DEPARTMENT OF THE ARMY
U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND
ARMAMENTS CENTER
PICATINNY ARSENAL, NEW JERSEY 07806-5000

5 Mar 2020

FCDD-ACD

MEMORANDUM FOR United States Nuclear Regulatory Commission, Region 1, 2100 Renaissance Boulevard, King of Prussia, PA, 19406-2713

SUBJECT: Submission of Final Status Survey Report for Building 315 at Picatinny Arsenal, NJ, License Number SUB-348

Mr. Lawyer:

Attached please find the final status survey report for your review. Armaments Center requests an uncontrolled release of the specified facility to remove this location off the SUB-348 license based on the attached survey results.

Please note that the name of our command and center have changed due to reorganizations which occurred in the Department of the Army. The former acronym for our command and technical center, RDECOM ARDEC, has changed to CCDC AC. However, personnel named in license SUB-348 have not changed positions or roles.

The point of contact for this document is Armaments Center Health Physicist, Radiation Safety Officer, Malgorzata (Margaret) Kouretas; malgorzata.e.kouretas.civ@mail.mil or 973-724-6518.

for JOHN F. HEDDERICH III
Director, Combat Capabilities Development
Command Armaments Center

ENCL
MARSSIM Final Status Survey

REVISION A

RADIOLOGICAL FINAL STATUS SURVEY REPORT FOR PICATINNY ARSENAL BUILDING 315

DOVER, NEW JERSEY

JANUARY 22, 2020

REVISION A

RADIOLOGICAL FINAL STATUS SURVEY REPORT FOR PICATINNY ARSENAL BUILDING 315

DOVER, NEW JERSEY

JANUARY 10, 2020

Prepared for:
U.S. Army
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LIST OF ACRONYMS AND ABBREVIATIONS

σ	standard deviation
Δ/σ	relative shift
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ARDEC	Armaments Research, Developments and Engineering Center
ARI	additional remedial investigation
ATG	Allied Technology Group
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	*Code of Federal Regulations*
cm^2	square centimeter(s)
cpm	counts per minute
D&D	decommissioning and demolition
DCGL	derived concentration guideline level
DCGLw	derived concentration guideline levels used for statistical tests
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DU	depleted uranium
EDM	Electro-Discharge Machining
FR	*Federal Register*
FSS	Final Status Survey
ft	foot/feet
HEPA	high efficiency particulate air
HWI	Hidden Water, Inc.
LBGR	lower bound of the gray region
m	meter(s)
m^2	square meter(s)
MARSSIM	*Multi-Agency Radiation Survey and Site Investigational Manual*
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	megaelectron Volt(s)
mrem	millirem
mSv	millisievert (s)
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Commission Regulation
Pa	protactinium
Pb	lead
PH1 RI	phase 1 remedial investigation
QC	quality control
RDX	royal demolition explosive
SN	serial number
Sr	strontium
SU	survey unit
TEDE	total effective dose equivalent

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

Th	thorium
U	uranium
World	World Environmental

1.0 INTRODUCTION

This document presents a radiological final status survey (FSS) report for the performance of radiological final status surveys at Building 315 on Picatinny Arsenal, New Jersey. Picatinny Arsenal is the Joint Center of Excellence for Armaments and Munitions, providing products and services to all branches of the U.S. military. Located on 4,500 acres of land in northern New Jersey, Picatinny Arsenal specializes in the research, development, acquisition and lifecycle management of advanced conventional weapon systems and advanced ammunition. Picatinny Arsenal's portfolio comprises nearly 90 percent of the U.S. Army's lethality and all conventional ammunition for joint warfighters.

1.1 OVERVIEW OF OPERATIONAL HISTORY

"On 6 September 1880, the War Department established the Dover Powder Depot. Four days later, it changed the name to Picatinny Powder Depot. In 1907, the U.S. Army altered the name to Picatinny Arsenal and established its first powder factory on the site. While continuing to produce munitions, the arsenal moved into research and development work with the start of a school to instruct officers in weaponry sciences in 1911 and the establishment of testing and control laboratories during the World War I era, and the beginning of a small, experimental plant for the design and development of artillery ammunition in 1919. In 1921, the arsenal took over responsibility for experimental work on fuses.

"The arsenal continued to realize its potential as a research and development facility in the years between the two world wars. Major accomplishments of this period included better methods for storing smokeless powder, improved processing of cyclonite, more commonly called [royal demolition explosive] RDX, and the discovery of a new explosive, haleite. The discoverer was Dr. George C. Hale, the arsenal's chief chemist.

"World War II interfered with the arsenal's efforts to concentrate on research and development. As one of the few facilities with the ability to manufacture munitions, it employed 18,000 people and ran three shifts turning out bombs and artillery shells. However, it still had its research triumphs, especially the development of a delay fuse for skip bombing and special bombs for dams and oil fields. It also pioneered production processes later transferred to munitions manufacturers around the country.

"After World War II, Picatinny refocused its efforts on developing new weapons and munitions. Its support to the American forces in Korea included an improved bazooka and an illuminating rifle grenade. In periods of peace, the arsenal made important contributions to progress in the areas of radar, pyrotechnics, missiles, time fuses, and nuclear munitions. When war broke out again, it gave troops in Vietnam a complete family of 40mm ammunition for grenade launchers and helicopter gunships.

"In 1977, the Army recognized Picatinny's leadership in weapons and munitions development by headquartering its Armament Research and Development Command at the arsenal and giving it responsibility for developing small caliber weapons and munitions.

"In 1983, the Army disestablished the Armament Research and Development Command and Picatinny became the home of the Armament Research and Development Center. In 1986, the name again changed to the Armament Research, Development and Engineering Center. Whatever the name, the installation leads the way in weapons and ammunition development." (Picatinny Arsenal 2015).

1.2 BUILDING 315

Use of Picatinny Arsenal Building 315 as a metallographic facility for the analysis and study of depleted uranium (DU) began sometime prior to 1980 and continued until 2005. Analyses performed included mechanical testing, metallurgical analysis, corrosion investigations and environmental studies (Chatterjee 2011). Areas utilized for DU operations include the Mechanical Test Laboratory, DU Machine Shop, Electro-Discharge Machining (EDM) Room, Metallography Laboratory, Microscopy Laboratory, Corrosion Laboratory, and Storage Room. See Figure 1 for historical building layout. No radiological work is known to have taken place in the bathroom, hallway, clean machine shop, or the two offices.

The exterior of Building 315 measures 148 feet [ft] (45 meters [m]) long, 32 ft (10 m) wide, and 18 ft (5.5 m) to the building shoulder or 37 ft (11 m) to the roof peak. Since 2005, most of Building 315 has been remodeled for use as office space. Exceptions include the Metallography Laboratory.

1.3 BUILDING 315 RADIOLOGICAL SURVEY HISTORY

1.3.1 Site 135 (Buildings 315 and 316) Environmental Investigations

Four environmental investigations were conducted at Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Site 135 which included Building 315 and 316: (1) radiological surveys and removal actions at Buildings 315 and 316 completed by Allied Technology Group (ATG) in 1994, (2) a second radiological removal action conducted by ATG at Building 316 in 1996, (3) environmental sampling at Building 315 during the phase 1 remedial investigation (PH1 RI) in 1995 and revision in 1997, and (4) sampling and surveys at Buildings 315 and 316 during the additional remedial investigation (ARI) in 1998. Site 135 historical radiological data as it relates to Building 315 is summarized following.

ATG 1994 and 1996: ATG completed a pre-disposal survey and post-removal "as left" radiological surveys in Building 315 and reported no contamination above the Nuclear Regulatory Commission (NRC) license requirements.

PH1 RI in 1995 and Revision in 1997: This investigation did not include radiological surveys or sampling.

ARI in 1998: The ATG radiological closure reports were reviewed, and it was determined that analysis of surface soil samples was not necessary for radiological parameters.

1.3.2 2006 Radiological Survey

In October 2006, World Environmental (World), mobilized to the Armaments Research, Developments Engineering Center (ARDEC), Picatinny Arsenal, to perform a radiological characterization survey which included characterization of equipment, furniture, and other ancillary items for disposition. The survey results are discussed in the, *Characterization and Survey of Building 315* (World 2006) and are summarized as follows:

The survey results were compared to Regulatory Guide 1.86 limits for both fixed and removable contamination applicable for DU as follows:

Fixed contamination:	5,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) (average alpha and beta)
	15,000 dpm/100 cm^2 (maximum alpha and beta)
Removable contamination:	1,000 dpm/100 cm^2 total (alpha and beta)

The surveyed items were segregated by radiological, hazardous, or non-hazardous criteria for disposal. With the exception of the materials, piping and ventilation system equipment in the Metallography Laboratory all surveyed items were dispositioned as part of the work activities associated with the project. The disposition of materials, piping and the ventilation system in the Metallography Laboratory was to be determined at a later time. After the equipment and material were removed, surveys were performed on the floors and walls of all the rooms within the building with the exception of the Metallography Laboratory, Microscopy Laboratory and Storage Room.

