cleaned by government employees using HEPA filtered vacuums. Material from the contaminated area in 3A was placed into a container and subsequently disposed of as low level radioactive waste by the government (Ref. 8.14).

Due to their close proximity to the remediated area described above and other storage locations, Warehouse 3, Section A, Bays 4, 6, and 7 were considered as potentially impacted bays. This provides a larger and complete buffer zone for survey around the remediated area.

Certain material was shipped prior to the sampling program. Records indicated the following types of material which could have contained enough Th or U to be considered licensed material. Because of this potential, the storage location list was appended.

Table 5-4. Potentially Licensed Material Shipped Prior to Sampling Program

Material	Lot No.	Storage Locations		
		Warehouse	Section	Bay
Tungsten Concentrates	27, 28, 29	1	D	12
Tungsten Concentrates	NR*	1	D	15
Columbite	NR	1	D	21
Tungsten Concentrates	NR	3	A	1
Tungsten Concentrates (Synthetic Scheelite)	P-3211-D	3	A	2
Tungsten Concentrates (Wolframite)	P-2743(AR)	3	A	2
Ferrotungsten	Item 1299; RR 7783	3	A	3
Tungsten Oxide Powder	Contract T-101 RR-7781	3	A	3
Tungsten Concentrates: Natural Scheelite & Sweeps	S-2 (Samples)	3	A	5
Tungsten Concentrates: Wolframite	S-3 Samples	3	A	5
Ferrotungsten	OOB, OOE, OOG	3	A	5
Synthetic Scheelite, Type E	P3002A,B, P2999E,F	3	A	5
Tungsten Concentrates	RR8791	3	A	11
Tungsten Metal Powder Hydrogen Reduced	7,8	3	A	11
Columbite/Tantalite Ores	NR	3	A	11
Ferrotungsten	Item 15, RR7608	3	A	14
Tungsten Concentrates (Hubernite)	107-111	3	A	15
Tungsten (various)	NR	3	A	19
Tungsten Metal Scrap	NR	3	A	19
Wolframite	NR	3	A	12-14
Wolframite	NR	4	A	20

*NR: Not Recorded

5.2.2 Impacted Decon Area

The Decon Trailer was used by the Depot personnel who participated in the sampling operations of the various ores and concentrates. The Decon Trailer was primarily a clothing change area for non-radioactive work. This trailer is currently located near the Administrative Building. No reports of contamination were noted.

5.2.3 Non-Impacted Areas

Certain warehouse sections currently contain packaged stockpile materials having small amounts of naturally occurring uranium and thorium which, although not in licensable quantities, could interfere with the required surveys. To avoid any potential confusion, these materials should be located at least 100 feet away from all areas designated as impacted for the FSS.

Table 5-5. Material and Locations Below Licensable Quantities

Warehouse/Section	Material	Container
Warehouse 1 Section E	Tungsten	Drums/wooden box
Warehouse 4 Section A	Tungsten	Drums
Warehouse 4 Section B	Tungsten	Drums/wooden box
Warehouse 4 Section C	Tungsten Scrap	Wooden boxes

Due to the limited operations and the historical accounting of use and storage, non-impacted areas are all remaining buildings and bays not listed as a sampling or storage bay.

All outside areas are non-impacted.

5.3 Potential Contaminated Media

A review of potential migration routes within impacted areas was conducted. Migration routes include drainage ditches; outside or inside structures such as floor drains, trenches, or sumps; exhaust/ventilation (e.g., hoods); and sinks (e.g., hand-washing or industrial sinks) that may allow or increase the migration of radionuclides beyond the area where the storage or handling of radioactive materials originally occurred. None of these appear to be an issue at this site except as noted below.

A likely place for contamination to accumulate and migrate within the warehouses would be the cracks and seams of the concrete floor. The floors in all warehouses had significant cracks where any available contamination could accumulate. The shower area within the Decon Area is also a potential area suspect to contamination accumulation.

5.4 Related Environmental Concerns

No related environmental concerns were identified. No environmental releases were identified either by air or water.

5.5 Surveys by Others

A radiological survey was conducted in warehouse sections 3A, 3E-1 and 3E-4 during September 2004; the survey report, dated October 2004, recommended release for unrestricted use (Ref 8.13). The results reported in Reference 8.13 support expectations that only very low levels of contamination exist.

6.0 SCOPING AND CHARACTERIZATION SURVEY

During this historical assessment, detailed information was available to establish specific bays within warehouse sections where NRC-licensed material was stored or sampled. The scoping/characterization surveys were designed to include only bays within a specific warehouse section identified as a storage or sampling area.

<u>Surveys were not performed in all impacted bays but were selected to be representative of the type of material stored or operations performed within the bays</u>. Reference areas were selected to mirror the period of construction and material of impacted bays.

6.1 Scoping and Characterization Survey

The scoping survey included of a walk-down of all potentially impacted areas to determine what material must be moved prior to FSS. Various non-radioactive materials in Warehouse 1, Section D must be removed prior to FSS.

Routinely, a scoping survey is performed with an HSA. As characterization is a more in-depth review, scoping surveys may be considered an integral part and not separate from characterization. To save survey time and other resources, all of the characterization survey data is designed to fit FSS data. All of the locations of the survey points for the Class 3 area are randomly generated and adding additional points will not negate the results of earlier measurements.

MARSSIM maintains that a characterization survey is warranted only for area classified as Class 1 or Class 2. As only one area has required remediation to date and considering the type of work performed at the depots, anticipated residual levels of contamination are low. Characterization will be performed in the traditional sense; collection of data to use in a review of the variation of background levels and potential contamination in impacted areas. MARSSIM is not specific between Class 2 and Class 3 regarding contamination levels but indicates that a Class 3 should only contain a small fraction of a DCGL. MARSSIM further indicates that a Class 2 area should not exceed the DCGL in any single measurement. A DQO for this project is that any static measurement indicating results greater than 35% of a DCGL; would be cause for classification review. MARSSIM definitions would be applied and the impacted area classified accordingly.

Except for the remediated area, all locations of survey points for impacted areas and reference areas are randomly generated. For the remediated area, survey points were determined using a systematic gridding pattern with a random starting location. Should the need occur during FSS to add additional points for a Class 3 area due to a high variance in the contamination level, including additional points will not negate the results of earlier measurements. Initially, impacted areas except for the remediated area are considered as MARSSIM Class 3 which is adequate for characterization regardless of later classification.

As stated, a primary objective of characterization is to collect sufficient data to determine the variance of the contamination levels in both the impacted areas and the reference areas. The characterization survey was designed to envelop all materials and related activities as shown in Table 6-1. All storage areas are identified in Figures 6 through 9.

For the single Class 1 area, characterization was performed and the results may be considered part of FSS. To aid in eliminating any question regarding the size of the area actually contaminated and its cleanup, the earlier described remediated area of 36 ft^2 has been included in a larger survey unit consisting of the eastern one-half of Warehouse 3 Section A, Bay 5. This new survey unit has an area of 625 ft^2 and designed to eliminate the need for an additional Class 2 buffer zone.

Table 6-1. Characterization and Reference Survey Locations

Material	Reason	Locations		
		Warehouse	Section	Bays
None	Reference*	3	E-2	All
None	Reference*	3	E-3	All
Tungsten Metal Scrap	Sampling	1	C	9,10,17,&18
Various	Storage	3	A	4,5,6,11,12,13,14, & 19
Various	Spill Record	3	A	5
Tantalum Natural Minerals	Storage	3	E-1	All
Tungsten Ores and Concentrates	Sampling	3	E-4	All
Tungsten Metal Scrap	Storage	4	C	31, 32
Tantalum (Lots A-D)	Sampling	Decon Trailer**	All	All

* This reference area serves for Warehouses 1, 3, and 4 regardless of material type.
** The need for a reference area for the Decon Trailer is pending FSS DQOs.

6.2 Background Reference Survey Units

The background survey units were chosen due to their similarity in construction materials, construction date and lack of history of storing or handling radioactive materials.