Prior to performing building surveys, different areas of the building were given a degree of potential contamination ranging from not probable to very probable. Using NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (DOD 2000) classifications as a guide, areas/rooms were given a Class 1, Class 2 or Class 3 designation. Work began in Class 3 areas, followed by Class 2 areas and followed by Class 1 areas. After equipment was removed then surveys of the structure were performed. The floor and 6 ft up the wall in all rooms were surveyed. The floor and wall areas were divided into 3-ft-by-3-ft (3'x3') grids.

The average beta contamination levels in the DU Machine Shop was 1,380 dpm/100 cm^2 which was several times higher than any of the other areas surveyed. The DU machine shop and other rooms were less than Regulatory Guide 1.86 limits for both fixed and removable contamination.

The High Efficiency Particulate Air (HEPA) Filtration System located above the DU machine shop was evaluated and as a result, the HEPA filters and pre filter were removed and disposed of as radiological waste. The remaining ventilation system (i.e., in the Metallography Laboratory) which includes the umbilical ducts were determined to be radiologically contaminated and were left in place for disposal at a later time.

Upon completion of the surveys on equipment, material and building surfaces, the ceiling tiles and insulation above the ceiling tiles were removed and surveyed. No contamination above criteria was identified during the surveys of the ceiling tiles or insulation.

After characterization survey activities were complete the Metallography Laboratory and potentially contaminated items were left to address at a later date and the building required a final status release survey.

1.3.3 2010 Radiological Survey

In August 2010, Hidden Water, Inc., (HWI) performed a building final release survey based on the Regulatory Guide 1.86 protocols summarized in Section 1.3.2 using 1 square meter (m^2) grids. Areas and equipment known to be contaminated were identified and remediated through decontamination or removal prior to performing final surveys of building surfaces.

For the final surveys, the building was divided into 8 areas:

1. West End
2. Metallography Lab
3. Hallway
4. Heater Room
5. Bathroom
6. DU Room
7. Garage
8. East End

The floor, walls up to 15 ft, and the horizontal beam at the roof peak was surveyed using scans, direct frisks, and large area dry wipes. Survey grids were established in the building west end, Metallography Lab, hallway, Heater Room, bathroom, DU Machine Shop, garage and East End.

In summary, there were over 5,200 smears, direct frisks, and scans obtained from more than 1,400 1-m² grids in addition to large area swipes of the horizontal beam of the roof peak and the ventilation intake on the southern wall of the hallway.

The wood studded framework load bearing walls of the DU Room were left intact because of the potentially DU contaminated asbestos containing floor tile under the sole plates. Subsequently, as a result of remodeling, new wall materials were installed and a poured epoxy floor was used which continued 6 to 8 inches above the existing floor/wall joint.

Note that although surveys of the floor under the sole plates could not previously be performed (and they were assumed to be potentially contaminated), surveys conducted in 2006 and 2010 demonstrated that the floors directly adjacent to the sole plates in the DU Room met release criteria, so there is no historical data to support that radioactive contamination exists in excess of criteria on the floor under the sole plates. Therefore, the inaccessible area under the sole plates in the DU Room were considered non-impacted.

Additional areas of the building that required survey included:

1. Roof Stacks
2. Floor Drains and P-Traps
3. Horizontal Beam at the Roof Peak
4. DU Room and Metallography Lab Mezzanines
5. Exposed pipes outside of the west end of the building
6. Air intake on the southern wall of the hallway

The survey results are discussed in the, *Hidden Water, Inc. Armament Research Development and Engineering Center (ARADEC) Building 315 Radiological Survey* (HWI 2010) and are summarized as follows.

Surveys of the exterior roof stacks, the horizontal beam at the interior roof peak, the HEPA ventilation system and stack on the mezzanine above the DU Room, the air intake on the southern wall of the hallway, the three floor drains in the bathroom and the drain in the shower in the Metallography Lab did not show any removable or fixed contamination above the Regulatory Guide 1.86 limit. Two other floor drains were determined to be both inaccessible and non-impacted, therefore no measurements were taken.

The areas found to exceed the criteria and were left to address at a later date because it was anticipated that future DU work was planned in the Metallography Laboratory. These items were:

- the Metallography fume hood;
- the ventilation system on the mezzanine in the Metallography Laboratory;
- the sink drains in the Metallography Laboratory which were part of the line that was connected to the grinding/polishing unit; and
- the drain line along the southern wall of the Metallography Laboratory where the grinding/polishing unit was attached (This drain line leads to a sump pump located in the northeast corner of the room. Previous surveys indicated that that the pump was internally contaminated).

2.0 HISTORICAL SITE ASSESSMENT

The U.S. Army Research, Development and Engineering Command, ARDEC has been issued NRC Source Material License SUB-348. This license authorizes possession and use of limited quantities of source materials including the materials formerly subjected to investigations and analyses in various parts of Building 315. This section summarizes the known information related to the historical use of radioactive materials in Building 315.

Records indicate Building 315 has been used as a sodium nitrate storehouse, as offices of the engineering division, as research and development laboratories, as physical sciences workshops, and as metallurgical laboratories. Metallography laboratory activities include analyzing and studying DU from 1985 to 2005. The principal areas where DU was handled, was in areas with equipment for conducting metallographic, corrosion, stress corrosion, and mechanical testing, or storage. These areas are shown on Figure 1 and include the following:

- the hot machine shop,
- the EDM test room,
- the mechanical test lab,
- the metallography lab,
- the microscopy lab, and
- the storeroom.

An undated Picatinny Arsenal memorandum addressed DU contamination in the corrosion laboratory, machine shop, metallographic laboratory, and mechanical testing area. The memorandum identified DU chips and fines as airborne contaminants in the previously noted areas. In addition, the metallographic laboratory generated wastewater contaminated with DU. Until 1992, the DU wastewater was piped to holding tanks located within the uranium workshop. The DU wastewater was decanted in one tank and discharged into another tank where it was tested for chemical content and radioactive concentration. The wastewater was then discharged into the sewer system. However, in 1992, the wastewater holding tank system was shut down due to leakage of one of the holding tanks. In May 1994, both DU wastewater tanks were removed. After 1992, the DU wastewater generated at Building 315 was stored in 30-gallon poly drums within the building and was transported by a waste hauler to an off-site disposal facility.

An Environmental Baseline Survey conducted on Building 315 in November 1993 identified wastewater contaminated with DU as a waste stream.

No radiological work has ever occurred in the bathroom, hallway, clean machine shop or the two offices. The hallways and clean machine shop had only been used for moving pallets of radioactive material shipped to building 315 into the storeroom where they were unpacked.

Most of Building 315 has been upgraded for use as office space with the exception of the metallographic lab. See Figure 2 for the current building layout. During the upgrade of the areas, the original walls in the impacted areas were removed or new walls were installed. Surveys of walls and floors from the 2010 building surveys indicated the building met the Regulatory Guide 1.86 (AEC 1974) limits for unrestricted use. There has been an absence of work with DU in the recent past and no work with DU is anticipated in the foreseeable future.

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3.0 SURVEY PARAMETERS

3.1 RADIONUCLIDE OF CONCERN

DU is the lone radionuclide of concern at Picatinny Arsenal. The primary constituent in DU is uranium (U)-238. As shown in Table 3.1, U-238 (half-life 4.5×10^9 years) decays to thorium (Th)-234 (half-life 24 days), which in turn decays to protactinium (Pa)-234 (half-life 1.7 minutes), then to U-234 (half-life 2.5×10^9 years). Given the relatively short half-lives of Th-234 and Pa-234 and the long half-life of U-238, a relatively stable state is reached between U-238 and its immediate progeny in a relatively short period of time. Although the primary mode of decay for U-238 itself is through alpha emission, the decay of the short-lived radionuclides (i.e., Th-234 and Pa-234) is through beta emission. Given the greater attenuation of alpha particles compared to beta, beta surveys were used as the primary method of detection, as recommended in MARSSIM Section 4.3.2 (DOD 2000) and NUREG-1757, Volume 2, Appendix O, Section O.3.3.5 (NRC 2006).

Table 3-1. Portion of the Uranium-Series Radionuclides

Isotope	Half-life	Radiation[a]	Energy Level (MeV)[a]	Frequency (%)
U-238	4.5×10^9 years	Alpha	4.3	75
		Alpha	0.7	25
Th-234	24.5 days	Beta	0.076	2.7
		Beta	0.095	6.2
		Beta	0.096	18.6
		Beta	0.1886	72.5
Pa-234m	1.7 minutes	Beta	2.28	98.6
Pa-234	6.7 hours	Beta	0.224	100
U-234	2.5×10^5 years	Alpha	4.72	27.4
		Alpha	4.77	72.3

[a] Primary radiations and energies of interest.

Lead (Pb)-206 is the stable daughter in the uranium decay chain.

MeV – megaelectron Volt(s)

3.2 GEOGRAPHIC SCOPE AND OVERVIEW OF RADIOLOGICAL SURVEYS

The work within the scope of this report was accomplished in accordance with the *Radiological Survey Plan for Structures at Picatinny Arsenal* (HWI 2019). Floors and walls up to 2 m above the floor in the Metallography Laboratory were surveyed as one Class 1 survey unit (SU). All other impacted room floors were surveyed as one Class 3 survey unit with the exception of the DU Machine Shop. The DU Machine Shop had additional epoxy floor covering installed that precludes measuring the beta contamination because of the thickness of the epoxy and remodeling of the area. MARSSIM allows the use of previously collected survey data as final status data if data quality objectives are met, therefore, an evaluation of previous beta survey data from the 2010 radiological survey was evaluated using 2 pi efficiency for strontium (Sr)-90 as specified on the calibration certificate and applying a 0.5 surface efficiency and comparing results to the screening-level derived concentration guideline level (DCGL).

The same evaluation was performed for 2010 impacted wall surveys throughout the building up to 2 m above the floor because the walls during the operation time frame were removed or replaced with new surfaces covering the surface surveyed during the 2010 survey. The DU Shop floor was designated as a Class 1 SU, the lower walls up to 2 meters were designated as Class 2 SUs.

The external of the building, the former bathroom area and walls/ overhead area above 2 m are non-impacted and no further surveys are planned in these areas.

The impacted rooms from the historical building layout are listed in Table 3-2. The historical building Layout is shown on Figure 1.

Table 3-2. Rooms in Building 315

Room
Metallography Laboratory
DU Machine Shop
EDM Room[a]
Microscopy Laboratory[b]
Storage Room[b]
Mechanical Test Laboratory[a]
Corrosion Laboratory[b]
Hallway
Machine Shop[a]

Note a and b – Walls have been removed from these areas resulting in a large open area on east end (a) and west end (b) of the building connected by the Hallway.

In addition to the building surfaces the following areas/items associated with the Metallography laboratory required further investigation and surveys or removal and disposal as radioactive waste:

- the fume hood;
- ventilation system in the overhead area of the Metallography Laboratory and survey of accessible areas of remaining system;
- operational surveys of the Metallography Lab mezzanine area after removal of the ventilation and HEPA to ensure there was no spread of contamination;
- sink drains which were connected to the grinding/polishing unit;
- drain lines along the southern wall.
- pump and drain lines in northeast corner of Metallography Laboratory;

See Section 7.1 for final disposition of these items.

3.3 OVERVIEW OF SURVEY APPROACH

Scan surveys and fixed point measurements were performed using Ludlum Model 43-93 and 43-89 dual phosphor detectors coupled with either Ludlum Model 2360 or 2224 scaler/rate meters. The instrumentation detects both alpha and beta activity, however, beta surveys were used as the primary method of detection and quantification for comparison to the screening-level DCGL. The alpha measurements from the 2018 and 2019 surveys are also included for informational purposes in the survey data tables.

Removable survey measurement were collected at Class 1 survey locations, drains and the ventilation system to confirm that average removable activity is no greater than 10 percent of the total activity and the assumption used in developing screening-level DCGLs is appropriate.

3.4 DERIVED CONCENTRATION GUIDELINE LEVELS

The first step in the process of releasing a given room, building, or site is to determine what release criteria apply. In June 1974, the U.S. Atomic Energy Commission (AEC) issued AEC Regulatory Guide 1.86 (AEC 1974), which provided guidance with respect to surface contamination limits. (Historically, this NRC document is commonly referred to as "NRC Reg Guide 1.86," although the NRC did not exist at the time this document was initially produced.) Limits contained in NRC Regulatory Guide 1.86 were derived based on detectability, rather than being dose- or risk-based, with removable contamination limits equating to 20 percent of the respective total contamination limits.

Regulatory Guide 1.86 (AEC 1974) limits are commonly used for materials and equipment. The levels are 5,000 dpm/cm^2 for fixed beta/gamma emitters and 1,000 dpm/100 cm^2 for removable beta/gamma emitters.

In 1997, the NRC published Title 10, *Code of Federal Regulations (CFR),* Part 20, Subpart E, "Radiological Criteria for License Termination," in the *Federal Register (FR)* (62 *FR* 39058). These regulations included dose-based cleanup levels, also referred to as DCGLs, for releases both with and without radiological restrictions. Section 20.1402 of Subpart E states that "A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a [total effective dose equivalent] (TEDE) to an average member of the critical group that does not exceed 25 [millirem] (mrem) (0.25 [millisievert] mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."

In addition to issuance of radiological criteria for license termination, the NRC also performed "generic modeling" that "addresses residual radioactive contamination inside buildings and in soils." NUREG screening-level DCGLs for structure surfaces were developed based on "building renovation and normal building occupancy" scenarios. The building occupancy scenario accounts for exposure to fixed and removable residual radioactivity on the walls, floor, and ceiling of a decommissioned facility. It assumes that the building will be used for commercial or light industrial activities (e.g., an office building or warehouse) and includes the external radiation, inhalation of (re)suspended removable residual radioactivity, and inadvertent ingestion of removable residual radioactivity. The screening value represents the surface concentration of individual radionuclides that would be deemed in compliance with the 25 mrem per year unrestricted release dose limit in 10 *CFR* 20.1402 and is derived using conservative assumptions. Given the conservatism built into screening-level DCGLs, analysis to demonstrate that the dose to the average member of the critical group is ALARA is not required.

The "Screening Values of Common Radionuclides for Building-Surface Contamination Levels," as defined in NRC Commission Paper SECY-98-242, lists decommissioning and demolition (D&D) screening values. The screening-level DCGLs specified represent the 90th percentile of the output dose distribution equivalent to 25 mrem per year for each of the listed radionuclides.

The NRC staff acknowledged several areas in which modeling used to develop screening-level DCGLs is overly conservative. One such area is in the selection of resuspension factors. Consequently, NRC issued guidance in NUREG-1720, *Re-Evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for NRC's License Termination Rule - Draft Report for Comment,* (NRC 2002), which recommends a resuspension

factor of 1 x 10^{-6} m^{-1}. Screening-level DCGLs have been recalculated using D&D Version 2.1, with the only change being the modification of the value of the resuspension factor to the recommended value of 1 x 10^{-6} m^{-1}. Using a 95 percent confidence level, this change resulted in derivation of the screening-level DCGL of 1,400 dpm/100 cm^2 for U-238. A copy of the D&D output summary report using the modified resuspension factor is included in Appendix A of this survey report.

Each decay of natural uranium results in emission of alpha particles from the U-238 series parent and from U-234 as well as two beta particles from Th-234 and Pa-234m. This results in an alpha/beta ratio of about 1. With DU by contrast, U-234 is preferentially extracted with U-235 resulting in an alpha/beta ratio typically on the order of approximately 1.6 (NRC 2006). As such, the ratio of 1.6 is applied to the U-238 screening-level of 1,400 to make it applicable for a total beta screening level of 2,240 dpm/100 cm^2 for DU. This value is more conservative than the activity concentration (i.e., 6,000 dpm/100 cm^2) specified for uranium in Table 5-2, "Screening levels for Clearance" of Department of Army Pamphlet 385-24 but is consistent with NRC license criteria contained in Title 10, *CFR* and with approaches recommended by NUREG-1757.

Consistent with NUREG-1757, *Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria,* (NRC 2003), Group 2 licensees include those who "can demonstrate compliance with 10 *CFR* Part 20.1402 (Radiological criteria for unrestricted use) using the screening methodology." Given the use of such criteria for building surveys at Picatinny Arsenal, the associated permittees are reasonably categorized as equivalent to Group 2 licensees.

With respect to ALARA, it should be noted that pursuant to NUREG-1757, Volume II, Revision 1, Appendix N, (NRC 2006) indicates that "absent information to the contrary that licensees who remediate building surfaces or soil to the generic screening levels do not need to provide the analyses to demonstrate that these screening levels are ALARA. In addition, if residual radioactivity cannot be detected, it may be assumed that it has been released to levels that are ALARA" (NRC 2006).