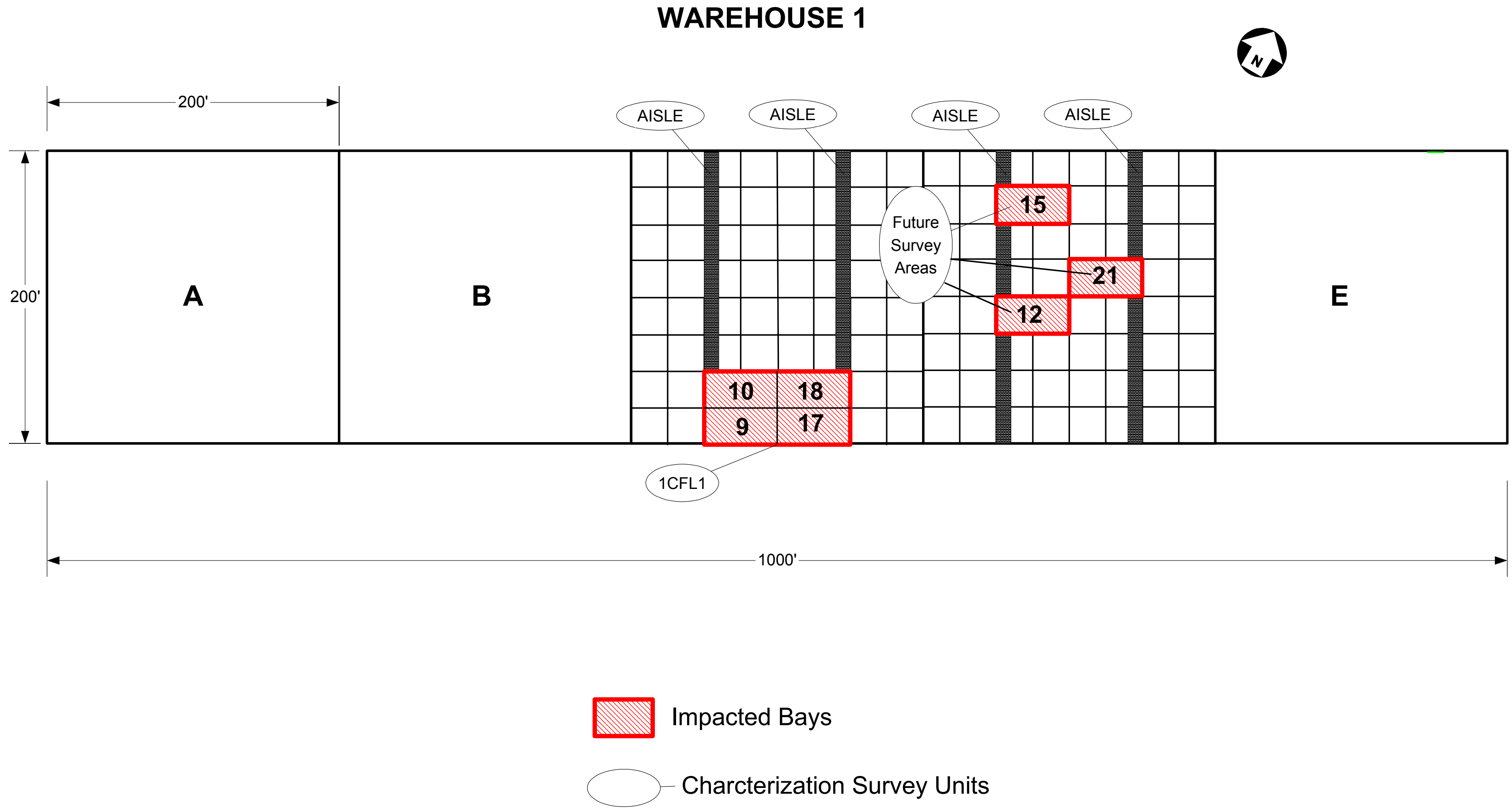


Figure 6- Warehouse 1

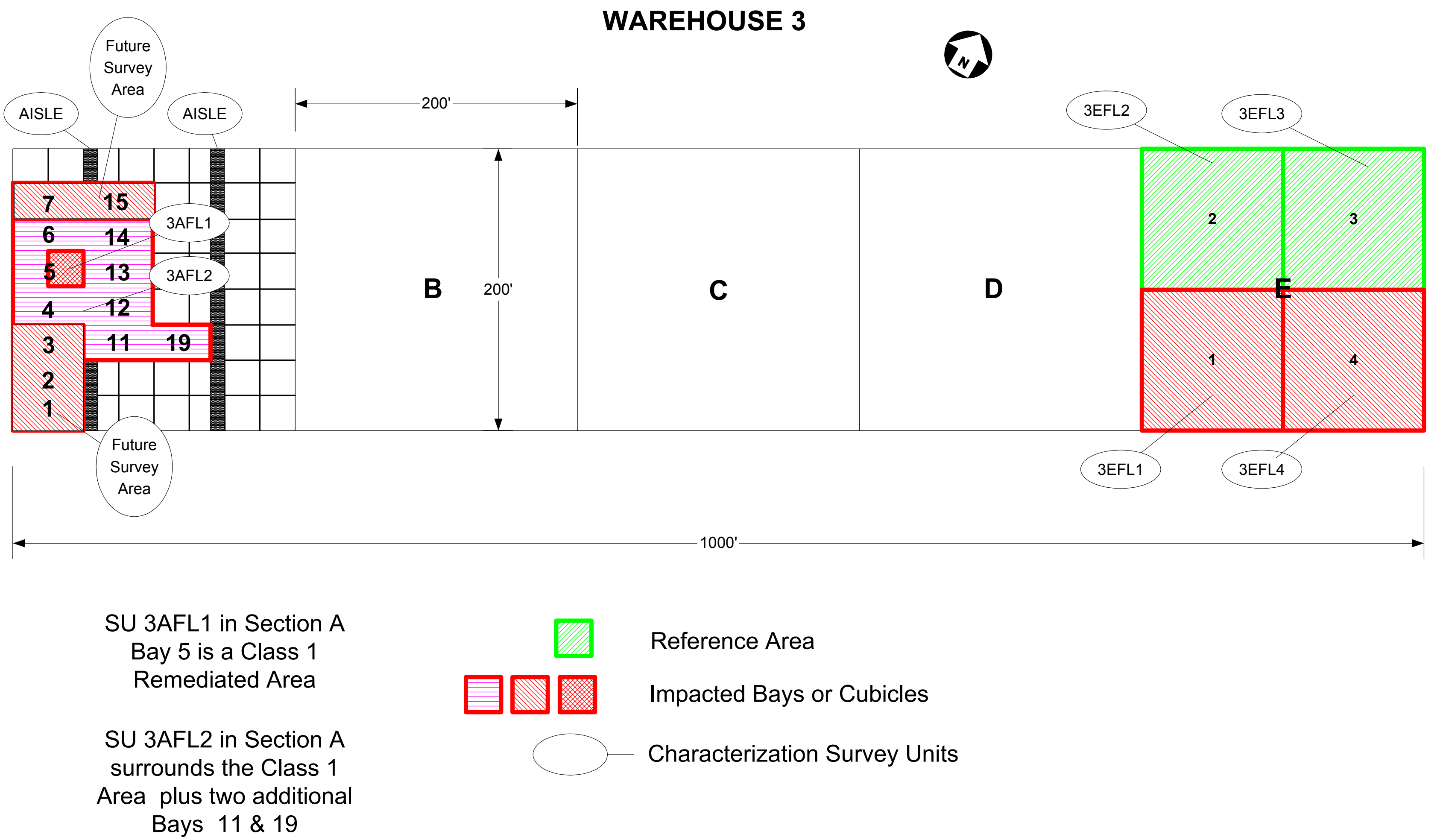


Figure 7 - Warehouse 3

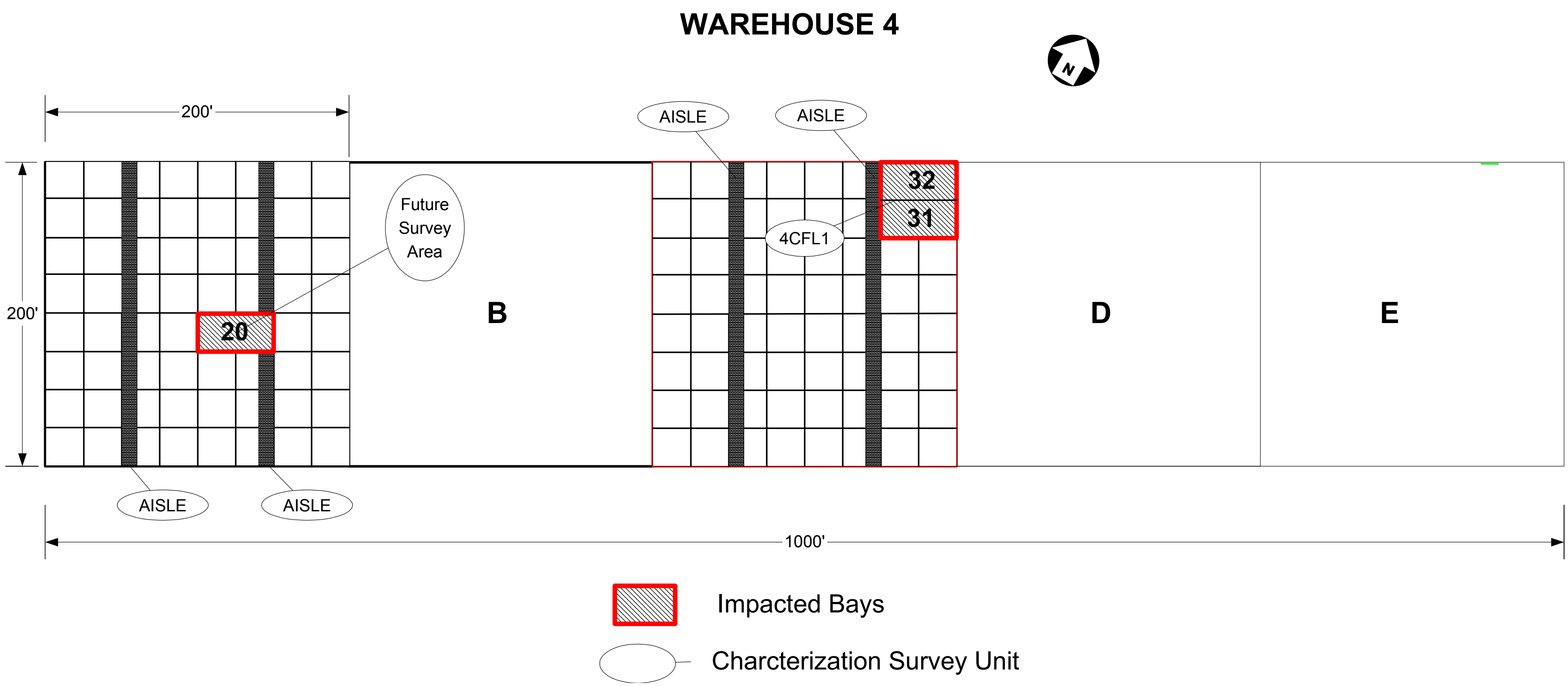
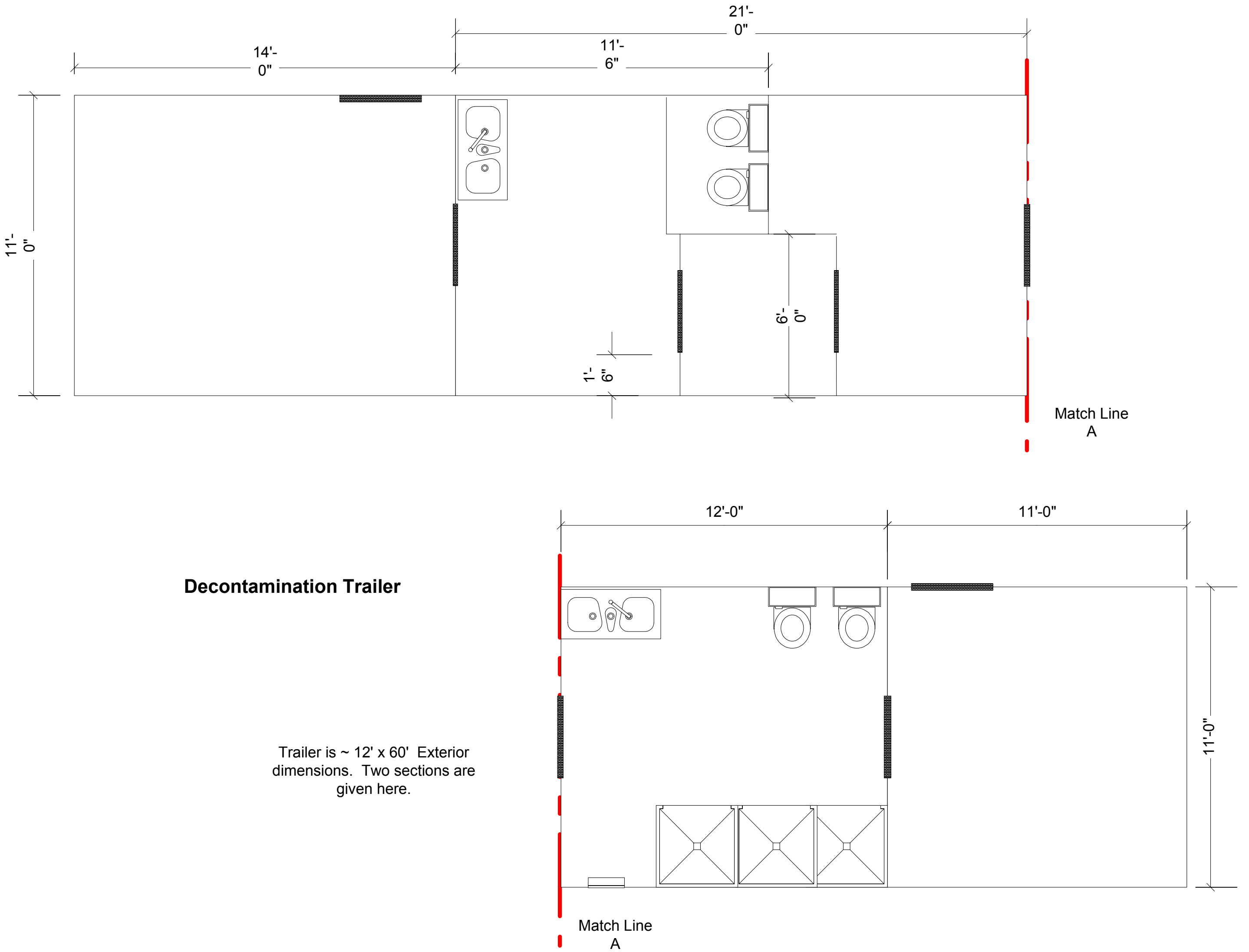


Figure 8 - Warehouse 4



Decontamination Trailer

Trailer is ~ 12' x 60' Exterior dimensions. Two sections are given here.

Figure 9 - Decon Trailer

6.3 Survey Techniques and Instrumentation

The characterization survey consisted of scans, fixed-point measurements (total surface contamination measurements), and smears (removable contamination measurements). The instruments selected for use are provided in Table 6-2.

6.3.1 Instrumentation

Table 6.3 lists the characteristics and application of the instruments; these or instruments of a similar type will be used. All Instruments were calibrated using NIST-traceable standards. Instruments were response checked daily to ensure they are operating properly. In keeping with ANSI guidance, an acceptable ± 20% response range was determined *a priori.*

Instrument records, including dates of use, efficiencies, probe areas, calibration due dates and source tractability are maintained. These records are integral to the application of ChesNuc's MARSS-Surveyor system for this project.

Although thorium and uranium and their progeny emit alpha, beta and gamma radiation, measurements for only alpha radiation will be performed. This is due to the anticipated very low DCGL for thorium and beta measurements are a duplicative effort. The type of instrumentation to be used will be industry standard instruments for alpha detection.

Table 6-2. Instruments

Application	Instrument	Probe Physical Area
Fixed-point measurements	Ludlum 2350-1 data logger with either detector (1) Ludlum 43-1, ZnS (Ag) scintillator *or* (2) Eberline SHP380AB, ZnS (Ag)	83 cm^2 100 cm^2
Alpha scans	Ludlum 2350-1 data logger with either (1) Ludlum 43-1, ZnS (Ag) scintillator *or* (2) Eberline SHP380AB, ZnS (Ag)	83 cm^2 100 cm^2
Smears	Ludlum Model 2929 sample counter; Detector Model 43-10-1 Alpha beta sample counter, scintillator is ZnS(Ag)	2" diameter

6.3.2 Typical Backgrounds

Reference 8.5 presents background count rates for various materials and instrument types; however, site specific values were measured. The values for instrument background rates are provided in Appendix B as about 1.4 or less cpm for the ZnS detectors. Ambient and material background rates were determined in the site reference areas and varied accordingly for the age and type of material, see Table 6.3.

6.3.3 Alpha Scanning

Scanning MDCs for alpha emitters must be derived differently than scanning for beta and gamma emitters. MARSSIM has formulas and probability concepts for scanning alpha contamination when the background is less than 3 cpm. Abelquist (Reference 8.11) has developed scan MDCs on structure surfaces for alpha radiation by use of Poisson summation statistics. Appendix J in MARSSIM provides a complete derivation of the formula used to determine the probability of observing a single count:

$$P(n \geq 1) = 1 - e^{-\left(\frac{G\varepsilon t}{60}\right)}$$

Where P(n $\geq$ 1) is the probability of observing a single count; G is the elevated area activity (αpm); ε is the detector efficiency (4π); and t is the residence time of the detector over the activity.

The scan process must be in two stages: continuous monitoring and stationary sampling (pausing). During the continuous monitoring, the surveyor listens to the number of clicks. Because the instrument background is low (<3 cpm), a single count gives the surveyor cause to stop and investigate further by pausing for an additional number of seconds. The scan MDC for alpha contamination must be based on the continuous monitoring stage which is illustrated as follows.

Per Abelquist's example pages193-197: setting the P(n $\geq$ 1) at the 90% level and solving for G which is now defined as the alpha scan MDC.

$$scanMDC_{alpha} = \frac{[-\ln(1 - P(n \geq 1))]60}{\varepsilon_i \varepsilon_s t}$$

where:

ε_i = Intrinsic instrument efficiency

ε_s = Surface efficiency

t = residence time (sec), calculated from scan rate

Reference 8.5, Table 5.5 gives a surface material effect for a distributed source on sealed concrete as 0.428 for ZnS detectors. This type of surface and contamination should represent the majority of any impacted areas. Further, per Reference 8.5, Table 5.6, the MDC for a point source on scabbled concrete versus a distributed source on sealed concrete would be higher by about 1.6. Although scabbled areas were not identified, cracks were present and should elevated readings be noted in cracks, the concept of a higher MDC would be included in the review of the data.

Even though the scan process is in two stages, all data is logged and any area with an elevated count may be revisited. The detector meter system logs measurements on an established frequency that is established to be consistent with the scan speed for ensuring complete data collection.

Once a count is recorded and the surveyor stops, the surveyor should wait a sufficient period of time such that, if activity at the MDC were present, it would be noticed. This time period can be estimated from the scan MDC and the time required for about another count to register. For example, an alpha activity of about 100 alphas per minute with efficiencies of 0.428 and 0.358, pausing for 4 seconds after the initial count is registered will yield one alpha count:

$$(100\ \alpha pm)(0.428)(0.358)(4\ sec)(1\ min/60sec) = 1\ count$$

If no additional counts are observed in the 4 second period, the initial count is either at background levels or less than scan MDC. This process is applied per planned residence time and the individual instrument efficiency; each work package will have a planned survey scan speed.

The survey technicians used a slow scan rate (automatically recorded in data loggers) for the remediated area as the interval time was 7.5 seconds as shown in Table 6-3. The scan MDC value for the remediated area was about 120 αpm/100cm^2. This data will be reviewed under the MARSSIM graded approach and FSS DQOs.

Other scan MDC values were higher. These higher levels of scan MDCs may be acceptable as MARSSIM does not require them to be lower than the DCGL. MARSSIM page 5-45 is quoted: "In Class 2 or 3 areas, neither measurements above the $DCGL_w$ nor areas of elevated activity are expected. Any measurement at a discrete location exceeding the $DCGL_w$ in these areas should be flagged for further investigation. Because the survey design for Class 2 and Class 3 survey units is not driven by the EMC, the scanning MDC might exceed the $DCGL_w$. In this case, any indication of residual radioactivity during the scan would warrant further investigation." This concept was employed; noting again that all measurements were logged. All characterization data will be reviewed for acceptability for the FSS.

Table 6-3. Instrument Scan Characteristics

Characterization Survey Unit	Material Background* (cpm)	Scan Interval Time (sec)	scanMDC (αpm/100cm2)	Probe
3AFL1	4.7	7.5	120	SHP380AB
3AFL2	4.7	1.2	751	SHP380AB
3EFL2	0.1	1.2	414	L43-1-1
3EFL4	4.7	1.2	414	L43-1-1

* An instrument background is shown for the reference area 3EFL2.

6.3.4 Static and Swipe Minimum Detectable Activities (MDC)

NUREG-1507, Reference 8.5, provides a rigorous derivation of the calculational expression for instrument sensitivity, typically stated as the minimum detectable concentration (MDC). The MDC equations and example values for both static measurements and swipe analysis are presented in this section.

For static measurements, background and indicator measurements are both typically one minute in duration. The following equation for the MDC from Reference 8.5, Equation 3-9, as modified for here applies:

$$MDC = \frac{3 + 4.65 * s_b}{(\varepsilon_s)(\varepsilon_i)\left(\frac{a}{100cm^2}\right)}$$

where:

s_b = standard deviation of background measurements
ε_i = Intrinsic instrument efficiency
ε_s = Surface efficiency
a = probe area in cm^2

As an example, 16 measurements were made in the reference area (Warehouse 3 Section E Cube 3) on the concrete floor and the results show a background rate of 4.8 cpm with a sigma of 2.4 cpm. The physical size of the probe was 100 cm^2. With a total efficiency of 0.153 cpm/αpm (this is the surface efficiency of 0.428 epm/αpm times the instrument efficiency of 0.358 cpm/epm), the MDC is about 93 αpm/100 cm^2.

Background and sample count times used to analyze a swipe are typically twenty minutes and one minute, respectively. When the background count time and the sample count time are different, the following MDC formula, taken from Reference 8.5, Equation 3-11, as modified for here, applies:

$$MDC = \frac{3 + 3.29\sqrt{R_B t_S \left(1 + \frac{t_S}{t_B}\right)}}{(\varepsilon_s)(\varepsilon_i)(t_S)\left(\frac{a}{100cm^2}\right)}$$

where:

R_B = Background count rate (cpm)
t_S = Sample counting time
t_B = Background counting time
ε_i = Intrinsic instrument efficiency
ε_s = Surface efficiency
a = area of surface smear in cm^2, nominally 100 cm^2

Smears were analyzed using a Ludlum Model 2929 with the MDC calculated using the daily background count time of 20 minutes. The total efficiency was determined from the reported emissions per minute (epm) on the calibration trace form of the source and the surface efficiency was set to approximate dirt loading on the smear paper. Per McFarland's data for filter paper, Reference 8.16, alpha particle counting efficiency is lowered by approximately 15% from dirt loading of 5 mg on the paper. As most smears are from "clean" surfaces which would typically contain 1-3 mg of dirt; a reasonable and conservative assumption would be to set the loss at 10%. Conservatively assuming no back-scatter and since alpha emissions are in equal directions (50% in either the up or down direction), a surface efficiency of 0.45 epm/αpm is set to account for the dust loading effect.

A typical MDC for the smear analysis unit, Ludlum 2929, is about 18.5 αpm/100 cm^2. This calculation includes the low background of 0.8 cpm over a 20 minute period and a source efficiency of 0.723 cpm/epm.

6.3.5 Surface Activity

A measurement for surface activity is performed over an area, represented by the physical surface area of the detector. To convert instrument counts to conventional surface activity units, the following equation is used:

$$\frac{dpm}{100cm^2} = \frac{\frac{C_s}{t_s} - \frac{C_b}{t_b}}{(\varepsilon_s)(\varepsilon_i)\left(\frac{a}{100cm^2}\right)}$$

where:

C_s = Integrated counts recorded by the instrument

C_b = Background counts recorded by the instrument

t_S = Sample counting time

t_B = Background counting time

ε_i = Intrinsic instrument efficiency

ε_s = Surface efficiency

a = probe area in cm^2, or
= area of surface smear in cm^2

6.4 Determining the Number of Survey Points

The following technique is presented for determining the number of samples required for a FSS; however, neither the variance of the activity in the survey or reference unit is now known. The number of survey points as estimated here may be increased but MARSSIM indicates the value to use; this value should be conservative until actual values are known. MARSSIM also recommends a minimum of 5 measurements to aid in determining the standard deviations in the residual contamination. A characterization DQO was that representative measurements would be collected, not necessarily from each impacted bay, but a particular area/material should have at least 5 measurements.

Reference area measurements can be used for multiple survey units as long as the material being surveyed in the survey unit is similar to that of the reference area.

For structure surfaces, the WRS test may be used. Reference 8.7, Section 5.5.2.2, describe the process for determining the number of survey measurements necessary to ensure a data set sufficient for statistical analysis. The method for determining the combined number of data points (N) for the survey unit and reference area is based on the expected contaminant variability and the predetermined acceptable Type I and Type II error rates.

The project data quality objectives (DQO) established the Type I and Type II error rates (α and β respectively) at 0.05.