4.0 DECISION ERROR

There are two types of decision error: Type I (alpha) and Type II (beta). Type I error is described as the probability of determining that the median concentration of a particular constituent is less than a criterion when it is actually not (false positive). Type II error is described as the probability of determining that the median is greater than criteria when it is not (false negative). The probability of making decision errors can be controlled by adopting an approach called hypothesis testing.

H_0 = the median concentration in the SU exceeds that in the reference area by more than the DCGL

where

H_0 = null hypothesis

This hypothesis assumes the site to be contaminated above criteria until proven otherwise. The Type I error refers to the probability of determining that the area is below the criterion when it is actually above the criterion (incorrectly releasing the survey unit). The Type II error refers to the probability of determining that the area is above the criterion when it is actually below the criterion (incorrectly failing to release the survey unit).

Based on the previously defined null hypothesis, lowering the Type I error decreases the probability of residual contamination exceeding site criteria, whereas increasing the Type I error would have the inverse effect. By contrast, lowering the Type II error decreases the probability of releasing a survey unit in which residual concentrations of contamination are below site criteria, generally resulting in increased costs for the removal of residuals that actually achieve criteria. Increasing the Type II error, by contrast, typically results in increased sampling costs but in a reduced probability of failing to release a survey unit that actually achieves cleanup criteria.

4.1 DECISION ERROR FOR SURVEYS AT BUILDING 315

The Type I error for Picatinny Arsenal has been set at 0.05 and the Type II error has been set at 0.2. This indicates a 5 percent probability of erroneously releasing a survey unit with a true mean greater than the DCGL and a 20 percent probability of not releasing a site that has attained the DCGL. This implies that if the mean is at a concentration that would produce an exposure at the criterion level, a 5 percent probability of erroneously finding it below the criterion exists, and a 20 percent probability of erroneously finding it to be greater than the criterion exists.

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5.0 SURVEY PARAMETERS

5.1 RELATIVE SHIFT

A material background reference area was not used for this survey and the number of samples was determined using the calculations for the Sign Test. The relative shift is defined as the Δ/σ where Δ is the DCGL - LBGR (lower bound of the gray region) and σ is the standard deviation of the contaminant distribution. MARSSIM recommends that the LBGR initially be set to one half of the DCGL, but that it should be adjusted if necessary to provide a Δ/σ value in the recommended range of 1 to 3. The total gross beta screening-level DCGL for Picatinny Arsenal was set to 2,240 dpm/100 cm^2. Thus, Δ can be found by:

$$\Delta = \text{DCGL} - \text{LBGR}$$

$$\Delta = 2{,}240\,\frac{dpm}{100\ cm^2} - \frac{2{,}240\,\frac{dpm}{100\ cm^2}}{2} = 1{,}120\,\frac{dpm}{100\ cm^2}$$

To determine standard deviation actual data may be used or consistent with MARSSIM guidance and with experience implementing the MARSSIM approach, "It is reasonable to assume a coefficient of variance of 30 percent" (DOD 2000).

Thus using a variance of 30 percent the relative shift was determined as follows:

$$relative\ shift = \frac{\Delta}{\sigma}$$

$$relative\ shift = \frac{1{,}120\,\frac{dpm}{100\ cm^2}}{672\,\frac{dpm}{100\ cm^2}} = 1.67$$

Given that MARSSIM guidance recommends a relative shift between 1.0 and 3.0, no adjustment was necessary.

5.2 THE NUMBER OF MEASUREMENTS PER SURVEY UNIT

The calculated value for the relative shift can be used to obtain the minimum number of measurements necessary to satisfy requirements using the MARSSIM equation:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(Sign\ p - 0.5)^2}$$

The calculated value, N, is the number of measurements from the SUs. Z1-α and Z1 β are critical values that can be found in MARSSIM Table 5.2, and Sign p is a measure of probability available from MARSSIM Table 5.4.

The number of data points, N, for the Sign Test of each SU is calculated using Equation 5-2 and Table 5.4 in MARSSIM, given 5 percent Type I error and 20 percent Type II error.

$$N = \frac{(1.645 + 0.842)^2}{4(0.945201 - 0.5)^2} = 8\ samples$$

The uncertainty associated with the calculation, N, should be accounted for during survey planning, thus the number of data points is increased by 20 percent and rounded up. This is to ensure there are sufficient data points to allow for any possible lost or unusable data.

$$N = 8 + 0.2(8) = 10\ measurements$$

Therefore 10 measurements were required for the structure survey units in Building 315. The number was further increased to 20 measurements to increase the power associated with the survey.

5.3 CLASSIFICATION OF SURVEY UNITS

As described in MARSSIM, SUs are subdivided into three classes. An SU is classified as a Class 1 SU if it meets any one of the following criteria:

1. The area is or was impacted (potentially influenced by contamination);
2. The area has potential for delivering a dose or risk greater than criteria;
3. There is potential for small areas of elevated activity; or
4. There is insufficient evidence to classify the area as Class 2 or Class 3.

An SU is classified as Class 2 if:

1. The area has the potential to have been impacted;
2. The area has low potential for delivering a dose or risk greater than criteria; or
3. There is little or no potential for small areas of elevated activity.

An SU is classified as Class 3 if:

1. The area has only minimum potential for being impacted;
2. The area has little or no potential for delivering a dose or risk greater than criteria; and
3. There is little or no potential for small areas of elevated activity.

Table 5-1 lists recommended surface areas for each class of SU.

Table 5-1. MARSSIM Suggested Survey Unit Areas

Classification	Suggested SU Areas for Structures
Class 1	Up to 100 m^2
Class 2	100 to 1,000 m^2
Class 3	No Limit

Source: DOD 2000

Using the previous criteria and also taking into consideration that the entire building had previously been surveyed and met Reg Guide 1.86 criteria with the exception of the Metallography Laboratory. It was determined that one Class 1 SU was necessary for the Metallography Laboratory floor and lower walls and one Class 3 SU was necessary for the remainder of floors requiring survey. In addition to the two survey units established for radiological survey there are 6 additional SUs that were established to evaluate the survey data previously collected in 2010. These SUs included one Class 1 SU for the DU Room floor and 5 Class 2 SU for the lower walls of the impacted areas of Building 315. The walls were designated as Class 2 SUs because there were no areas of elevated

activity identified in 2010 and readings were collected using a 1 m^2 grid pattern rather than random points for a Class 3 SU. The wall areas were divided into SUs based on the wall surveys performed in 2010 and having 1 m^2 grids provided sufficient data for each SU.

5.4 CALCULATION OF MEASUREMENT GRID SPACING

The appropriate spacing for a triangular grid on the floor the floor and lower walls of a 67 m^2 Class 1 area requiring 10 measurements was 2.8 m. The actual number of fixed-point measurements collected (in a triangular grid) in the Class 1 SU was increased to 20 measurements result in a grid spacing of approximately 2.0 m.

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6.0 SURVEY IMPLEMENTATION

6.1 INSTRUMENTATION SELECTION

Survey instruments used for quantitative radiological measurements were:

- selected based on the survey instrument's detection capability for alpha and beta activity;
- calibrated in accordance with American National Standards Institute (ANSI) N323A, Radiation Protection Instrumentation Test and Calibration – Portable Survey Instruments (ANSI 1997);
- calibrated with National Institute of Standards and Technology (NIST) traceable sources to obtain definitive quantitative measurements; and
- operated and maintained by qualified personnel, in accordance with Health Physics Program procedures (e.g., physical inspection, background checks, response/operational checks).

Radiological field instrumentation used for this survey was calibrated in accordance with manufacturers' recommendations and ANSI N323A within the past 12 months. Daily quality control (QC) checks were conducted on each instrument and performed in accordance with Health Physics Procedures. Only data obtained using instruments that satisfy these performance requirements have been accepted for use during this survey. (See instrument calibrations in Appendix B.)

6.1.1 Scan Minimum Detectable Concentrations

The minimum detectable concentration (MDC) is an activity level that a specific instrument and measurement technique can be expected to detect 95 percent of the time. Detection sensitivities (i.e., scan MDCs) were initially calculated in accordance with the approach detailed in NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC 1998). Calculations and associated results for Ludlum 43-89, Ludlum 43-93, and Ludlum 43-37 detectors are provided in Appendix C of this document and instrument summaries are listed in Table 6-1, following, for the survey instrumentation.

Table 6-1. Evaluation of Instruments Used at Picatinny Arsenal

Detector Model	Radiation of Interest	Background (cpm)	Instrument Efficiency (cpm/dpm)	Scan MDC[a] (dpm/100 cm^2)	Static MDC[a] (dpm/100 cm^2)
2018 and 2019 Surveys					
Ludlum Model 2360 Scaler with Model 43-93 Detector SN: 260691	Beta	226	0.451	860	226
Ludlum Model 2360 Scaler with Model 43-93 Detector SN: 200115	Beta	204	0.451	816	215
Ludlum Model 2360 Scaler with Model 43-93 Detector SN: 311200	Beta	252	0.506	811	213

Table 6-1. Evaluation of Instruments Used at Picatinny Arsenal (Continued)

Detector Model	Radiation of Interest	Background (cpm)	Instrument Efficiency (cpm/dpm)	Scan MDC[a] (dpm/100 cm^2)	Static MDC[a] (dpm/100 cm^2)
2018 and 2019 Surveys (Continued)					
Ludlum Model 2360 Scaler with Model 43-93 Detector SN: 311200	Beta	246	0.506	800	210
Ludlum Model 3030E with Model 43-10-1 Detector SN: PR360356	Beta	65.8	0.404	N/A	71.5
2010 Surveys					
Ludlum Model 2224 Scaler with Model 43-89 Detector SN: 170449	Beta	280	0.358	930	362
Ludlum Model 2224 Scaler with Model 43-89 Detector SN: 170449	Beta	290	0.358	943	368
Ludlum Model 2360 Scaler with Model 43-93 Detector SN: 244555	Beta	280	0.499	868	324
Ludlum Model 2221 Scaler with Model 43-37 Detector SN: 15934	Beta	1409	0.569	107	236

[a] The derivation of site-specific scan MDCs is presented in Appendix C.

SN – serial number; cpm – counts per minute; dpm – disintegrations per minute

6.1.2 Fixed-Point Measurement Calculations

Fixed-point beta measurement results in units of counts per minute (cpm) are converted to units of dpm/100 cm^2 using the following equation:

$$\text{Result}\left(\frac{dpm}{100cm^2}\right) = \frac{\left(R_g\right) - \left(R_b\right)}{\left(\varepsilon_i\right)\left(\varepsilon_s\right)\left(\frac{\text{Probe Area}}{100}\right)}$$

where:

R_g is the static data point gross count rate (cpm)
R_b is the instrument field background count rate (cpm)
ε_i is the instrument 2 π efficiency (cpm/disintegrations per minute [dpm])
ε_s is the surface efficiency (e.g., 0.50 for higher energy beta)
Probe Area (square centimeters [cm^2]) (e.g., 100 cm^2 for Ludlum Model 43-93).

7.0 RADIOLOGICAL INVESTIGATIONS AND SURVEYS RESULTS

Surveys and investigations described in this survey report addresses the removal and disposition of various equipment, the radiological surveys performed in May 2018 and November 2019 of the Building floor area designated as a Class 3 SU and the Metallography Laboratory floor and lower walls, drains and ventilation ducting. After the 2010 survey of the building floors and walls using Regulatory Guide 1.86 limits for release, an epoxy coating between 6 to 8 inches thick was placed over the DU Machine Shop floor and remodeling and installation of new wall material was installed making resurvey impractical. Therefore the relevant data collected in 2010 was evaluated using 2 pi efficiency for Sr-90 and applying a 0.5 surface efficiency to compare to the beta screening-level DCGL consistent with the 2018 and 2019 surveys. The impacted areas surveyed and evaluated were divided into 8 SUs. There are two Class 1 SUs, five Class 2 SUs and 1 Class 3 SU that were designated to evaluate the impacted areas of Building 315.

7.1 INVESTIGATION AND DISPOSTION OF POTENTIALLY CONTAMINATED ITEMS

In 2018 all contaminated drain lines and the sump pump in the Metallography Laboratory were removed and disposed of as radioactive waste. The fume hood was disconnected from the ventilation system and removed from against the wall, wiped down and surveyed by direct frisk for release. A glass drain attached to the fume hood was contaminated and was left for removal during the site mobilization in 2019.

The ventilation system above the Metallography Laboratory was confirmed to be contaminated in 2018 and the HEPA filters were removed and disposed of as radioactive waste. The ventilation ducting was left to be removed and addressed during the 2019 mobilization.

In 2019 the glass drain was removed from the fume hood and smears were collected. The fume hood was surveyed for release in 2018 and 2019 and is not part of the remaining structure surveys.

In 2019 the HEPA ducting, HEPA housing and the inlet and outlet transition piece from the HEPA housing were removed. The ventilation ducting was disposed of as radioactive waste and the inlet and outlet transition piece were wiped down and surveyed for release. After removal of the HEPA housing outlet transition piece the blower inlet was surveyed with all pieces below the scan MDC. The blower and blower exhaust ducting discharging to the roof stack are the only remaining portions of the HEPA ventilation that are part of the building structure. The removed pieces were released, however, readings were collected on all components at the highest location identified during the scan and compared to the screening-level DCGL.

After removal and survey of the ventilation components a scan survey was performed on 100 percent of the floor area of the overhead mezzanine area and no readings above the scan MDC were identified. Three fixed point readings were collected in the work area.

The ventilation system above the DU Machine Shop was removed wiped down and released in 2010. A new fume hood was installed in the Adhesives Laboratory and an investigation was done in the overhead mezzanine area to determine if any portion of the previous system was re-used and thus part of the building structure. The HEPA housing and blower unit that were previously released were still in the mezzanine area but were not part of the new ventilation system and not part of the permanent structure. Only the roof stack exhaust piping was in use. A scan survey of the HEPA housing and the blower inlet were performed and did not exceed the scan MDC. Measurements were also collected for comparison to the screening-level DCGL to confirm the 2010 surveys, indicating no contamination downstream of the HEPA filters. The measurement data from the ventilation systems and the mezzanine area can be found in Appendix D. Table D-1.

There were 4 drains in the impacted area of Building 315. A floor drain and a pipe drain in the southeast corner of the Metallography Laboratory, a floor drain in the Adhesives Laboratory, and a sink drain in the warehouse (formerly the Garage) in the eastern portion of building 315. Readings were collected at the drain opening and compared to the screening-level DCGL in 2019. Only the sink drain had a cover that could be removed and a reading was also taken on the bottom of the drain cover. All readings were below the screening-level DCGL. The measurement data from the drains can be found in Appendix D, Table D-2.

7.2 BUILDING STRUCTURE SURVEY MEASUREMENT AND SCAN RESULTS

Information provided in this section summarizes the measurement results for the building surface SUs. The actual number of systematic measurements collected exceeded the minimum required number for the Building 315 SUs. Table 7-1 contains the calculated minimum number of samples, the actual number of measurements collected for each SU and the results of a retrospective evaluation of the minimum number of samples using the SU mean as the LBGR and the SU standard deviation.

Table 7-1. Number of Systematic Fixed-Point Measurements

SU	Area	Minimum Number of Measurements per MARSSIM Calculation	Actual Number of Systematic or Random Measurements Collected	Retrospective Analysis of the Minimum Number of Measurements per MARSSIM Calculation
1	Metallography Laboratory	10	19	8
2	Class 3 Floor Area	10	20	8
3	DU Machine Shop Floor	10	35	9
4	DU Machine Shop Walls	10	41	8
5	West End Walls	10	100	8
6	Hallway Walls	10	86	8
7	Garage Walls	10	44	8
8	East End Garage Walls	10	34	8

7.2.1 Metallography Laboratory Floor and Lower Walls SU-1

The Metallography Laboratory floor and walls up to 2 m were classified as a MARSSIM Class 1 SU and measurements were collected on a systematic grid as shown on Figure 3.

One hundred (100) percent of the surface area was subjected to gross beta scan surveys. There were four locations identified during the scan survey that required further investigation and collection of a biased measurement. A small area of approximately 1 ft^2 in size directly in front of the door had elevated activity and two fixed point measurements were collected at the two locations with the highest readings identified during the scan, measurement location 21 and 22. Measurement location 22 exceeded the screening-level DCGL. This location was wiped down with a cleaner and rags and allowed to dry and resurveyed. The final measurement (22a) met the screening-level DCGL. In the area that was behind where the fume hood had been located there was an area with elevated activity identified on the scan on the floor area adjacent to the wall and on the bottom of the wall each approximately 100 cm^2 in size. One fixed point reading was taken on the reading on both the floor and the lower wall, locations 23 and 24 respectively and both met the screening-level DCGL. All other surface scan results were below the investigation level.