The "relative shift" (Δ/σ) is the ratio involving the concentration to be measured (Δ) relative to the expected variability in that concentration sigma (σ), and can be thought of as an expression of the resolution of the measurements. The sigma (σ) is selected from the larger of that found in the survey unit or the reference area. The shift (Δ) is the width of the statistical gray region or difference in the release criterion and the lower bound of the gray region (LBGR). The gray region is the area where the impact of making an incorrect error decision (Type I or Type II error) is small.

The LBGR is estimated as one-half of the DCGL. MARSSIM recommends assuming a coefficient of variation of 30% for sigma when preliminary data are not available, an assumption of 0.3 times the DCGL. All of this is summarized in the following formulas:

$$\frac{\Delta}{\sigma} = \frac{DCGL - 0.5 * DCGL}{\sigma}$$

$$\frac{\Delta}{\sigma} = \frac{0.5}{0.3}$$

$$\frac{\Delta}{\sigma} \approx 1.7$$

To determine the actual number of data points needed for a FSS in each survey unit and reference area, Reference 8.7 lookup Table 5.3 is used. Therefore, <u>each</u> structure survey unit and the reference area are expected to have a <u>minimum</u> of 15 survey points. (All of this data is to be used as representative; actual needs will be determined post characterization survey.)

6.5 Reference and Impacted Area Survey Requirements

The information collected about operations and storage of radioactive material indicate that very little contamination, if any, could be expected. Per Reference 8.7, there are no size limitations on Class 3 and Reference Areas. Except for the one remediated area, All areas were to be treated as Class 3 unless characterization showed otherwise.

Prior to a survey at each sampling location, the floor was cleaned with a non-greasy "Swifter" cloth to remove dust which could interfere with the alpha counting efficiency. All survey units received a 5% alpha scan at the random locations and also bias scans along cracks and seams in the concrete floors. Each survey unit and the reference area were initially designed to have a <u>minimum</u> of 15 randomly located survey points. (If 15 data points were not collected during characterization, the need for additional points will be evaluated at time of the FSS.) A smear was collected at each survey point which was performed after the scan and direct measurements . An exception to this technique was that only bias sampling was performed in the Decon Room to permit the technician more freedom in evaluating drains and sink areas.

As described in Reference 8.9, walls and ceilings of structures are expected to have contamination levels of 50% and 10%, respectively, of the contamination level on the floor. As the floor contamination levels are expected to be minimal and no use/operation has been identified which would contaminate the walls, the distribution of residual radioactivity, if any, should follow the 50% and 10% respective levels.

As directed by Reference 8.7, each survey unit will receive a surface scan using appropriate survey instruments. For surface contamination detectors, scanning at no greater than one detector width per second will ensure that the scan MDC meets the project DQOs. Scan speed is normally one detector width per second or slower. Class 3 survey unit scanning sections are arbitrary sections of the survey unit that can be defined. For example, if there are 15 fixed-point measurements in a 1,000 ft^2 (100 m^2) survey unit, the technician should survey 3 - 4 ft^2 around each fixed-point. The scanned area meets the 5% scan coverage for Class 3 areas for this characterization survey. For each scanning section, the average and maximum count rates (in gross cpm) were recorded. Judgmental scans were performed in areas of highest potential (*e.g.*, corners, seams between concrete pours, or base of support poles) based on professional judgment. This provides a qualitative level of confidence that no areas of elevated activity were missed by the random measurements or that there were no errors made in classification.

6.6 Survey Results

The locations of static measurements and scanning sections are illustrated in Attachment B. Statistical data in Appendix B are shown by rounding and minor errors may propagate.

6.6.1 Reference Area Results

Table 6-4 summarizes the results of the static and smear measurements while Table 6-5 summarizes the results of scan measurements for one of the reference units. Detailed results of static, smear, and scan measurements for each individual location are provided in Appendix B. An estimated material background for the Decon Trailer was not made pending FSS resolution of material to use as a background; however, the intrinsic instrument background was applied.

Table 6-4. Summary of Reference Units Static and Smear Measurements

Function	Static Measurements Activity (αpm/100cm^2)		Smear Measurements Activity (αpm/100cm^2)	
	3EFL02	3EFL03	3EFL02	3EFL03
Number	15	16	15	16
Minimum	4	4	-2.5	-2.5
Maximum	56	56	9.8	9.8
Average	21	22	1.2	1.2
Std Dev	16	15	3.5	3.6

Table 6-5. Summary of Warehouse 3 Section E Cube 2 Reference Area Scan Measurements

Location	Net Results* (αpm/100cm^2)	
	Average	Maximum
1	8	23
2	7	24
3	14	48
4	10	30
5	11	25
6	10	37
7	10	37
8	14	35
9	21	44
Average:	12	

*Background averages have been subtracted. No scan result exceeded the scan MDC.

6.6.2 Characterization Survey Unit Results

Tables 6-6, 6-7, and 6-8 summarize the results of the static, scan, and smear measurements for the selected characterization survey units. Details of measurement results for each individual location are provided in Appendix B.

Table 6-6. Summary of Characterization SU Static Measurements

Characterization Survey Unit	Warehouse/ Section	Bays	Net Results* (αpm/100cm^2)	
			Average	Maximum
1CFL1	1C	9, 10, 17, 18	< 0	22
3AFL1	3A	5	< 0	28
3AFL2	3A	4-6, 11-14, 19	< 0	22
3EFL1	3E Cube 1	All	9	54
3EFL4	3E Cube 4	All	< 0	8
4CFL1	4C	31, 32	< 0	15
DTFL1	Decon Trailer	All	< 0	10

*Background averages have been subtracted.

Table 6-7. Summary of Characterization SU Scan Measurements

Characterization Survey Unit	Warehouse/ Section	Bays	Net Results* (αpm/100cm^2)	
			Average	Maximum
1CFL1	1C	9, 10, 17, 18	Not Scanned	
3AFL1	3A	5 (partial)	< 0	58
3AFL2	3A	4-6, 11-14, 19	< 0	66
3EFL1	3E Cube 1	All	Not Scanned	
3EFL4	3E Cube 4	All	< 0	27
4CFL1	4C	31, 32	Not Scanned	
DTFL1	Decon Trailer	All	Not Scanned	

*Background averages have been subtracted. No scan result exceeded the scan MDC.

Table 6-8. Summary of Characterization SU Smear Measurements

Function	Activity (αpm/100cm^2)						
	1CFL01	3AFL01	3AFL02	3EFL01	3EFL04	4CFL01	DTFL01
Number	16	16	18	16	16	15	15
Minimum	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5
Maximum	9.8	6.8	16.0	6.8	9.8	12.9	9.8
Average	2.2	1.8	3.5	0.6	2.2	2.5	1.4
Std Dev	3.7	2.9	4.4	3.6	3.5	4.0	3.4

6.7 Gross Surface Activity DCGLs

To complete the final status survey, this plan focuses on the evaluation of alpha emissions. The NRC has released DandD version 2.1 for use by licensees which includes the ability to calculate DCGLs for natural thorium and natural uranium. For this evaluation reverse engineering was applied and the number of simulations was 10,000 to assure that the estimated DCGLs would not exceed 25.0 mrem/yr. As DandD provides estimates in terms of dpm, these estimates were converted to αpm for use at this site.

6.7.1 DandD Code Evaluations

For natural thorium, the estimated DCGL for the Building Occupancy Scenario was 5.9 dpm/100cm^2. To obtain a DCGL for natural uranium, a mixture of U-238+C and U-235+C was used and 11.6 and 0.556 dpm/100cm^2, respectively, were determined as the combined activity for the DCGL. The U-235 activity of 0.556 dpm/100cm^2 is the natural abundance at 2.34% of the total activity (Table 3.1.1 of Reference 8.17) for natural uranium. Results of the DandD computer runs are in Appendix B. These DCGL values are developed into DCGLs based on alpha emissions as follows.

Reference 8.18 was used to establish the number of alpha emissions per parent decay in each chain.

- As Th-232 is in equilibrium with its progeny, there are six alpha emissions for each decay of a Th-232 atom. The alpha emissions are one each from Th-232, Th-228, Ra-224, Rn-220, Po-216 while Bi-212 and Po-212 combined emissions yield one from both. The alpha based DCGL for 5.9 dpm/100cm^2 is then six times that or ~36 αpm/100cm^2.

- As natural uranium consists of U-238, U-234 and U-235, the number of alphas emitted per decay of a U-238 atom requires consideration of the activity abundance of each found in nature, 48.83%, 48.83%, and 2.34%.

  U-238 and U-234 are considered in the same decay chain with a total of eight alpha emissions for each decay of a U-238 atom. The alpha emissions are counted as one each from U-238, U-234, Th-230, Ra-226, Rn-222, Po-218, Po-214, and Po-210. Credit was not taken for the insignificant alpha emission fractions of At-218, Pb-210, and Bi-210. The contribution to the natural uranium alpha based DCGL from U-238+C at 11.6 dpm/100cm^2 is eight times that or 92.8 αpm/100cm^2.

For the U-235 series, the alpha emissions total seven for each decay of a U-235 atom with one each from U-235, Pa-231, Th-227, Ra-223, Rn-219, Po-215, and Bi-211. Credit was not taken for the insignificant alpha emission fractions of Ac-227, Fr-223, At-215, and Po-211. The contribution to the natural uranium alpha based DCGL from U-235+C at 0.556 dpm/100cm^2 is seven times that or 3.9 αpm/100cm^2.

The combined alpha DCGL from U-238+C and U-235+C at 11.6 and 0.556 dpm/100cm^2, respectively, is 96.7 αpm/100cm^2.

6.7.2 Dose Multiples of Federal Guidance Report No.13

Multiples of individual radionuclide dose factors of FGR-11 to FGR-13 were then applied to determine the dose that would be calculated if the DandD code used FGR-13 dose factors. This was done for both the ingestion and inhalation pathways holding the external pathway as constant. The dose was reduced by a factor of 6.36 and 4.63 for natural thorium and natural uranium, respectively.

Simple ratios were applied to obtain the increased DCGLS based on the dose reductions.

- For natural thorium, the estimated FGR-13 DCGL for the Building Occupancy Scenario was 37.3 dpm/100cm^2. The alpha based DCGL for 37.3 dpm/100cm^2 is then six times that or about 224 αpm/100cm^2.
- The values calculated for a combined radionuclide FGR-13 DCGL for natural uranium from a mixture of U-238+C and U-235+C were 53.7 and 2.57 dpm/100cm^2, respectively. The U-235 activity of 2.57 dpm/100cm^2 is the natural abundance at 2.34% of the total activity for natural uranium.

  The contribution to the natural uranium alpha based FGR-13 DCGL from U-238+C at 53.7 dpm/100cm^2 is eight times that or about 430 αpm/100cm^2.

  The contribution to the natural uranium alpha based DCGL from U-235+C at 2.57 dpm/100cm^2 is seven times that or about 18 αpm/100cm^2.

  The combined alpha FGR-13 DCGL for natural uranium from U-238+C and U-235+C at 53.7 and 2.57 dpm/100cm^2, respectively, is 448 αpm/100cm^2.

The following table summarizes the DCGLs and their reference source developed in this paragraph.

Table 6-9. DCGL Comparisons

Reference	DCGL (dpm/100cm^2)	
	Th-nat	U-Nat*
DandD*	5.9	11.6
Alpha Based w DandD	36	97
FGR-13*	37	54
Alpha Based w FGR-13	224	448

* DandD and FGR-13 line values are for U-238; lines for Alpha Based includeU-235+C.

Note that Table 6.9 reflects 6 alpha emissions per dpm for thorium and about 8.3 alpha emissions per dpm of U-238.

6.7.3 Commodity Specific DCGLs

From the concentrations listed per lot given in Appendix A, a dpm per gram ratio was established and then alpha emission rates were calculated.

As an example, the weight percentages for the Tantalum Natural Minerals Lot A from Table 5.1 are given as 0.153% and 0.026% for uranium and thorium respectively. The activity/mass relationship is defined by the US Department of Transportation (DOT), 10 CFR Part 49 (Reference 8.19). The alpha rate per gram is then calculated individually for natural uranium and natural thorium; a ratio is then made of alphas from natural uranium to natural thorium. The following equation is used.

$$AlphaRate/gram = WgtFraction * A/Mass * Nuclide_{fraction} * CF * Alphas/Element$$

where:

Wgt Fraction	= Respective % converted to fraction from Table 5.1.
A/Mass	= Activity to mass relationship established by DOT as 7.1E-7 Ci/g for natural uranium and 2.2E-7 Ci/g for thorium.
$Nuclide_{fraction}$	= Fraction of activity abundance for the tracking nuclide; 0.4883 for U-238 and 1.0 for natural thorium.
CF	= Conversion factor; 2.22E12 dpm/Ci.
Alphas/Element	= The number of alpha emissions per natural thorium or natural uranium expected for the nuclide fraction; 6 for natural thorium and 8.3 for U-238.

Continuing with the Tantalum Natural Minerals Lot A example, and substituting the values for uranium into the above equation:

AlphaRate/gram = 0.00153 * 7.1E-7 Ci/g *0.4883* 2.22E12 *8.3

AlphaRate/gram = 9,773 alphas/gram

Similarly for thorium:

AlphaRate/gram = 0.00026 * 2.2E-7 Ci/g *1.0* 2.22E12 *6

AlphaRate/gram = 762 alphas/gram

The ratio of uranium to thorium alphas is the ratio of the above two rates: 9,773/762 or 12.8 alphas from uranium to 1 alpha from thorium.

An alpha emission ratio was established per lot (shown in Table 6-10) and the gross activity $DCGL_{alpha}$ was determined per the following equation.

$$GrossActivityDCGL_{alpha} = \frac{1}{\left(\frac{fi}{DCGL_1} + \frac{f_2}{DCGL_2}\right)}$$

Where: f_1 is the alpha fraction for natural thorium

f_2 is the alpha fraction for natural uranium

$DCGL_1$ is the alpha DCGL for natural thorium

$DCGL_2$ is the alpha DCGL for natural uranium

As an example, the calculation is shown for the FGR-13 value for the Tantalum Natural Minerals Lot A as indicated in Table 6-10. The calculation uses the emissions ratio indicated in Table 6-10 with the DCGL from Table 6-9. Per Table 6-10, the alphas from thorium represent a fraction of 1/13.8 of the total emissions and those from uranium are about 12.8/13.8 of the total. These values are entered into the above equation.

$$GrossActivityDCGL_{alpha} = \frac{1}{\left(\frac{0.0725}{224} + \frac{0.9275}{448}\right)} \text{ αpm/100cm}^2$$

$$GrossActivityDCGL_{alpha} = 418 \text{ αpm/100cm}^2$$

A $DCGL_{alpha}$ value for each lot of the Tungsten Metal Scrap and Tantalum Natural Minerals are shown in Table 6-10. For the Tungsten Metal Scrap, all reported weight percentages were reported as less than MDL and the conservative DCGL for 100% thorium is listed for this material. As expected in that Tantalum Natural Minerals contain some quantity amount of thorium, the $DCGL_{alpha}$(s) are somewhat lesser than that for natural uranium.

Table 6-10. Surface Gross Activity DCGLs

Commodity	Lot	Ratio of U/Th Alphas	FGR-13 DCGL (αpm/100cm2)
Tungsten Metal Scrap	1	NA*	224
	2	NA	224
	6	NA	224
Tantalum Natural Minerals	A	12.8	418
	B	9.0	407
	C	13.5	419
	D	12.1	416
	E	11.5	415
	F	10.3	411
	G	8.5	405

*NA- Not applicable as all material was considered as thorium.

For those areas for which sampling and testing was not performed on the stored materials, a conservative approach would be to use the lowest DCGL (that for the Tungsten Metal Scrap).

6.8 Comparison of Survey Measurements, MDCs, and DCGLs

Table 6-11 provides a comparison per characterization survey unit of the maximum measurements, the respective DCGLs, and both static and scan MDCs. DCGLs reflect the particular commodity or activity in the survey unit. For example, the DCGL for DTFL1 indicates that material was identified from Lots A-D and therefore the lowest DCGL of those lots should be applied.

Table 6-11. Comparison of Survey Measurements, MDCs, and DCGLs

Survey Unit	FGR-13 $DCGL_{alpha}$ αpm/ 100cm^2	MDC_{static} αpm/ 100cm^2	MDC_{scan} αpm/ 100cm^2	Net Results (αpm/100cm2)	
				Static Maximum	Scan Maximum
1CFL1	224	92	Not Scanned	22	Not Scanned
3AFL1	224	92	120	28	58
3AFL2	224	92	751	22	66
3EFL1	405	92	Not Scanned	54	Not Scanned
3EFL4	405	92	414	9	27
4CFL1	224	92	Not Scanned	15	Not Scanned
DTFL1	224	92	Not Scanned	10	Not Scanned

7.0 CONCLUSIONS

The following conclusions are presented:

- Impacted warehouses from storage of radioactive materials at the depot consisted of Warehouses 1, 3 and 4. The Decon Trailer was also identified as potentially impacted as samples were tested there. Sampling and repackaging appear to be the only operations which would provide any opportunity for building surface contamination.
- A review of the chemical or isotopic analysis and storage time (50 years plus) indicates that that any residual quantities of Th-232 and natural uranium would exist in secular equilibrium with their progeny.
- DCGLs based on use of the FGR-13 dosimetry listed in Table 6-11 may be derived from the weight percentages of Th and U in a given lot. As storage of material is defined by lots in specific Warehouses and Bays throughout the years, it may be possible to use a specific DCGL for a respective lot. DandD DCGLs are very low and may be impractical even with state-of-the-art instruments used during the characterization; three survey units had static measurements which would require Class 2 classification under DandD DCGLs.