Nineteen systematic measurements were collected on a systematic grid. The original grid was established for 20 grid point measurements but one location was inadvertently collected on the north wall rather than the east wall. This measurement, location (5), was included as a biased location

rather than a systematic. A retrospective analysis of the data indicated that 8 measurements were the minimum required for the statistical test and therefore the 19 measurements that were collected are adequate for evaluating the SU. There were no systematic measurements that exceeded the screening-level DCGL See Appendix D Table D-3 for survey data.

MARSSIM states that if the largest SU measurement is less than the derived concentration guideline levels used for statistical tests ($DCGL_w$), the Sign test will always show that the SU always meets the release criterion. No systematic measurements exceeded the $DCGL_w$, therefore, a Sign test was not required and SU-1 meets the release criterion. Sufficient information has been collected to reject the null hypothesis that the area in question exceeds the $DCGL_w$.

7.2.2 Class 3 Floor Area SU-2

The remainder of the Building 315 impacted floor with the exception of the DU Machine Shop floor was classified as a MARSSIM Class 3 SU and measurements were collected at random locations as shown on Figure 4.

Gross beta scan surveys were performed at an area of approximately 2 m^2 around each fixed point measurement, on 100 percent of the accessible areas in the hallway from the Metallography Laboratory up to the warehouse on the east end of the building and areas directly in front of doorways exiting the building. Scan surveys did not reveal any areas that were radiologically elevated with respect to the investigation level which was established at the beta scan MDC.

Twenty random measurements were collected. The statistical design only required 10 samples and the number was increased to 20 to ensure adequate power was achieved. There were no random measurements that exceeded the screening-level DCGL. See Appendix D Table D-4 for survey data.

MARSSIM states that if the largest SU measurement is less than the $DCGL_w$, the Sign test will always show that the SU always meets the release criterion. No systematic measurements exceeded the $DCGL_w$, therefore, a Sign test was not required and SU-2 meets the release criterion. Sufficient information has been collected to reject the null hypothesis that the area in question exceeds the $DCGL_w$.

7.2.3 DU Machine Shop Floor SU-3

The DU Machine Shop floor was surveyed in 2010 using a 1 m^2 grid and the results were compared to Regulation Guide 1.86 limits to allow for release of the building structure. The 1 m^2 grid survey data collected in 2010 is being re-evaluated as a MARSSIM Class 1 SU and compared to the screening-level DCGL. See Figure 5 for the 2010 building layout and Figure 6 for the floor systematic grid locations.

One hundred (100) percent of the surface area was subjected to gross beta scan surveys. There were seven bolt holes that had elevated readings identified during the scan survey. The concrete was chipped away and wiped down using a cleaner then the area was rescanned to verify the contamination was removed. No post decontamination fixed point measurements were recorded. It should be noted that the beta investigation action level in cpm for 5,000 dpm/100 cm^2 using 4 pi efficiency and a surface of efficiency of 1 is only slightly higher than the action level would be when using 2 pi instrument efficiency and a 0.5 surface efficiency using the following equation:

$$CPM = \left(Limit \times InstEff \times SurfEff \times \left(\frac{ProbeArea}{100} \right) + fieldBKGD \right)$$

- Regulatory Guide 1.86 action level= 5000 x 0.081 x 1 x 1.25 + 280 = 786 cpm
- Screening-level DCGL action level= 2240 x 0.358 x 0.5 x 1.25 + 280 = 781 cpm

There is a very small difference between the scanning action levels and essentially the same for a surveyor in the field monitoring a ratemeter. The small difference in action levels provides assurance that the final scans in 2010 meet the beta screening-level DCGL.

Thirty five systematic measurements were collected on the 1 m^2 systematic grid. Two of the elevated bolt hole readings also used for the systematic grid measurement. As mentioned previously, these locations were decontaminated and scanned to ensure the contamination was removed but no additional fixed point measurements were collected. The original elevated readings are included in the data set table and in the Sign Test. See Appendix D Table D-5 for survey data.

Two systematic measurements exceeded the screening-level DCGL, therefore, a Sign test was required. The Sign test shows that SU-3 passes and meets the release criterion. Sufficient information has been collected to reject the null hypothesis that the area in question exceeds the $DCGL_w$. See Appendix E for the SU-3 Sign Test.

7.2.4 Building 315 Lower Walls SU-4 through SU-8

The Building 315 lower walls were surveyed in 2010 using a 1 m^2 grid and the results were compared to Regulation Guide 1.86 limits to allow for release of the building structure. The 1 m^2 grid survey data collected on the lower walls in 2010 is being re-evaluated as five MARSSIM Class 2 SUs and compared to the screening-level DCGL. The SUs include walls from the following:

- DU Machine Shop (SU-4)
- West End (SU-5)
- Hallway (SU-6)
- Garage (SU-7)
- East End Garage (SU-8)

See Figure 5 for the 2010 Building layout and Figures 6 through 10 for the wall systematic grid locations associated with each SU respectively.

One hundred (100) percent of the SU accessible wall surface area was subjected to gross beta scan surveys. There were no locations with elevated activity identified during the scan that required remediation. No post decontamination fixed point measurements were recorded.

Systematic measurements were collected at each 1 m^2 grid with the actual number collected for each SU shown in Table 7-1. The statistical design required 10 samples and the number was increased to 20 to ensure adequate power was achieved. Each SU exceeded 20 systematic measurements. There were no measurements that exceeded the screening-level DCGL. See Appendix D Tables D-6 through D-10 for survey data.

MARSSIM states that if the largest SU measurement is less than the DCGLw, the Sign test will always show that the SU always meets the release criterion. None of the systematic measurements exceeded the DCGLw, therefore, a Sign test was not required in any of the wall SUs and SUs- 4 through 8 meet the release criterion. Sufficient information has been collected to reject the null hypothesis that the wall SUs in question exceeds the DCGLw.

7.3 REMOVABLE CONTAMINATION EVALUATION

NUREG-1757, Volume 2, notes that screening level DCGLs developed by the NRC are based on the assumption that the fraction of removable surface contamination is equal to 0.1. As such, if areas of elevated radioactivity are encountered, the percentage of removable activity is generally

evaluated to assure that the fraction of removable activity is consistent with the underlying assumption. Removable survey measurements were collected for the Class 1 systematic and biased locations and were also collected for drain and ventilation measurements. The locations that had positive results for the fixed point and removable measurements were compared to evaluate the average fraction of removable activity. The average removable activity fraction was less than 0.1. See Table 7-2 for removable results.

Table 7-2. Removable Contamination Evaluation

Measurement Location	Removable Beta Activity			Removable Alpha Activity			
	gross cpm	net cpm	dpm/100 cm^2	gross cpm	net cpm	dpm/100 cm^2	% removable*
Metallography Laboratory #1	54.5	0	0	0	0	0	
Metallography Laboratory #2	62.0	0	0	0	0	0	
Metallography Laboratory #3	63.5	0	0	0	0	0	
Metallography Laboratory #4	71.5	5.7	14	0	0	0	0.30
Metallography Laboratory #5	64.0	0	0	0	0	0	
Metallography Laboratory #6	52.5	0	0	0	0	0	
Metallography Laboratory #7	75.0	9.2	23	1	0.9	3	0.11
Metallography Laboratory #8	63.5	0	0	1	0.9	3	
Metallography Laboratory #9	66.0	0.2	0	1	0.9	3	0.00
Metallography Laboratory #10	75.0	9.2	23	0	0	0	0.07
Metallography Laboratory #11	60.0	0	0	0	0	0	
Metallography Laboratory #12	67.5	1.7	4	1.5	1.4	4	0.07
Metallography Laboratory #13	62.0	0	0	1	0.9	3	
Metallography Laboratory #14	61.5	0	0	1.5	1.4	4	
Metallography Laboratory #15	72.0	6.2	15	1.5	1.4	4	0.10
Metallography Laboratory #16	67.0	1.2	3	0	0	0	
Metallography Laboratory #17	61.0	0	0	0.5	0.4	1	
Metallography Laboratory #18	51.0	0	0	0	0	0	
Metallography Laboratory #19	68.0	2.2	5	0.5	0.4	1	
Metallography Laboratory #20	62.5	0	0	0	0	0	
Metallography Laboratory #21	67.0	1.2	3	0.5	0.4	1	0.00
Metallography Laboratory #22	62.5	0	0	3.5	3.4	10	
Metallography Laboratory #23	79.5	13.7	34	5	4.9	14	0.02
Metallography Laboratory #24	63.0	0	0	0	0	0	
Metallography Laboratory Blower Inlet	64.5	0	0	0.5	0.4	1	
Metallography Laboratory HEPA Outlet Transition	53.0	0	0	0	0	0	
Metallography Laboratory HEPA Housing	66.5	0.7	2	1.5	1.4	4	0.00
Metallography Laboratory HEPA Inlet Transition	62.5	0	0	0	0	0	
DU Machine Shop HEPA Housing	59.0	0	0	0.5	0.4	1	
DU Machine Shop Blower Inlet	64.0	0	0	0	0	0	
Metallography Laboratory Floor Drain	54.5	0	0	0	0	0	
Metallography Laboratory Pipe Drain	59.0	0	0	0	0	0	
Warehouse (former Garage) Sink Drain	60.5	0	0	0	0	0	
Adhesive Laboratory Drain	66.5	0.7	2	0	-0.1	0	0.02
						Average Removable Fraction	**0.07**

Notes:

The counting instrument used was Ludlum Model 3030E serial #327699 coupled with Ludlum Model 43-10-1 serial #PR360356. Cal Due 9/20/2020.