- No static measurement exceeded either DandD or FGR-13 DCGL values. The highest percentage for a static measurement of an FGR-13 DCGL was 13%.

- Results for smear (non-fixed) radioactive contamination average levels ranged from 1 to 4 αpm/100 cm^2 with a maximum of 17 αpm/100 cm^2. Averages for the reference survey units were both 1.2 αpm/100 cm^2 with a maximum of 10 αpm/100 cm^2. The highest average for any survey unit is about 2% of the applicable FGR-13 $DCGL_{alpha}$.

- The results for scan measurements of impacted areas were less than MDCs. All scan measurement results were less than DCGLs. The average scan result for each area was less than zero; an indication that these measurements will not affect the classification. No change in classification is justified for these scan results considering the range of the background and the MDC.

- The residual contamination on walls, if any, should be less than these measured values due to the control over the limited operations which took place.

- As Warehouses 1 and 4 are currently used for storage of various items, the following areas should be noted to be emptied of all material at FSS. Areas of concern in Warehouse 2 and 3 appear to be unused.

    - Warehouse 1 Section C Bays 9, 10, 17, 18.
    - Warehouse 1 Section D Bays 12, 15, 21 and 30.
    - Warehouse 4 Section A Bay 20
    - Warehouse 4 Section C Bays 31 and 32

8.0 REFERENCES

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8.7 *Multi-Agency Radiation Survey and Site Investigation Manual*, EPA/402/R-97-016, Revision 1. NUREG 1575, U.S. NRC, August, 2000.

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8.10 Source Materials License STC-133, U.S. NRC, May 5, 2003.

8.11 "Standards for Protection Against Radiation," Title 10 Code of Federal Regulations, Part 20 (10 CFR 20), U.S. NRC, as amended.

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8.13 *Final Status Survey Report for the Defense National Stockpile Center's Somerville Depot Section 3A, and Cubicles 3E-1& 3E-4 Somerville, NJ,* Tetratech NUS, Oct. 15, 2004.

8.14 Inter-Office Memorandum, 17 Jun 2004, Subject: Decontamination WHSE 3 Sections A & E1 and 4, Jason Boynton to Kevin Reilly.

8.15 *Decommissioning Health Physics*, EW Abelquist, IOP Publishing Ltd, 2001.

8.16 McFarland, RC, *Determination of Alpha Particle Counting Efficiency for Wipe Test Samples*, Radioactivity & Radiochemistry, Vol. 9, No. 1, 1998.

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8.18 *The Health Physics and Radiological Handbook,* Revised Edition, Scinta, Inc. Silver Spring, MD 20902, 1992.

8.19 "Activity-mass Relationship for Uranium and Natural Thorium, "Title 49 Code of Federal Regulations, Part 49 (49 CFR Chapter I Part 173 Section 173.434), U.S. DOT.

Appendix A - Characterization Measurement Results

Instrument Efficiency Calculation

SITE: DLA

Date:	**11/07/05**

Instrument Information		
Type/Serial #	2350-1	180729
Probe/Serial #:	SHP380AB	00176
Calibration Due Date:	11/5/2006	

Source Information	
Isotope	Th230
Serial Number	A2-743
2π Emission Rate(EPM)	17610

	Source counts	Bkg counts
1	6343	1
2	6424	1
3	6284	1
4	6198	1
5	6169	2
6	6399	1
7	6274	1
8	6330	0
9	6195	4
10	6268	0
11	6401	1
12	6319	1
13	6366	2
14	6306	2
15	6274	1
16	6440	1
17	6261	3
18	6324	2
19	6357	0
20	6222	2
SUM	126154	27
Average	6308	1.4

Count Time in minutes	1

$$\text{Inst. Eff.} = \frac{\text{Avg Source CPM} - \text{Avg Bkg CPM}}{\text{Source } 2\pi \text{ Activity (epm)}}$$

Inst. Eff.= 0.358

Instrument Efficiency Calculation

SITE: DLA

Date:	**11/07/05**

Instrument Information		
Type/Serial #	L2350-1	142513
Probe/Serial #:	43-1-1	PR093536
Calibration Due Date:	11/5/2006	

Source Information	
Isotope	Th230
Serial Number	A2-743
2π Emission Rate(EPM)	17610

	Source counts	Bkg counts
1	11380	0
2	11505	0
3	11349	0
4	11340	0
5	11302	0
6	11334	0
7	11394	0
8	11136	0
9	11410	0
10	11302	1
11	11402	0
12	11467	0
13	11268	0
14	11518	0
15	11384	0
16	11448	0
17	11391	0
18	11538	0
19	11370	0
20	11438	0
SUM	227676	1
Average	11383.8	0.1

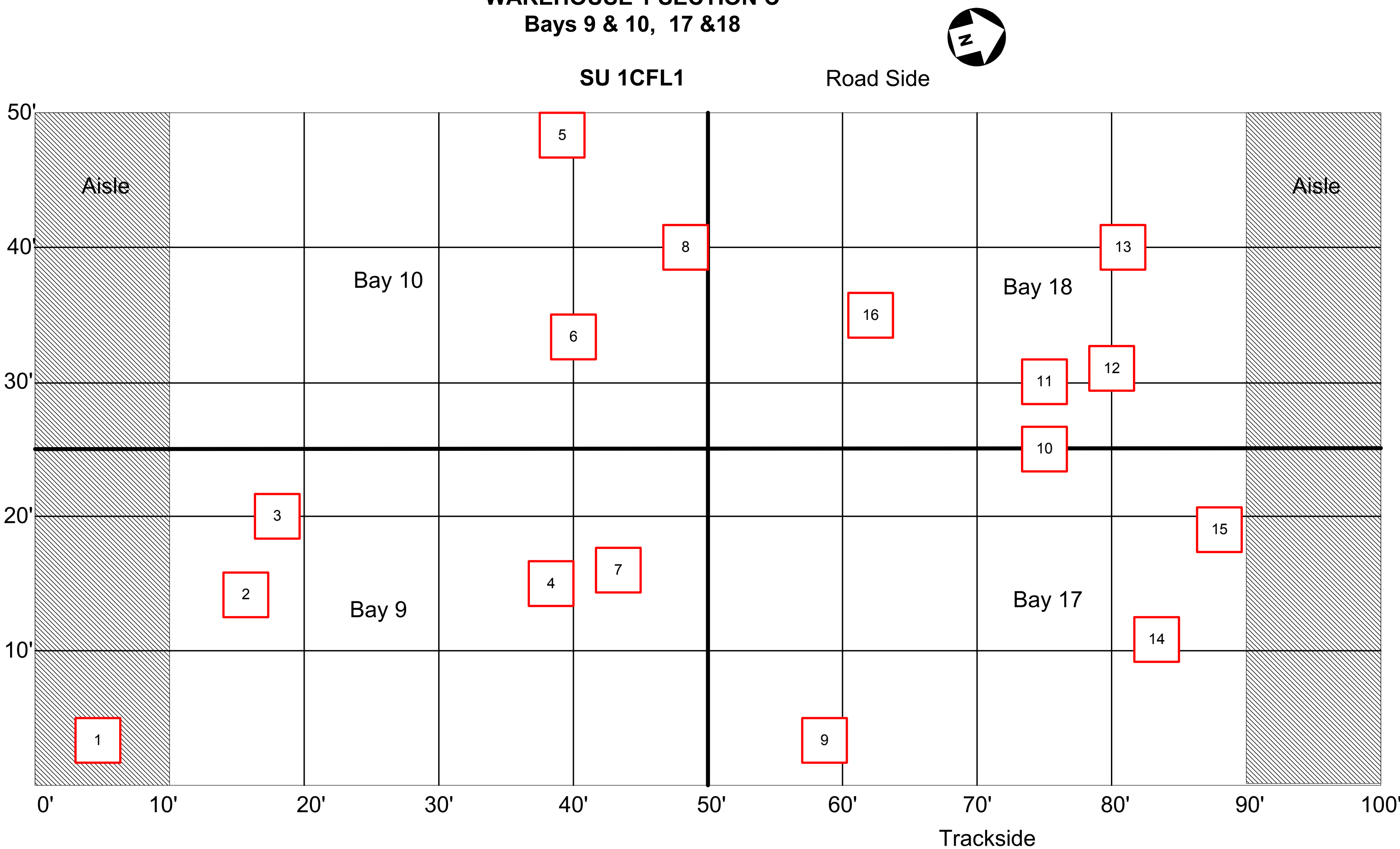
Count Time in minutes	1

$$\text{Inst. Eff.} = \frac{\text{Avg Source CPM} - \text{Avg Bkg CPM}}{\text{Source } 2\pi \text{ Activity (epm)}}$$

Inst. Eff.= 0.646

WAREHOUSE 1 SECTION C
Bays 9 & 10, 17 &18

SU 1CFL1



Survey Unit 1CFL1	Coordinates (ft)		
N	**X**	**Y**	
1	5	3	
2	15	14	
3	17	20	
4	38	15	
5	39	47	
6	40	33	
7	43	16	
8	48	40	
9	58	4	
10	75	25	
11	75	30	
12	80	31	
13	81	40	
14	83	11	
15	87	19	
16	62	35	Bias

Summary of Static Measurements - Alpha

Survey Unit: 1CFL1
Description: Storage Area
Survey Date: 11/15/2005

Location	Gross (counts)	Net (αpm/100 cm²) Activity	Net (αpm/100 cm²) Uncertainty @ 95% CL
1	1	-24.15	13.8
2	3	-11.09	22.7
3	5	1.96	29.0
4	3	-11.09	22.7
5	4	-4.57	26.1
6	5	1.96	29.0
7	2	-17.62	18.8
8	2	-17.62	18.8
9	5	1.96	29.0
10	4	-4.57	26.1
11	4	-4.57	26.1
12	2	-17.62	18.8
13	2	-17.62	18.8
14	8	21.54	36.5
15	4	-4.57	26.1
16	3	-11.09	22.7
Minimum:	1	-24.1	
Maximum:	8	21.5	
Average:	3.6	-7.4	
Std Dev:	1.7	11.2	

Analysis Parameters

Material: concrete
Background: 4.7 cpm
Background Count Time: 30 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 92 αpm/100 cm2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AE	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 1CFL1
Description: Storage Area
Survey Date: 11/15/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	0	-2.5	5.4
2	0	-2.5	5.4
3	1	0.6	8.1
4	3	6.8	11.7
5	3	6.8	11.7
6	2	3.7	10.1
7	1	0.6	8.1
8	2	3.7	10.1
9	1	0.6	8.1
10	1	0.6	8.1
11	1	0.6	8.1
12	1	0.6	8.1
13	1	0.6	8.1
14	0	-2.5	5.4
15	4	9.8	13.2
16	3	6.8	11.7
Minimum:	0	-2.5	
Maximum:	4	9.8	
Average:	1.5	2.2	
Std Dev:	1.2	3.7	

Analysis Parameters

Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2
Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 12/2/2005

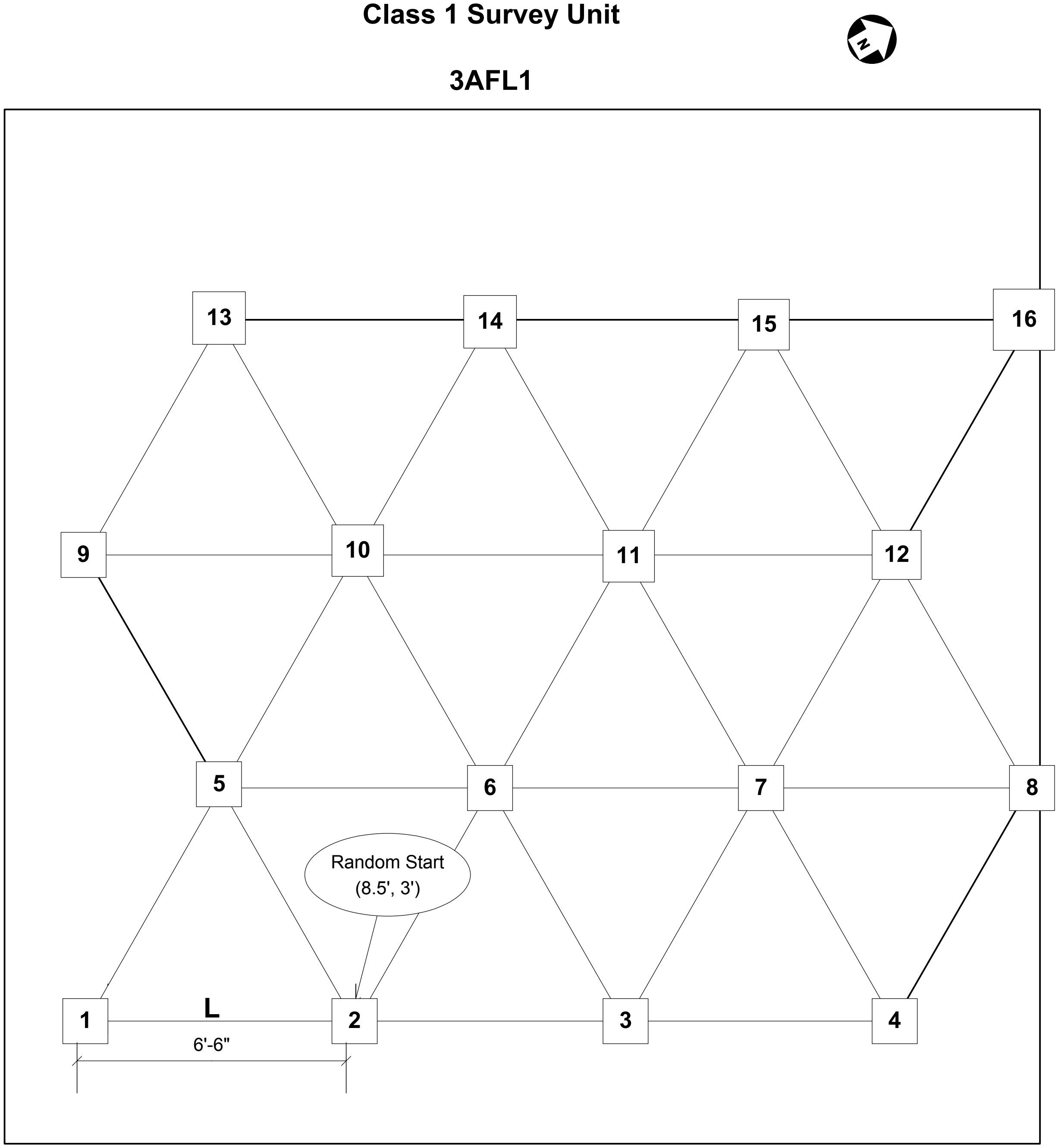
Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Warehouse 3 A Bay 5 -
Class 1 Survey Unit

3AFL1



Class 1 Area: 3AFL01

Number of samples to be taken (N/2):	15		
Size of survey area:	625	ft^2	
Calculated "L" Value:	6.9	ft	
Survey pattern spacing (L):	6' 6"	Rounded down length of side in feet (rounding recommended by MARSSIM)	
Scan Data			
Total Scan Area	625	ft^2	
Scan Area per Point	42	ft^2	**Only one point was scanned during HSA**
Center to Edge Distance	2.0	ft	
Scan Time	2906	sec	For one point.
Scan Rate	0.014	ft^2/sec	
Probe Area	100	cm^2	
	0.108	ft^2	
Scan Rate	0.13	detector area/sec	
Scan Interval	7.5	sec	

Random Start	**X**	**Y**	
	8.5	3	feet

Summary of Static Measurements - Alpha

Survey Unit: 3AFL1
Description: Class 1 Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	5	1.96	29.0
2	2	-17.62	18.8
3	5	1.96	29.0
4	3	-11.09	22.7
5	4	-4.57	26.1
6	3	-11.09	22.7
7	7	15.01	34.2
8	2	-17.62	18.8
9	6	8.48	31.7
10	9	28.06	38.7
11	3	-11.09	22.7
12	4	-4.57	26.1
13	4	-4.57	26.1
14	6	8.48	31.7
15	5	1.96	29.0
16	4	-4.57	26.1
Minimum:	2	-17.6	
Maximum:	9	28.1	
Average:	4.5	-1.3	
Std Dev:	1.9	12.2	

Analysis Parameters

Material: concrete
Background: 4.7 cpm
Background Count Time: 30 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 92 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AE	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 3AFL1
Description: Class 1 Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	3	6.8	10.5
2	1	0.6	6.1
3	2	3.7	8.6
4	1	0.6	6.1
5	0	-2.5	1.2
6	1	0.6	6.1
7	2	3.7	8.6
8	2	3.7	8.6
9	2	3.7	8.6
10	2	3.7	8.6
11	0	-2.5	1.2
12	1	0.6	6.1
13	3	6.8	10.5
14	0	-2.5	1.2
15	1	0.6	6.1
16	1	0.6	6.1
Minimum:	0	-2.5	
Maximum:	3	6.8	
Average:	1.4	1.8	
Std Dev:	1.0	2.9	

Analysis Parameters

Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2

Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 11/18/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Summary of Scan Results - Alpha

Survey Unit: 3AFL1
Description: Class 1 Area
Survey Date: 11/16/2005

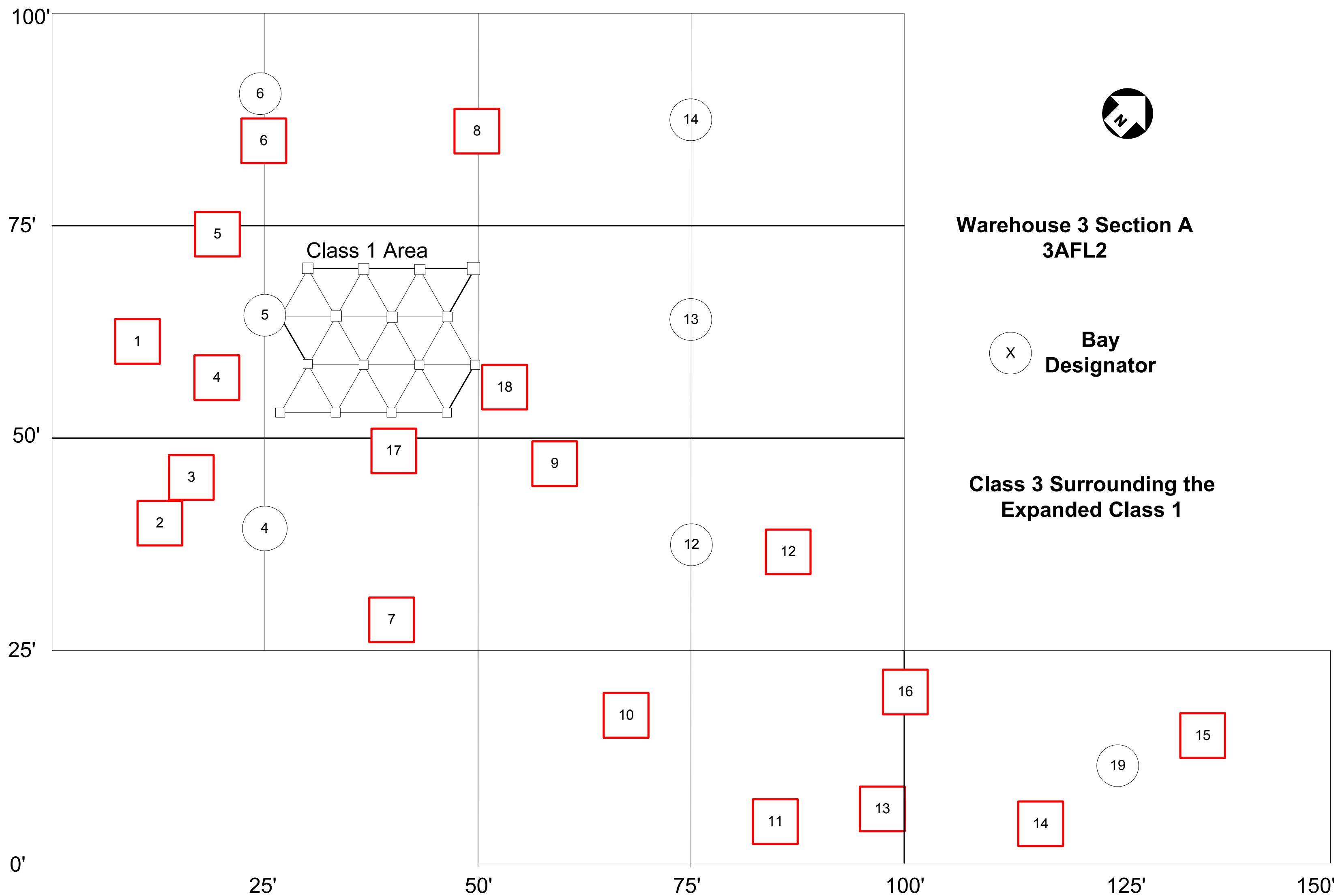
	Gross (cpm)			Net (αpm/100 cm^2)		
Location	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
1	0.0	13.6	3.6	-30.7	58.0	-7.1
		Average:	3.6		**Average:**	-7.1

Analysis Parameters

		P(n>1)	90%
Material:	concrete	**Data Recorded:**	Yes
Background:	4.7 cpm	**Time Interval:**	7.5 s
Reference Area:	3EFL2		
Surface Efficiency:	0.428 epm/dpm	**MDC:**	120 αpm/100 cm^2

Instrument Data

	Model	Serial No		
Instrument:	L2350-1	180729	**Probe Area:**	100 cm^2
Detector:	SHP380AE	00176	**Instrument Efficiency:**	0.358 cpm/epm


100'
75'
50'
25'
0'
25'
50'
75'
100'
125'
150'
Class 1 Area
Warehouse 3 Section A
3AFL2
X
Bay Designator
Class 3 Surrounding the Expanded Class 1
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Survey Unit 3AFL2	Coordinates (ft)	
N	**X**	**Y**
1	10	61
2	12	40
3	17	45
4	19	57
5	19	74
6	25	85
7	40	28
8	50	86
9	59	46
10	68	18
11	84	4
12	87	36
13	97	7
14	116	4
15	135	15
16	100	20
17	40	48
18	53	56
Scan Rate	0.86	detector area/sec
Scan Interval	1.2	sec

Summary of Static Measurements - Alpha

Survey Unit: 3AFL2
Description: Storage Area
Survey Date: 11/15/2005

Location	Gross (counts)	Net (αpm/100 cm2) Activity	Uncertainty @ 95% CL
1	8	21.54	36.5
2	1	-24.15	13.8
3	1	-24.15	13.8
4	2	-17.62	18.8
5	1	-24.15	13.8
6	2	-17.62	18.8
7	5	1.96	29.0
8	3	-11.09	22.7
9	5	1.96	29.0
10	2	-17.62	18.8
11	3	-11.09	22.7
12	5	1.96	29.0
13	5	1.96	29.0
14	5	1.96	29.0
15	2	-17.62	18.8
16	1	-24.15	13.8
17	6	8.48	31.7
18	0	-30.67	5.1
Minimum:	0	-30.7	
Maximum:	8	21.5	
Average:	3.2	-10.0	
Std Dev:	2.2	14.4	

Analysis Parameters

Material: concrete
Background: 4.7 cpm
Background Count Time: 30 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 92 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AE	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 3AFL2
Description: Storage Area
Survey Date: 11/15/2005

Location	Gross (counts)	Net (αpm/100 cm2) Activity	Net (αpm/100 cm2) Uncertainty @ 95% CL
1	3	6.8	11.7
2	2	3.7	10.1
3	2	3.7	10.1
4	1	0.6	8.1
5	2	3.7	10.1
6	2	3.7	10.1
7	0	-2.5	5.4
8	1	0.6	8.1
9	3	6.8	11.7
10	1	0.6	8.1
11	3	6.8	11.7
12	0	-2.5	5.4
13	2	3.7	10.1
14	2	3.7	10.1
15	6	16.0	15.7
16	3	6.8	11.7
17	0	-2.5	5.4
18	2	3.7	10.1
Minimum:	0	-2.5	
Maximum:	6	16.0	
Average:	1.9	3.5	
Std Dev:	1.4	4.4	

Analysis Parameters

Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2
Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 12/2/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Summary of Scan Results - Alpha

Survey Unit: 3AFL2
Description: Storage Area
Survey Date: 11/16/2005

	Gross (cpm)			Net (αpm/100 cm^2)		
Location	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
1	1.9	8.9	5.0	-18.4	27.5	2.0
2	0.7	8.7	3.4	-26.1	25.9	-8.7
3	0.5	5.9	2.3	-27.6	7.6	-15.9
4	0.0	10.5	3.2	-30.7	38.2	-9.9
5	1.4	9.6	4.8	-21.5	32.0	0.8
6	0.9	14.3	4.3	-24.6	62.6	-2.9
7	1.2	6.3	3.2	-23.0	10.6	-10.1
8	0.9	9.8	3.2	-24.6	33.6	-9.5
9	0.7	11.3	4.4	-26.1	42.7	-2.1
10	0.7	14.8	5.7	-26.1	65.7	6.5
11	0.7	8.0	3.6	-26.1	21.3	-7.4
12	1.9	14.1	5.5	-18.4	61.1	5.3
13	1.9	12.4	5.9	-18.4	50.4	7.6
14	0.5	6.8	2.9	-27.6	13.7	-11.8
15	0.5	12.9	4.1	-27.6	53.5	-4.1
16	0.7	8.9	3.7	-26.1	27.5	-6.6
17	0.7	10.3	3.7	-26.1	36.6	-6.4
18	0.0	7.5	3.0	-30.7	18.3	-10.8
		Average:	4.0		**Average:**	-4.7

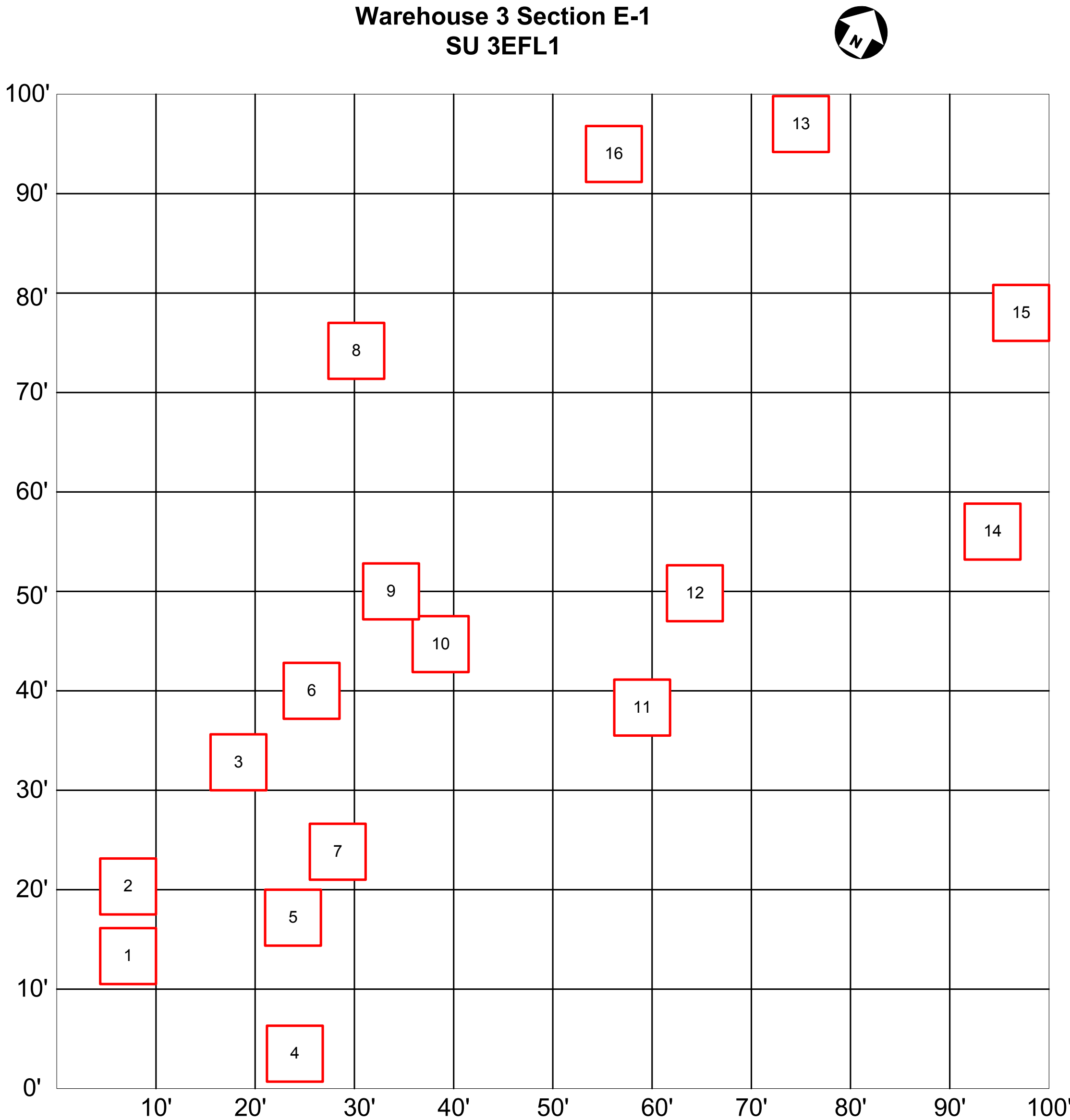
Analysis Parameters

		P(N>1)	90%
Material:	concrete	**Data Recorded:**	Yes
Background:	4.7 cpm	**Time Interval:**	1.2 s
Reference Area:	3EFL2		
Surface Efficiency:	0.428 epm/dpm	**MDC:**	751 αpm/100 cm^2

Instrument Data

	Model	Serial No		
Instrument:	L2350-1	180729	**Probe Area:**	100 cm^2
Detector:	SHP380AE	00176	**Instrument Efficiency:**	0.358 cpm/epm

Warehouse 3 Section E-1
SU 3EFL1



Survey Unit
3EFL1

	Coordinates (ft)	
N	**X**	**Y**
1	8	13
2	8	22
3	18	34
4	24	4
5	24	17
6	26	40
7	28	24
8	30	74
9	33	50
10	39	43
11	59	38
12	64	50
13	75	97
14	94	56
15	97	78
16	56	94

Summary of Static Measurements - Alpha

Survey Unit: 3EFL1
Description: Storage Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm²) Activity	Net (αpm/100 cm²) Uncertainty @ 95% CL
1	13	54.17	46.4
2	4	-4.57	26.1
3	4	-4.57	26.1
4	8	21.54	36.5
5	6	8.48	31.7
6	8	21.54	36.5
7	3	-11.09	22.7
8	5	1.96	29.0
9	7	15.01	34.2
10	5	1.96	29.0
11	4	-4.57	26.1
12	4	-4.57	26.1
13	8	21.54	36.5
14	3	-11.09	22.7
15	7	15.01	34.2
16	8	21.54	36.5
Minimum:	3	-11.1	
Maximum:	13	54.2	
Average:	6.1	8.9	
Std Dev:	2.6	17.1	

Analysis Parameters

Material: concrete
Background: 4.7 cpm
Background Count Time: 30 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 92 αpm/100 cm²

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AE	00176

Probe Area: 100 cm²
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 3EFL1
Description: Storage Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net ($dpm/100\ cm^2$) Activity	Net ($dpm/100\ cm^2$) Uncertainty @ 95% CL
1	3	6.8	11.7
2	3	6.8	11.7
3	0	-2.5	5.4
4	0	-2.5	5.4
5	1	0.6	8.1
6	1	0.6	8.1
7	1	0.6	8.1
8	0	-2.5	5.4
9	0	-2.5	5.4
10	1	0.6	8.1
11	0	-2.5	5.4
12	2	3.7	10.1
13	0	-2.5	5.4
14	0	-2.5	5.4
15	1	0.6	8.1
16	3	6.8	11.7
Minimum:	0	-2.5	
Maximum:	3	6.8	
Average:	1.0	0.6	
Std Dev:	1.2	3.6	