Alpha efficiency- 34.85%, Beta efficiency 40.4%.

Beta minimum detectable activity (MDC) = 71.5 dpm/100 cm^2, alpha MDC= 7.4 dpm/100 cm^2. (10 minute background with 2 minute count time).

* Included % removable when both fixed and removable were positive results.

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8.0 CONCLUSION

Radiological final status surveys including building surface scans and fixed point measurements were performed to assess the status of Building 315. Surveys were designed and conducted to determine if radiologically impacted areas met the criteria for unrestricted release in accordance with 10 *CFR* 20, Subpart E.

Sufficient data exist for all impacted areas of Building 315 to demonstrate that residual concentrations of U-238 from past operations with DU achieve the beta screening-level DCGL of 2,240 dpm/100 cm^2. MARSSIM FSS demonstrates that the null hypothesis, "that residual activity in Building 315 exceeds the DCGL" is rejected. Measurement results collected from impacted areas demonstrate that each SU meets the criterion. See Appendix D for survey results.

Results demonstrated that residual activity in each SU was compliant with the NRC surface activity screening-level DCGL. The screening-level DCGL was developed by the NRC such that it conservatively corresponds to the 25 mrem per year dose limit for the average member of the critical group. As such, compliance with this screening-level DCGL necessarily demonstrates compliance with the NRC unrestricted release standards prescribed by 10 *CFR* 20, Subpart E.

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FIGURES

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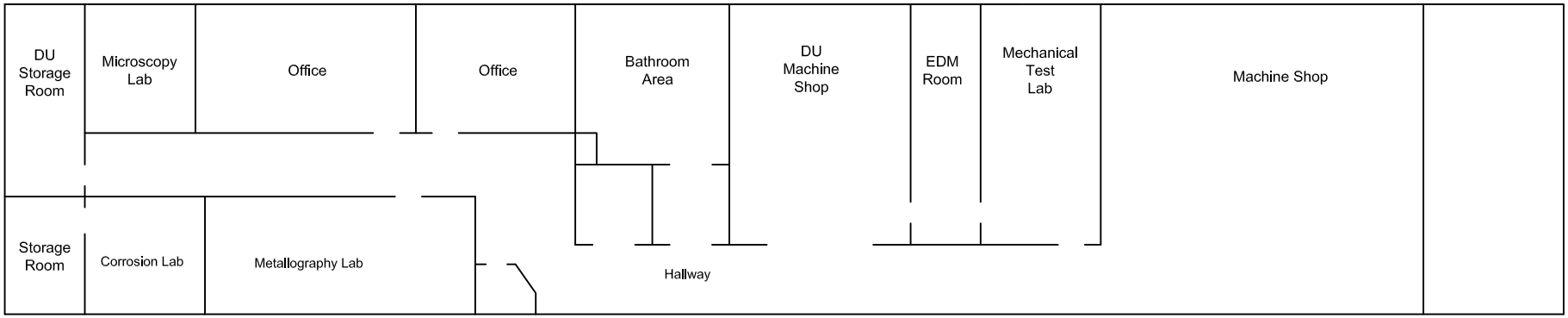
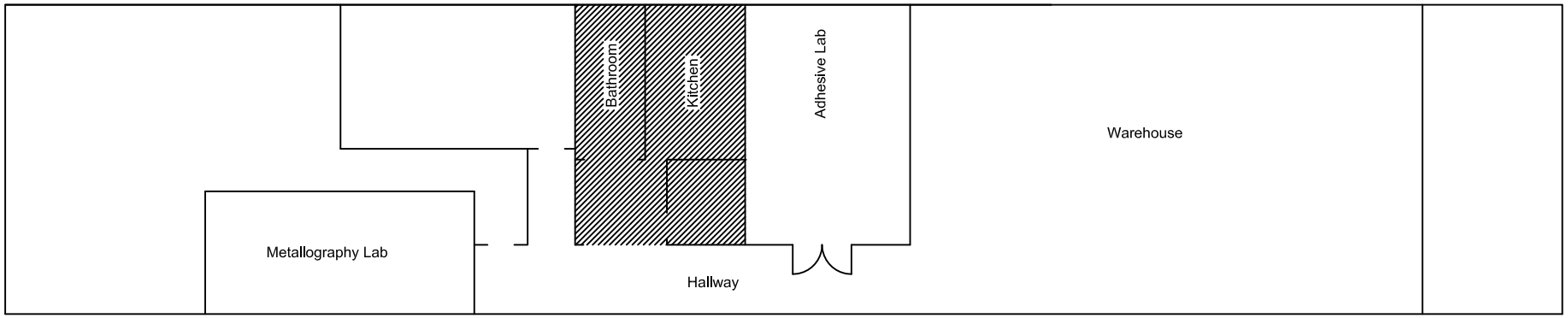
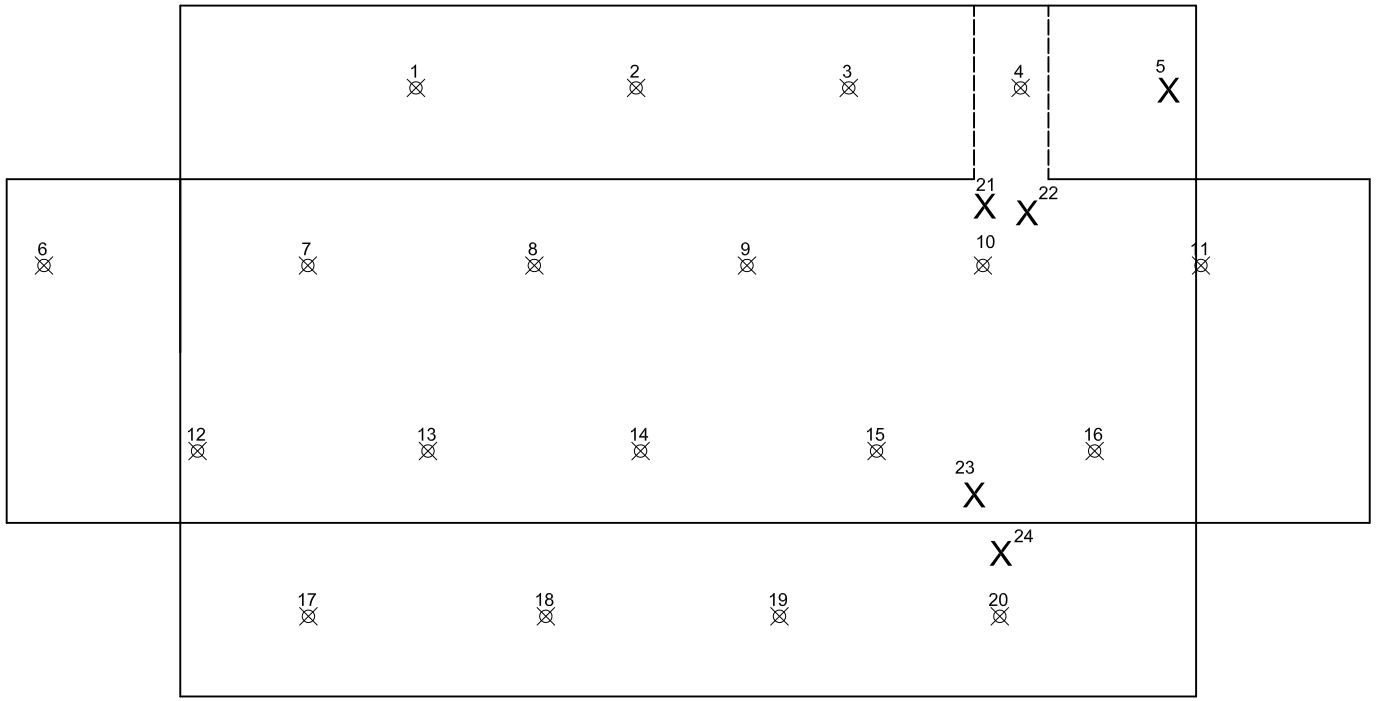