Analysis Parameters

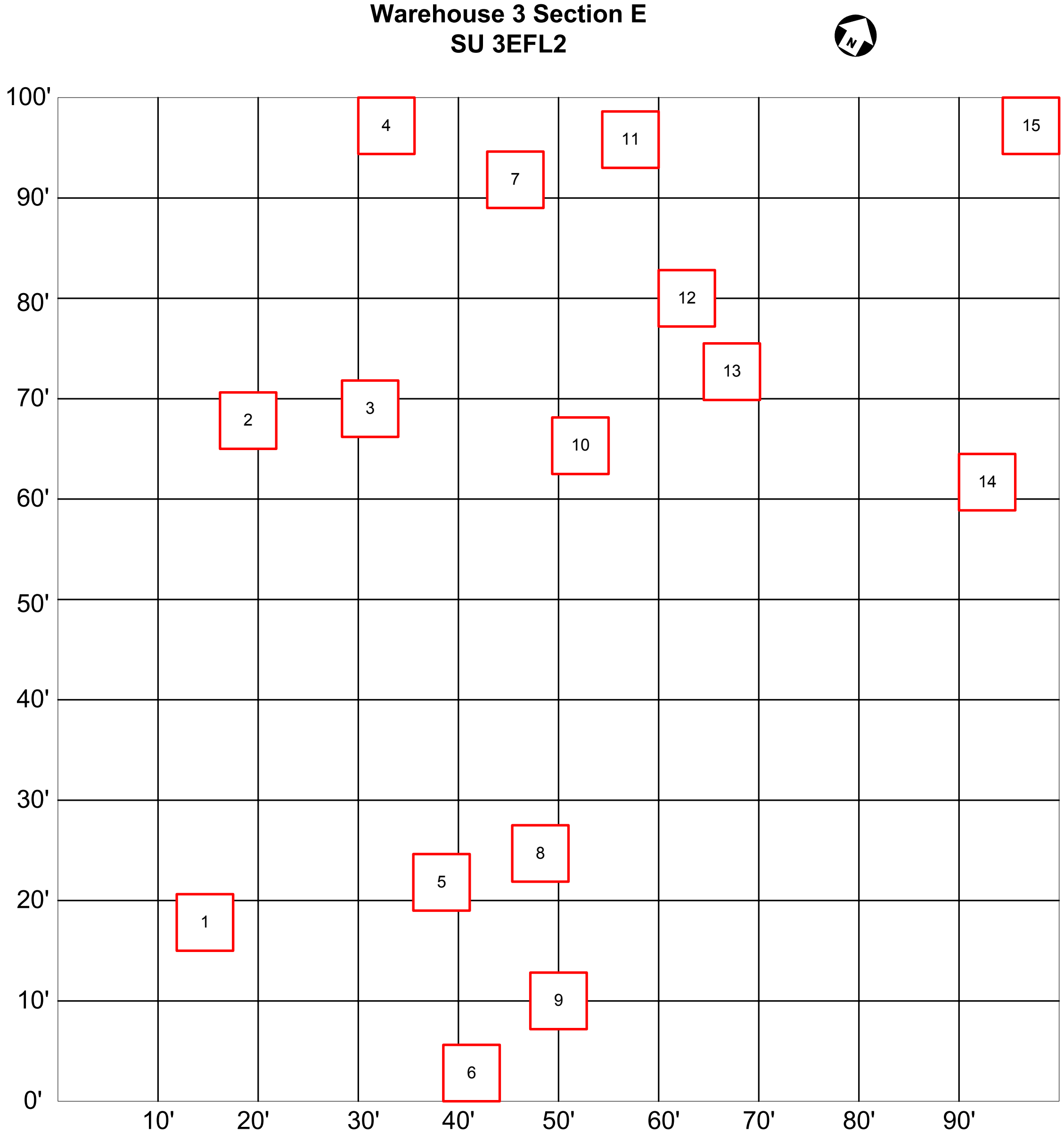
Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2
Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 11/18/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Warehouse 3 Section E
SU 3EFL2



Survey Unit	3EFL2	
	Coordinates (ft)	
N	**X**	**Y**
1	15	17
2	19	68
3	31	69
4	33	97
5	38	22
6	41	3
7	46	92
8	48	25
9	50	10
10	52	66
11	57	96
12	63	80
13	67	73
14	93	62
15	97	97
Scan Rate	0.82	detector area/sec
Scan Interval	1.2	sec

Summary of Static Measurements - Alpha

Survey Unit: 3EFL2
Description: Reference Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	7	36.55	37.1
2	2	3.92	23.6
3	4	16.97	29.7
4	3	10.44	26.8
5	2	3.92	23.6
6	9	49.60	41.3
7	5	23.50	32.4
8	3	10.44	26.8
9	4	16.97	29.7
10	4	16.97	29.7
11	3	10.44	26.8
12	3	10.44	26.8
13	4	16.97	29.7
14	6	30.02	34.8
15	10	56.13	43.2
Minimum:	2	3.9	
Maximum:	10	56.1	
Average:	4.6	20.9	
Std Dev:	2.4	15.8	

Analysis Parameters

Material: concrete
Background: 1.4 cpm
Background Count Time: 20 min
Reference Area: Instrument Blank
Surface Efficiency: 0.428 epm/dpm

Sample Time: 1 min
MDC: 25.4 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AE	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 3EFL2
Description: Reference Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	0	-2.5	5.4
2	4	9.8	13.2
3	1	0.6	8.1
4	1	0.6	8.1
5	2	3.7	10.1
6	1	0.6	8.1
7	0	-2.5	5.4
8	1	0.6	8.1
9	1	0.6	8.1
10	1	0.6	8.1
11	0	-2.5	5.4
12	3	6.8	11.7
13	1	0.6	8.1
14	2	3.7	10.1
15	0	-2.5	5.4
Minimum:	0	-2.5	
Maximum:	4	9.8	
Average:	1.2	1.2	
Std Dev:	1.1	3.5	

Analysis Parameters

Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2
Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 12/2/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Summary of Scan Results - Alpha

Survey Unit: 3EFL2
Description: Reference Area
Survey Date: 11/16/2005

	Gross (cpm)			Net (αpm/100 cm^2)		
Location	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
1	0.0	5.4	1.9	-0.4	23.1	7.9
2	0.0	5.6	1.6	-0.4	24.1	6.7
3	0.5	11.0	3.3	1.6	47.6	13.8
4	0.0	7.0	2.4	-0.4	30.2	10.2
5	0.7	5.9	2.6	2.6	25.1	10.7
6	0.0	8.7	2.4	-0.4	37.4	10.0
7	0.0	8.7	2.4	-0.4	37.4	10.2
8	0.5	8.2	3.3	1.6	35.3	13.9
9	0.7	10.1	4.9	2.6	43.5	20.7
		Average:	2.8		**Average:**	11.6

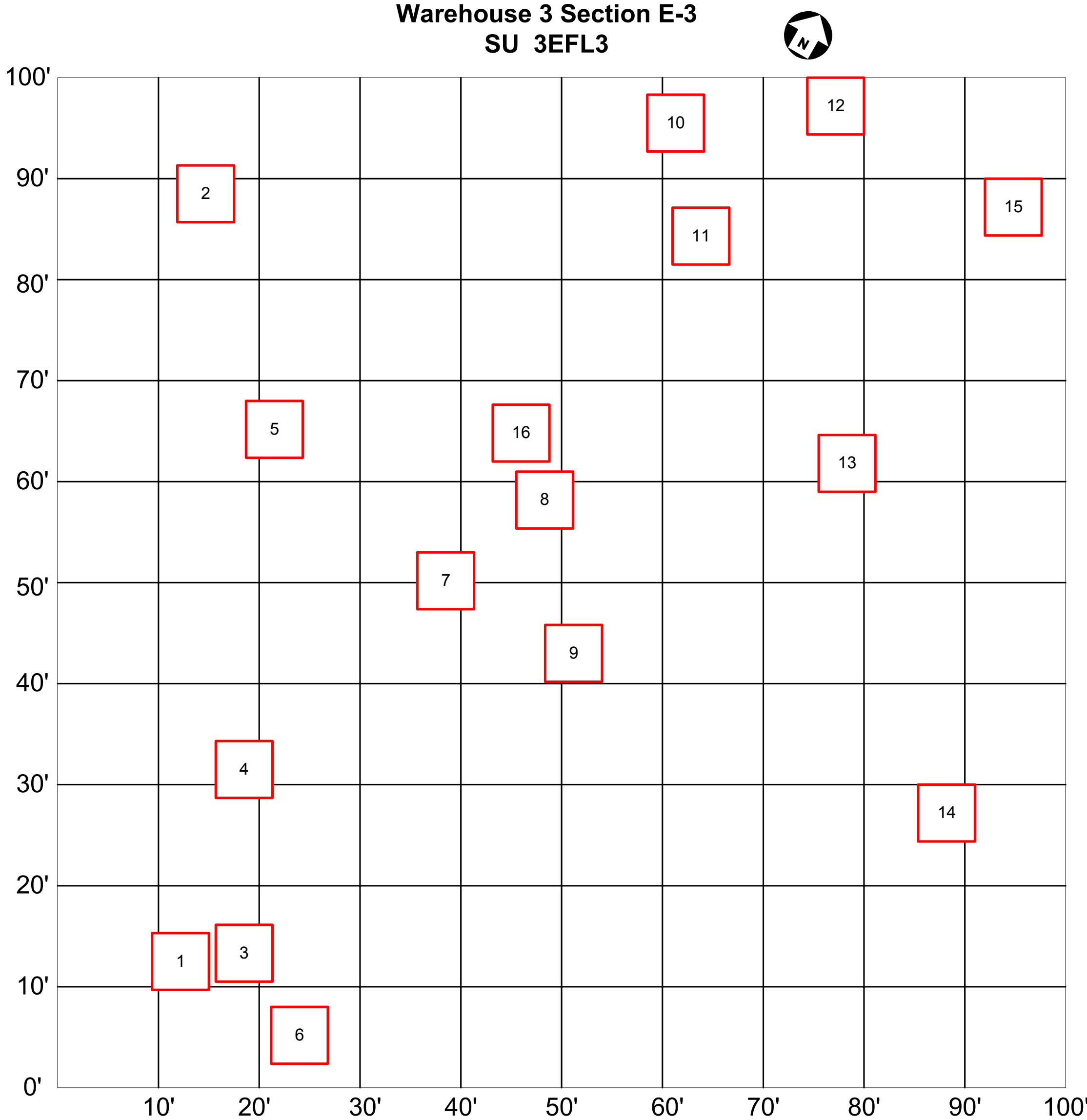
Analysis Parameters

		P(n>1)	90%
Material:	concrete	**Data Recorded:**	Yes
Instrument Background:	0.1 cpm	**Time Interval:**	1.2 s
Reference Area:	N/A		
Surface Efficiency:	0.428 epm/dpm	**MDC:**	414 αpm/100 cm^2

Instrument Data

	Model	Serial No		
Instrument:	L2350-1	142513	**Probe Area:**	83 cm^2
Detector:	L43-1-1	PR093536	**Instrument Efficiency:**	0.646 cpm/epm

Warehouse 3 Section E-3
SU 3EFL3



Survey Unit **3EFL3**

	Coordinates (ft)		
N	**X**	**Y**	
1	12	13	
2	14	89	
3	19	14	
4	19	32	
5	21	65	
6	24	6	
7	38	50	
8	48	58	
9	51	43	
10	61	96	
11	64	84	
12	77	97	
13	78	61	
14	88	27	
15	95	87	
16	46	65	Bias

Summary of Static Measurements - Alpha

Survey Unit: 3EFL3
Description: Reference Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	4	16.97	25.8
2	3	10.44	22.4
3	3	10.44	22.4
4	4	16.97	25.8
5	3	10.44	22.4
6	5	23.50	28.8
7	10	56.13	40.6
8	2	3.92	18.4
9	4	16.97	25.8
10	7	36.55	34.0
11	4	16.97	25.8
12	4	16.97	25.8
13	3	10.44	22.4
14	9	49.60	38.5
15	4	16.97	25.8
16	8	43.07	36.3
Minimum:	2	3.9	
Maximum:	10	56.1	
Average:	4.8	22.3	
Std Dev:	2.4	15.48	

Analysis Parameters

Material: concrete
Background: 1.4 cpm
Background Count Time: 20 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 25.4 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AB	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 3EFL3
Description: Storage Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	1	0.61	6.1
2	0	-2.46	1.2
3	0	-2.46	1.2
4	0	-2.46	1.2
5	0	-2.46	1.2
6	1	0.61	6.1
7	1	0.61	6.1
8	2	3.69	8.6
9	2	3.69	8.6
10	1	0.61	6.1
11	0	-2.46	1.2
12	1	0.61	6.1
13	4	9.84	12.1
14	1	0.61	6.1
15	3	6.76	10.5
16	2	3.69	8.6
Minimum:	0	-2.5	
Maximum:	4	9.8	
Average:	1.2	1.2	
Std Dev:	1.2	3.6	

Analysis Parameters

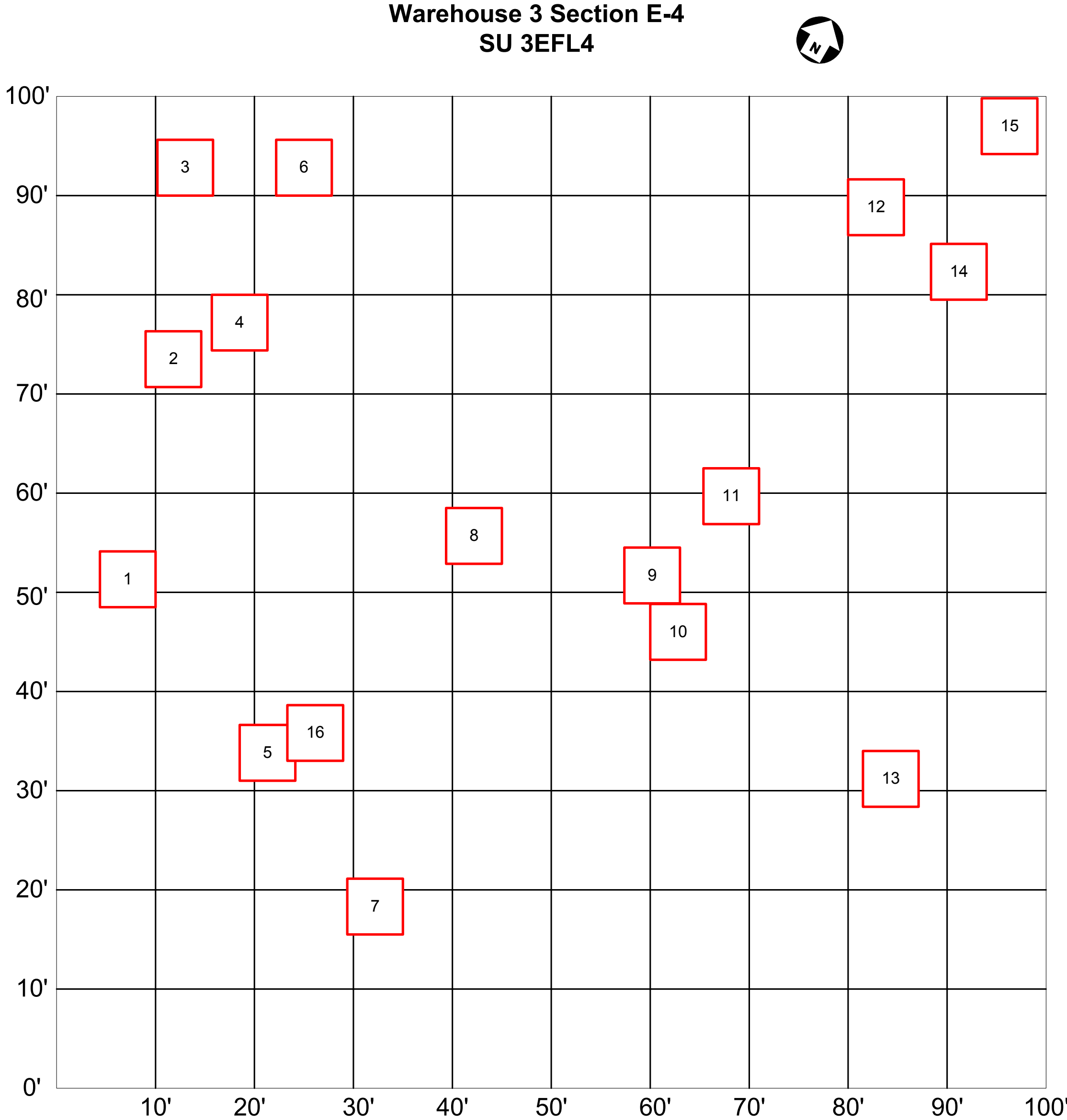
Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2
Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 12/2/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Warehouse 3 Section E-4
SU 3EFL4



Survey Unit	**3EFL4**		
	Coordinates (ft)		
N	**X**	**Y**	
1	7	51	
2	12	74	
3	14	93	
4	18	77	
5	21	34	
6	25	93	
7	32	18	
8	42	56	
9	60	52	
10	63	46	
11	68	60	
12	83	89	
13	84	31	
14	91	82	
15	96	97	
16	26	36	Bias
Scan Rate	0.82	detector area/sec	
Scan Interval	1.2	sec	

Summary of Static Measurements - Alpha

Survey Unit: 3EFL4
Description: Storage Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	3	-11.09	22.7
2	4	-4.57	26.1
3	4	-4.57	26.1
4	2	-17.62	18.8
5	2	-17.62	18.8
6	6	8.48	31.7
7	2	-17.62	18.8
8	1	-24.15	13.8
9	4	-4.57	26.1
10	6	8.48	31.7
11	4	-4.57	26.1
12	3	-11.09	22.7
13	4	-4.57	26.1
14	5	1.96	29.0
15	3	-11.09	22.7
16	3	-11.09	22.7
Minimum:	1	-24.1	
Maximum:	6	8.48	
Average:	3.5	-7.8	
Std Dev:	1.4	9.2	

Analysis Parameters

Material: concrete
Background: 4.7 cpm
Background Count Time: 30 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 92 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AB	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 3EFL4
Description: Storage Area
Survey Date: 11/14/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	1	0.6	8.1
2	1	0.6	8.1
3	2	3.7	10.1
4	0	-2.5	5.4
5	1	0.6	8.1
6	1	0.6	8.1
7	3	6.8	11.7
8	4	9.8	13.2
9	3	6.8	11.7
10	2	3.7	10.1
11	0	-2.5	5.4
12	0	-2.5	5.4
13	1	0.6	8.1
14	2	3.7	10.1
15	1	0.6	8.1
16	2	3.7	10.1
Minimum:	0	-2.5	
Maximum:	4	9.8	
Average:	1.5	2.2	
Std Dev:	1.2	3.5	

Analysis Parameters

Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2
Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 11/18/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Summary of Scan Results - Alpha

Survey Unit: 3EFL4
Description: Storage Area
Survey Date: 11/15/2005

	Gross (cpm)			Net (αpm/100 cm^2)		
Location	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
1	0.0	8.9	2.0	-12.2	26.6	-3.6
2	0.0	4.0	1.3	-12.2	5.2	-6.6
3	0.0	5.4	1.3	-12.2	11.3	-6.5
4	0.0	8.4	1.6	-12.2	24.6	-5.1
5	0.0	7.3	1.7	-12.2	19.5	-4.8
6	0.0	4.9	1.5	-12.2	9.2	-5.8
7	0.5	7.5	2.1	-10.2	20.5	-3.0
8	0.0	4.7	1.5	-12.2	8.2	-5.8
9	0.0	4.5	1.0	-12.2	7.2	-7.6
10	0.0	5.9	1.4	-12.2	13.3	-6.1
11	0.0	6.3	1.7	-12.2	15.4	-4.7
12	0.5	7.3	2.2	-10.2	19.5	-2.6
13	0.0	2.6	0.9	-12.2	-1.0	-8.4
14	0.0	4.0	1.0	-12.2	5.2	-7.6
15	0.0	4.2	1.0	-12.2	6.2	-7.7
16	0.0	4.5	0.9	-12.2	7.2	-8.2
		Average:	1.4		**Average:**	-5.9

Analysis Parameters

P(n>1) 90%
Material: concrete
Data Recorded: Yes
Background: 2.8 cpm
Time Interval: 1.2 s
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm
MDC: 414 αpm/100 cm^2

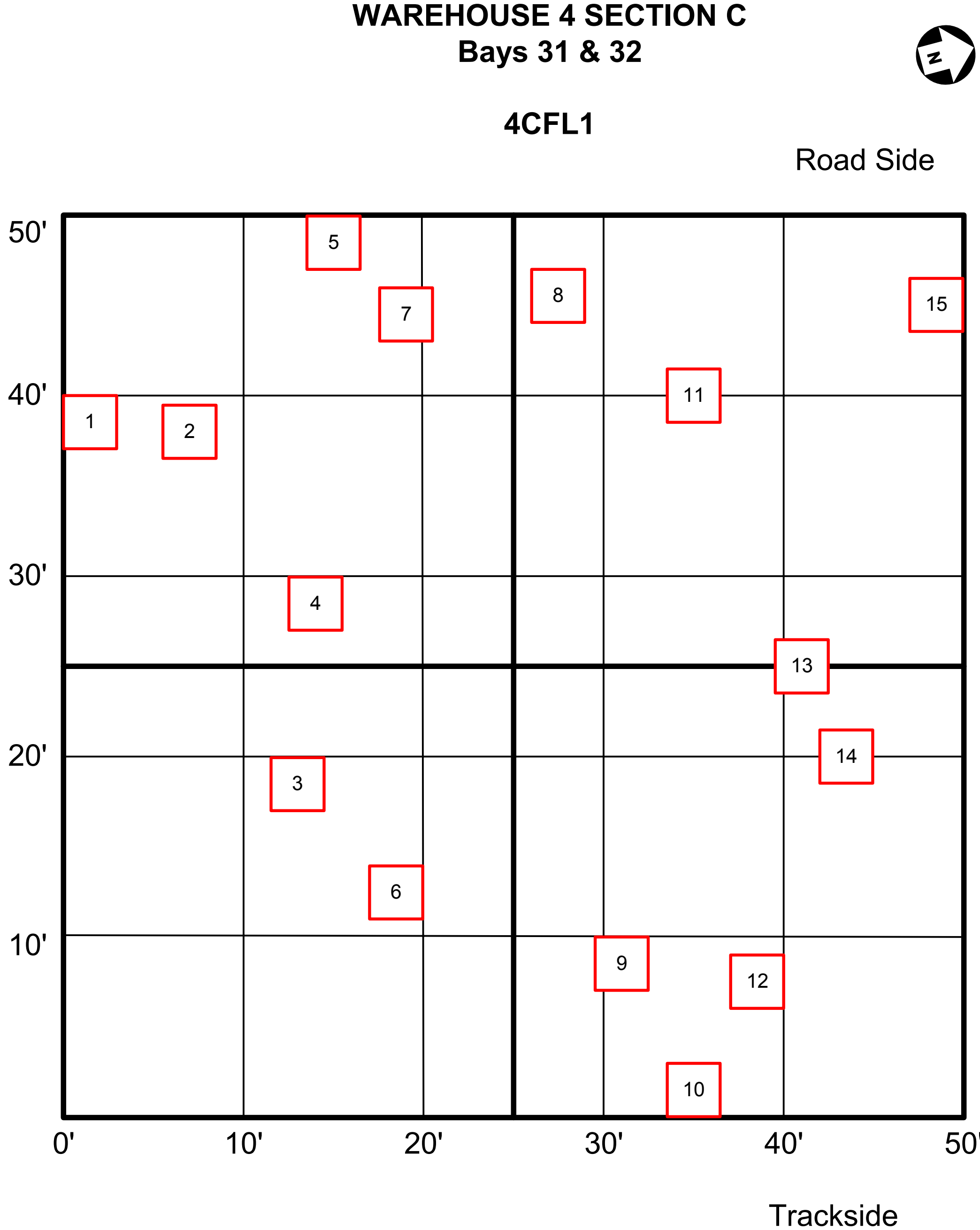
Instrument Data

	Model	Serial No
Instrument:	L2350-1	142513
Detector:	L43-1-1	PR093536

Probe Area: 83 cm^2
Instrument Efficiency: 0.646 cpm/epm

WAREHOUSE 4 SECTION C
Bays 31 & 32

4CFL1



Survey Unit **4CFL1**

	Coordinates (ft)	
N	**X**	**Y**
1	2	38
2	7	37
3	12	19
4	14	28
5	15	48
6	18	12
7	20	44
8	28	46
9	31	9
10	34	2
11	35	40
12	38	7
13	41	25
14	43	20
15	48	45

Summary of Static Measurements - Alpha

Survey Unit: 4CFL1
Description: Storage Area
Survey Date: 11/15/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	5	1.96	29.0
2	7	15.01	34.2
3	4	-4.57	26.1
4	4	-4.57	26.1
5	4	-4.57	26.1
6	4	-4.57	26.1
7	1	-24.15	13.8
8	3	-11.09	22.7
9	2	-17.62	18.8
10	0	-30.67	5.1
11	2	-17.62	18.8
12	4	-4.57	26.1
13	3	-11.09	22.7
14	3	-11.09	22.7
15	7	15.01	34.2
Minimum:	0	-30.7	
Maximum:	7	15.0	
Average:	3.5	-7.6	
Std Dev:	1.9	12.5	

Analysis Parameters

Material: concrete
Background: 4.7 cpm
Background Count Time: 30 min
Reference Area: 3EFL2
Surface Efficiency: 0.428 epm/dpm

Sample Time: 1 min
MDC: 92 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AB	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: 4CFL1
Description: Storage Area
Survey Date: 11/15/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	1	0.6	8.1
2	5	12.9	14.5
3	2	3.7	10.1
4	2	3.7	10.1
5	1	0.6	8.1
6	2	3.7	10.1
7	1	0.6	8.1
8	2	3.7	10.1
9	0	-2.5	5.4
10	2	3.7	10.1
11	0	-2.5	5.4
12	2	3.7	10.1
13	3	6.8	11.7
14	1	0.6	8.1
15	0	-2.5	5.4
Minimum:	0	-2.5	
Maximum:	5	12.9	
Average:	1.6	2.5	
Std Dev:	1.3	4.0	

Analysis Parameters

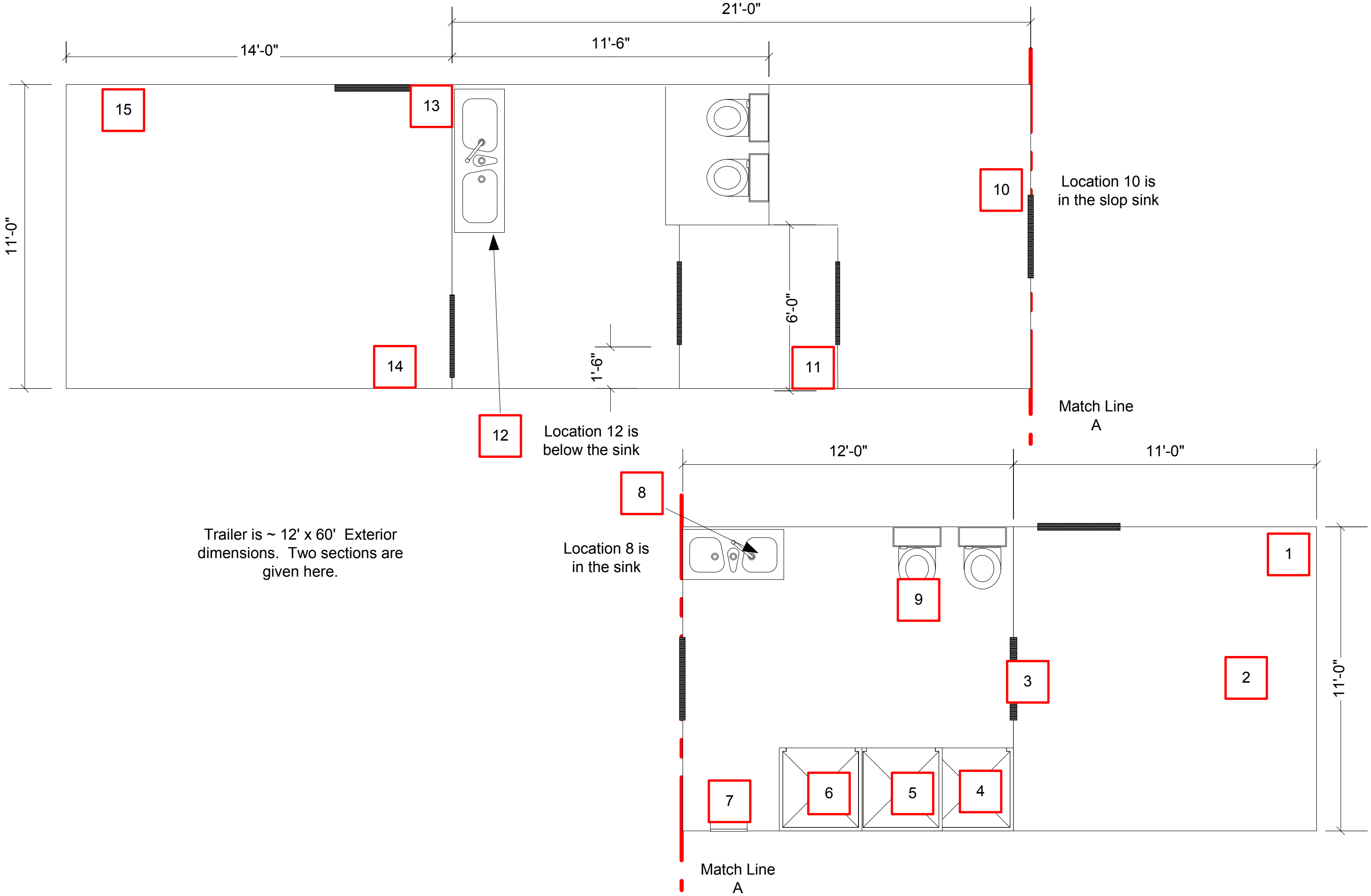
Background:	0.8 cpm	**Sample Time:**	1 min
Background Count Time:	20 min	**MDC:**	18.5 αpm/100 cm^2
Surface Efficiency:	0.45 epm/dpm	**Analysis Date:**	12/2/2005
Smear Area:	100 cm^2		

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Decontamination Trailer



Trailer is ~ 12' x 60' Exterior dimensions. Two sections are given here.

Summary of Static Measurements - Alpha

Survey Unit: DTFL1
Description: Decontamination Trailer
Survey Date: 11/16/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Uncertainty @ 95% CL
1	1	-2.61	13.4
2	0	-9.14	3.9
3	3	10.44	22.5
4	1	-2.61	13.4
5	1	-2.61	13.4
6	1	-2.61	13.4
7	2	3.92	18.5
8	0	-9.14	3.9
9	1	-2.61	13.4
10	2	3.92	18.5
11	3	10.44	22.5
12	1	-2.61	13.4
13	2	3.92	18.5
14	0	-9.14	3.9
15	0	-9.14	3.9
Minimum:	0	-9.1	
Maximum:	3	10.4	
Average:	1.2	-1.3	
Std Dev:	1.0	6.6	

Analysis Parameters

Material: vinyl flooring
Instrument Background: 1.4 counts
Background Count Time: 15 min
Reference Area: To Be Determined
Surface Efficiency: 0.428 epm/dpm
Sample Time: 1 min
MDC: 92 αpm/100 cm^2

Instrument Data

	Model	Serial No
Instrument:	L2350-1	180729
Detector:	SHP380AB	00176

Probe Area: 100 cm^2
Instrument Efficiency: 0.358 cpm/epm

Summary of Smear Measurements - Alpha

Survey Unit: DTFL1
Description: Decontamination Trailer
Survey Date: 11/16/2005

Location	Gross (counts)	Net (αpm/100 cm^2) Activity	Net (αpm/100 cm^2) Uncertainty @ 95% CL
1	1	0.6	8.1
2	1	0.6	8.1
3	1	0.6	8.1
4	2	3.7	10.1
5	4	9.8	13.2
6	0	-2.5	5.4
7	1	0.6	8.1
8	0	-2.5	5.4
9	1	0.6	8.1
10	3	6.8	11.7
11	1	0.6	8.1
12	1	0.6	8.1
13	2	3.7	10.1
14	1	0.6	8.1
15	0	-2.5	5.4
Minimum:	0	-2.5	
Maximum:	4	9.8	
Average:	1.3	1.4	
Std Dev:	1.1	3.4	

Analysis Parameters

Instrument Background: 0.8 cpm
Background Count Time: 20 min
Surface Efficiency: 0.45 epm/dpm
Smear Area: 100 cm^2

Sample Time: 1 min
MDC: 18.5 αpm/100 cm^2
Analysis Date: 11/18/2005

Instrument Data

	Model	Serial No
Instrument:	2929	176108
Detector:	43-10	

Instrument Efficiency: 0.723 cpm/epm

Appendix B - DandD Computer Run Printouts

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 8/19/2005 12:48:52 PM
Site Name: Binghamton and Somerville
Description: Reverse Engineering to document 25 mrem /year from estimated DCGL
FileName:C:\DLA-Proposal\DandD Runs\Th Natural 25 mrem.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 10000
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution

Th_Nat	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Estimated value for 25 mrem/year		Value 5.85E+00

Chain Data:

Number of chains: **1**

Chain No. 1: **Th_Nat**
Nuclides in chain: **12**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m^2))	15 cm Dose Rate Factor ((Sv/d)/(Bq/m^3))
232Th	1	5.13E+12					7.38E-07	4.43E-04	4.76E-14	2.40E-16
228Ra	2	2.10E+03	1	1	0	0	3.88E-07	1.29E-06	0.00E+00	0.00E+00
228Ac	Implicit		2	1			5.85E-10	8.33E-08	8.01E-11	2.38E-12
228Th	3	6.99E+02	2	1	0	0	1.07E-07	9.23E-05	2.03E-13	3.60E-15
224Ra	4	3.66E+00	3	1	0	0	9.89E-08	8.53E-07	8.26E-13	2.26E-14
220Rn	Implicit		4	1			0.00E+00	0.00E+00	3.29E-14	9.52E-16
216Po	Implicit		4	1			0.00E+00	0.00E+00	1.43E-15	4.21E-17
212Pb	5	4.43E-01	4	1	0	0	1.23E-08	4.56E-08	1.23E-11	3.13E-13
212Bi	Implicit		5	1			2.87E-10	5.83E-09	1.54E-11	4.63E-13
212Po	Implicit		5	0.6407			0.00E+00	0.00E+00	0.00E+00	0.00E+00
208Tl	Implicit		5	0.3593			0.00E+00	0.00E+00	2.58E-10	8.36E-12

Th_Nat	1	0.00E+00					0.00E+00	0.00E+00	2.58E-10	8.36E-12

Initial Concentrations:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 quantile value

Nuclide	Surface Concentration (dpm/100 cm**2)
232Th	5.85E+00
228Ra	5.85E+00
228Ac	5.85E+00
228Th	5.85E+00
224Ra	5.85E+00
220Rn	5.85E+00
216Po	5.85E+00
212Pb	5.85E+00
212Bi	5.85E+00
212Po	3.75E+00
208Tl	2.10E+00

Model Parameters:

General Parameters:

Parameter Name	Description	Distribution

To:Time In Building	The time in the building during the occupancy period	CONSTANT(hr/week)	
Default value used		Value	4.50E+01
Tto:Occupancy Period	The duration of the occupancy exposure period	CONSTANT(days)	
Default value used		Value	3.65E+02
Vo:Breathing Rate	The average volumetric breathing rate during building occupancy for an 8-hour work day	CONSTANT(m**3/hr)	
Default value used		Value	1.40E+00
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * FI	DERIVED(1/m)	
Default value used			
GO*:Ingestion Rate	Effective secondary ingestion transfer rate of removable surface activity from building surfaces to the mouth during building occupancy = GO * FI	DERIVED(m**2/hr)	
Default value used			
Tstart:Start Time	The start time of the scenario in days	CONSTANT(days)	
Default value used		Value	0.00E+00
Tend:End Time	The ending time of the scenario in days	CONSTANT(days)	
Default value used		Value	3.65E+02
dt:Time Step Size	The time step size	CONSTANT(days)	
Default value used		Value	3.65E+02
Pstep:Print Step Size	The time steps for the history file. Doses will be written to the history file every n time steps	CONSTANT(none)	

Default value used		Value 1.00E+00
AOExt:External Exposure Area	Minimum surface area to which occupant is exposed via external radiation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOInh:Inhalation Exposure Area	Minimum surface area to which occupant is exposed via inhalation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOIng:Secondary Ingestion Exposure Area	Minimum surface area to which occupant is exposed via secondary ingestion during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AO:Exposure Area	Minimum surface area to which occupant is exposed during the occupancy period	DERIVED(m**2)
Default value used		
Fl:Loose Fraction	Fraction of surface contamination available for resuspension and ingestion	CONSTANT(none)
Default value used		Value 1.00E-01
Rfo:Loose Resuspension Factor	Resuspension factor for loose contamination	CONTINUOUS LOGARITHMIC(1/m)
Default value used		Value / Probability 9.12E-06 / 0.00E+00 1.10E-04 / 7.67E-01 1.46E-04 / 9.09E-01 1.62E-04 / 9.50E-01 1.85E-04 / 9.90E-01 1.90E-04 / 1.00E+00

GO:Loose Ingestion Rate	The secondary ingestion transfer rate of loose removable surface activity from building surfaces to the mouth during building occupancy	CONSTANT(m**2/hr)
Default value used		Value 1.10E-04

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 10000 **calculated TEDE values are <** 2.47E+01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 2.44E+01 **to** 2.50E+01 **mrem/year**

Detailed Results:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

Concentration at Time of Peak Dose:

Nuclide	Surface Concentration (dpm/100 cm**2)
232Th	5.85E+00
228Ra	5.85E+00
228Ac	5.85E+00
228Th	5.85E+00
224Ra	5.85E+00

220Rn	5.85E+00
216Po	5.85E+00
212Pb	5.85E+00
212Bi	5.85E+00
212Po	3.75E+00
208Tl	2.10E+00

Pathway Dose from All Nuclides (mrem)

All Pathways Dose	External	Inhalation	Secondary Ingestion
2.50E+01	1.92E-02	2.49E+01	3.38E-02

Radionuclide Dose through All Active Pathways (mrem)

Nuclide	All Pathways Dose
232Th	2.06E+01
228Ra	6.95E-02
228Ac	1.15E-02
228Th	4.28E+00
224Ra	4.21E-02
220Rn	3.13E-06
216Po	1.36E-07
212Pb	3.59E-03
212Bi	1.74E-03

212Po	0.00E+00
208Tl	8.81E-03
All Nuclides	2.50E+01

Dose from Each Nuclide through Each Active Pathway (mrem)

Nuclide	External	Inhalation	Secondary Ingestion
232Th	4.52E-06	2.05E+01	1.85E-02
228Ra	0.00E+00	5.98E-02	9.74E-03
228Ac	7.61E-03	3.86E-03	1.47E-05
228Th	1.93E-05	4.28E+00	2.69E-03
224Ra	7.85E-05	3.95E-02	2.48E-03
220Rn	3.13E-06	0.00E+00	0.00E+00
216Po	1.36E-07	0.00E+00	0.00E+00
212Pb	1.17E-03	2.11E-03	3.09E-04
212Bi	1.46E-03	2.70E-04	7.20E-06
212Po	0.00E+00	0.00E+00	0.00E+00
208Tl	8.81E-03	0.00E+00	0.00E+00

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 1/31/2006 1:28:45 PM
Site Name: Binghamton and Somerville Depots
Description: Combination of U-235+C and U-238+C at natural uranium concentration ratios.

Demonstration of DCGL for 25 mrem/y
FileName:C:\DLA\Revision\DCGLs\U-235+C and U-238+C.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 10000
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
235U+C	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Fraction of activity at natural value of 0.0234 fraction of total.		Value 5.56E-01
238U+C	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Value set per natural radioactivity ratio of 0.4883 fraction of total activity.		Value 1.16E+01

Chain Data:

Number of chains: **2**

Chain No. 1: **235U+C**
Nuclides in chain: **13**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m^2))	15 cm Dose Rate Factor ((Sv/d)/(Bq/m^3))
235U+C	1	2.57E+11								
231Th	2	1.06E+00	1	1	0	0	3.65E-10	2.37E-10	1.60E-12	1.68E-14
231Pa	3	1.20E+07	2	1	0	0	2.86E-06	3.47E-04	3.52E-12	8.30E-14
227Ac	4	7.95E+03	3	1	0	0	3.80E-06	1.81E-03	1.36E-14	2.26E-16
223Fr	Implicit		4	0.0138			2.33E-09	1.68E-09	4.88E-12	8.74E-14
227Th	5	1.87E+01	4	0.9862	0	0	1.03E-08	4.37E-06	8.94E-12	2.29E-13

223Ra	6	1.14E+01	5	1	4	0.0138	1.78E-07	2.12E-06	1.11E-11	2.67E-13
219Rn	Implicit		6	1			0.00E+00	0.00E+00	4.74E-12	1.33E-13
215Po	Implicit		6	1			0.00E+00	0.00E+00	1.51E-14	4.30E-16
211Pb	Implicit		6	1			1.42E-10	2.35E-09	4.38E-12	1.26E-13
211Bi	Implicit		6	1			0.00E+00	0.00E+00	3.96E-12	1.10E-13
211Po	Implicit		6	0.0028			0.00E+00	0.00E+00	6.57E-13	1.94E-14
207Tl	Implicit		6	0.9972			0.00E+00	0.00E+00	3.25E-13	8.19E-15

Chain No. 2: **238U+C**
Nuclides in chain: **16**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor $((Sv/d)/(Bq/m^2))$	15 cm Dose Rate Factor $((Sv/d)/(Bq/m^3))$
238U+C	1	1.63E+12								
234Th	2	2.41E+01	1	1	0	0	3.69E-09	9.47E-09	7.18E-13	1.12E-14
234mPa	Implicit		2	0.998			0.00E+00	0.00E+00	1.32E-12	3.62E-14
234Pa	Implicit		2	0.002	0	0.0013	5.84E-10	2.20E-10	1.59E-10	4.65E-12
234U	3	8.93E+07	2	1	0	0	7.66E-08	3.58E-05	6.46E-14	1.85E-16
230Th	4	2.81E+07	3	1	0	0	1.48E-07	8.80E-05	6.48E-14	5.52E-16
226Ra	5	5.84E+05	4	1	0	0	3.58E-07	2.32E-06	5.56E-13	1.42E-14
222Rn	6	3.82E+00	5	1	0	0	0.00E+00	0.00E+00	3.41E-14	9.81E-16
218Po	Implicit		6	1			0.00E+00	0.00E+00	7.67E-16	2.27E-17
214Pb	Implicit		6	0.9998			1.69E-10	2.11E-09	2.10E-11	5.78E-13

218At	Implicit		6	0.0002			0.00E+00	0.00E+00	0.00E+00	0.00E+00
214Bi	Implicit		6	1			7.64E-11	1.78E-09	1.22E-10	3.77E-12
214Po	Implicit		6	0.9998			0.00E+00	0.00E+00	7.02E-15	2.07E-16
210Pb	7	8.15E+03	6	1	0	0	1.45E-06	3.67E-06	2.14E-13	1.13E-15
210Bi	8	5.01E+00	7	1	0	0	1.73E-09	5.29E-08	9.06E-14	1.61E-15
210Po	9	1.38E+02	8	1	0	0	5.14E-07	2.54E-06	7.16E-16	2.11E-17

Initial Concentrations:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

Nuclide	Surface Concentration (dpm/100 cm**2)
235U	5.56E-01
231Th	5.56E-01
231Pa	5.56E-01
227Ac	5.56E-01
223Fr	7.67E-03
227Th	5.48E-01
223Ra	5.56E-01
219Rn	5.56E-01
215Po	5.56E-01
211Pb	5.56E-01
211Bi	5.56E-01
211Po	1.56E-03

207Tl	5.54E-01
238U	1.16E+01
234Th	1.16E+01
234mPa	1.16E+01
234Pa	2.32E-02
234U	1.16E+01
230Th	1.16E+01
226Ra	1.16E+01
222Rn	1.16E+01
218Po	1.16E+01
214Pb	1.16E+01
218At	2.32E-03
214Bi	1.16E+01
214Po	1.16E+01
210Pb	1.16E+01
210Bi	1.16E+01
210Po	1.16E+01

Model Parameters:

General Parameters:

Parameter Name	Description	Distribution

To:Time In Building	The time in the building during the occupancy period	CONSTANT(hr/week)
Default value used		Value 4.50E+01
Tto:Occupancy Period	The duration of the occupancy exposure period	CONSTANT(days)
Default value used		Value 3.65E+02
Vo:Breathing Rate	The average volumetric breathing rate during building occupancy for an 8-hour work day	CONSTANT(m**3/hr)
Default value used		Value 1.40E+00
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	DERIVED(1/m)
Default value used		
GO*:Ingestion Rate	Effective secondary ingestion transfer rate of removable surface activity from building surfaces to the mouth during building occupancy = GO * Fl	DERIVED(m**2/hr)
Default value used		
Tstart:Start Time	The start time of the scenario in days	CONSTANT(days)
Default value used		Value 0.00E+00
Tend:End Time	The ending time of the scenario in days	CONSTANT(days)
Default value used		Value 3.65E+02
dt:Time Step Size	The time step size	CONSTANT(days)
Default value used		Value 3.65E+02
Pstep:Print Step Size	The time steps for the history file. Doses will be written to the history file every n time steps	CONSTANT(none)

Default value used		Value 1.00E+00
AOExt:External Exposure Area	Minimum surface area to which occupant is exposed via external radiation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOInh:Inhalation Exposure Area	Minimum surface area to which occupant is exposed via inhalation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOIng:Secondary Ingestion Exposure Area	Minimum surface area to which occupant is exposed via secondary ingestion during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AO:Exposure Area	Minimum surface area to which occupant is exposed during the occupancy period	DERIVED(m**2)
Default value used		
Fl:Loose Fraction	Fraction of surface contamination available for resuspension and ingestion	CONSTANT(none)
Default value used		Value 1.00E-01
Rfo:Loose Resuspension Factor	Resuspension factor for loose contamination	CONTINUOUS LOGARITHMIC(1/m)
Default value used		Value / Probability 9.12E-06 / 0.00E+00 1.10E-04 / 7.67E-01 1.46E-04 / 9.09E-01 1.62E-04 / 9.50E-01 1.85E-04 / 9.90E-01

		1.90E-04	1.00E+00
GO:Loose Ingestion Rate	The secondary ingestion transfer rate of loose removable surface activity from building surfaces to the mouth during building occupancy	CONSTANT(m**2/hr)	
Default value used		Value	1.10E-04

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 10000 **calculated TEDE values are <** 2.47E+01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 2.44E+01 **to** 2.50E+01 **mrem/year**

Detailed Results:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

Concentration at Time of Peak Dose:

Nuclide	Surface Concentration (dpm/100 cm**2)
235U	5.56E-01
231Th	5.56E-01
231Pa	5.56E-01

227Ac	5.56E-01
223Fr	7.67E-03
227Th	5.48E-01
223Ra	5.56E-01
219Rn	5.56E-01
215Po	5.56E-01
211Pb	5.56E-01
211Bi	5.56E-01
211Po	1.56E-03
207Tl	5.54E-01
238U	1.16E+01
234Th	1.16E+01
234mPa	1.16E+01
234Pa	2.32E-02
234U	1.16E+01
230Th	1.16E+01
226Ra	1.16E+01
222Rn	1.16E+01
218Po	1.16E+01
214Pb	1.16E+01
218At	2.32E-03
214Bi	1.16E+01
214Po	1.16E+01

210Pb	1.16E+01
210Bi	1.16E+01
210Po	1.16E+01

Pathway Dose from All Nuclides (mrem)

All Pathways Dose	External	Inhalation	Secondary Ingestion
2.50E+01	2.81E-02	2.48E+01	1.47E-01

Radionuclide Dose through All Active Pathways (mrem)

Nuclide	All Pathways Dose
235U	1.47E-01
231Th	1.64E-05
231Pa	1.54E+00
227Ac	7.98E+00
223Fr	7.87E-07
227Th	1.91E-02
223Ra	9.86E-03
219Rn	4.28E-05
215Po	1.36E-07
211Pb	5.03E-05
211Bi	3.58E-05

211Po	1.66E-08
207Tl	2.93E-06
238U	2.94E+00
234Th	1.19E-03
234mPa	2.48E-04
234Pa	6.00E-05
234U	3.29E+00
230Th	8.10E+00
226Ra	2.31E-01
222Rn	6.43E-06
218Po	1.45E-07
214Pb	4.16E-03
218At	0.00E+00
214Bi	2.32E-02
214Po	1.32E-06
210Pb	4.10E-01
210Bi	4.97E-03
210Po	2.59E-01
All Nuclides	2.50E+01

Dose from Each Nuclide through Each Active Pathway (mrem)

Nuclide	External	Inhalation	Secondary Ingestion

235U	1.16E-04	1.46E-01	1.72E-04
231Th	1.45E-05	1.04E-06	8.71E-07
231Pa	3.18E-05	1.53E+00	6.82E-03
227Ac	1.23E-07	7.97E+00	9.07E-03
223Fr	6.08E-07	1.02E-07	7.67E-08
227Th	7.97E-05	1.90E-02	2.42E-05
223Ra	1.00E-04	9.34E-03	4.25E-04
219Rn	4.28E-05	0.00E+00	0.00E+00
215Po	1.36E-07	0.00E+00	0.00E+00
211Pb	3.96E-05	1.04E-05	3.39E-07
211Bi	3.58E-05	0.00E+00	0.00E+00
211Po	1.66E-08	0.00E+00	0.00E+00
207Tl	2.93E-06	0.00E+00	0.00E+00
238U	8.97E-06	2.94E+00	3.42E-03
234Th	1.35E-04	8.70E-04	1.84E-04
234mPa	2.48E-04	0.00E+00	0.00E+00
234Pa	5.99E-05	4.04E-08	5.81E-08
234U	1.22E-05	3.29E+00	3.81E-03
230Th	1.22E-05	8.09E+00	7.37E-03
226Ra	1.05E-04	2.13E-01	1.78E-02
222Rn	6.43E-06	0.00E+00	0.00E+00
218Po	1.45E-07	0.00E+00	0.00E+00
214Pb	3.96E-03	1.94E-04	8.41E-06

218At	0.00E+00	0.00E+00	0.00E+00
214Bi	2.30E-02	1.64E-04	3.80E-06
214Po	1.32E-06	0.00E+00	0.00E+00
210Pb	4.03E-05	3.37E-01	7.22E-02
210Bi	1.71E-05	4.86E-03	8.61E-05
210Po	1.35E-07	2.33E-01	2.56E-02