Hidden Water Inc. 3939 W. McKinley Ave Milwaukee, WI 53208	Title: Figure 1 Original Configuration	Date: December 28, 2019	Location: Building 315	Scale: As Shown 0 5 10 15 20 25 40
	Project: Building 315	Job Number: USA 2015-017	Picatinny Arsenal RDAR-QES-F Building 315 Picatinny Arsenal, NJ 07806	



Unimpacted Areas

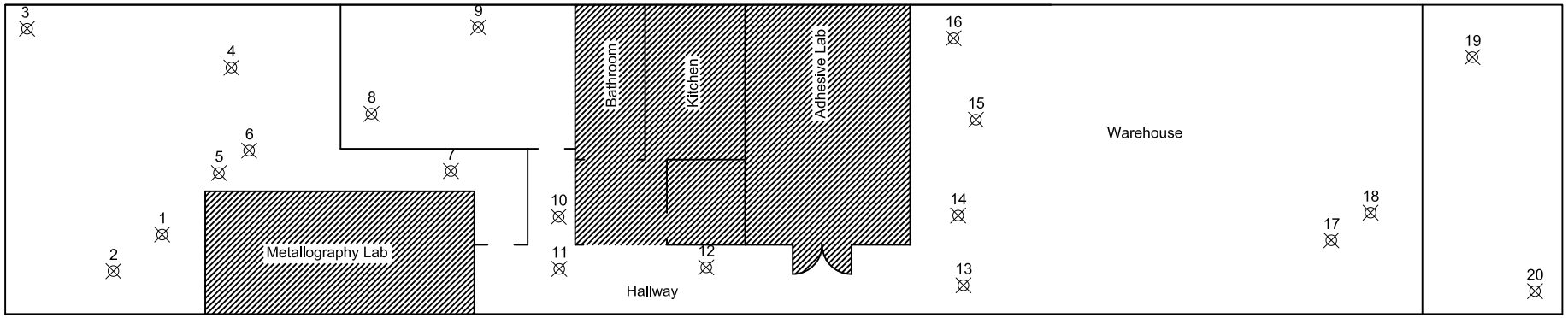
Hidden Water Inc. 3939 W. McKinley Ave Milwaukee, WI 53208	Title: Figure 2 Current Configuration	Date: December 28, 2019	Location: Building 315	Scale: As Shown 0 5 10 15 20 25 40
	Project: Building 315	Job Number: USA 2015-017	Picatinny Arsenal RDAR-QES-F Building 315 Picatinny Arsenal, NJ 07806	



⊠ Random Survey Points

X Biased Survey Points

Hidden Water Inc. 3939 W. McKinley Ave Milwaukee, WI 53208	Title: Figure 3 Metallography Room-Class 1	Date: December 28, 2019	Location: Building 315	Scale: As Shown 0 1 2 3 4 5 10
	Project: Building 315	Job Number: USA 2015-017	Picatinny Arsenal RDAR-QES-F Building 315 Picatinny Arsenal, NJ 07806	



Not included in the Class 3 survey unit

Hidden Water Inc. 3939 W. McKinley Ave Milwaukee, WI 53208	Title: Figure 4 Class 3 Survey Unit	Date: December 28, 2019	Location: Building 315	Scale: As Shown 0 5 10 15 20 25 40
	Project: Building 315	Job Number: USA 2015-017	Picatinny Arsenal RDAR-QES-F Building 315 Picatinny Arsenal, NJ 07806	

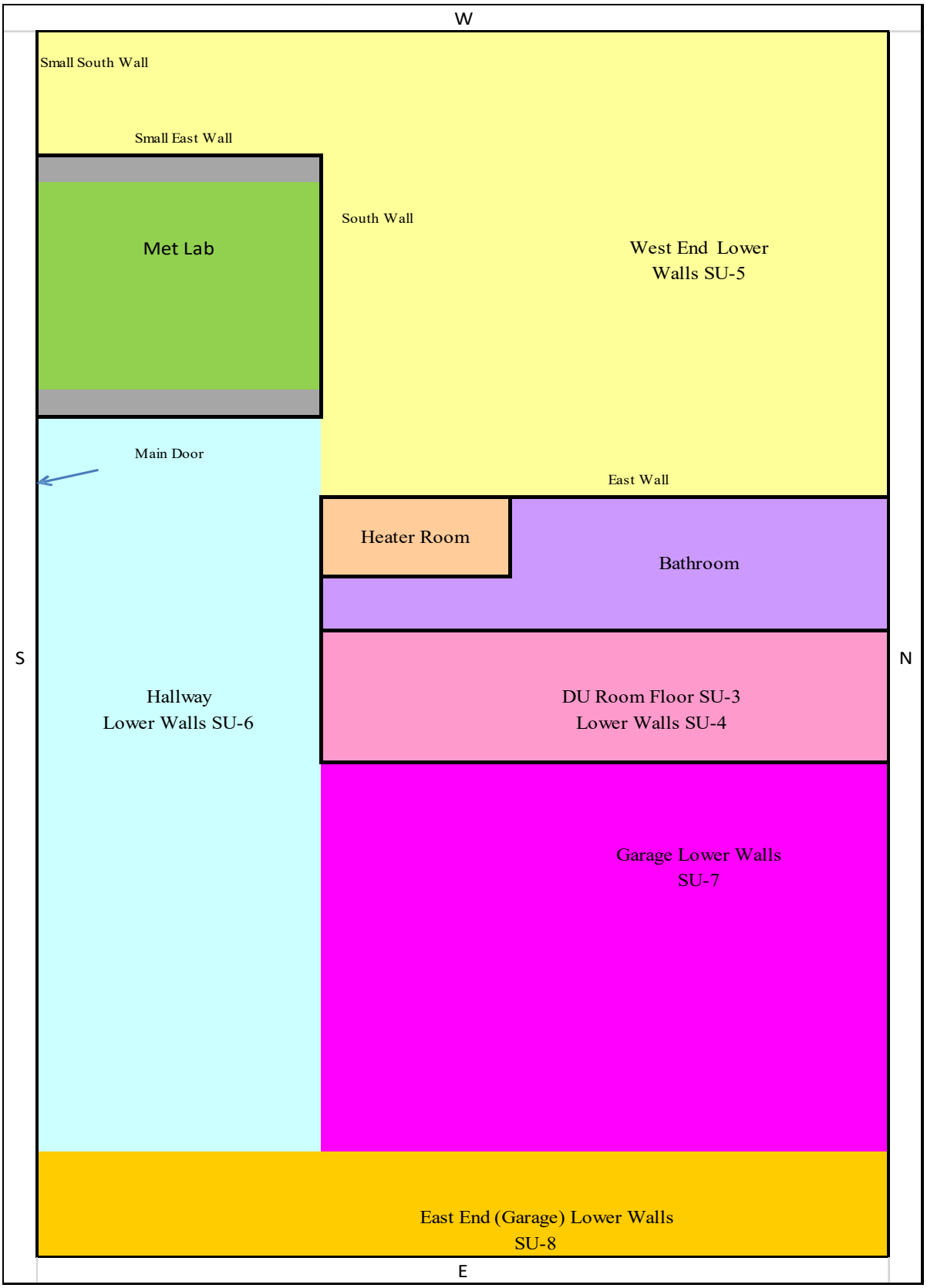


Figure 5. Building 315 2010 Survey Layout

SU-3 DU Room Floor						
1	6	11	16	21	26	31
2	7	12	17	22	27	32
3	8	13	18	23	28	33
4	9	14	19	24	29	34
5	10	15	20	25	30	35

SU-4 West Wall					
> 2m					
7	8	9	10	11	12
1	2	3	4	5	6

SU-4 North Wall				
> 2m				
18	19	20	21	22
13	14	15	16	17

SU-4 East Wall					
> 2m					
28	29	30	31	Door	32
23	24	25	26		27

SU-4 South Wall				
> 2m				
37	38	39	40	41
33	34	Door	35	36

Figure 6. DU Machine Shop Floor (SU-3) and Walls (SU-4)

West Wall								
> 2m								
10	11	12	13	14	15	16	17	18
1	2	3	4	5	6	7	8	9

North Wall																
> 2m																
36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

East Wall						
> 2m						
60	61	62	63	64	65	66
53	54	55	56	57	58	59

Small East Wall			
> 2m			
87	88	89	90
83	84	85	86

South Wall							
> 2m							
75	76	77	78	79	80	81	82
67	68	69	70	71	72	73	74

Small South Wall				
> 2m				
96	97	98	99	100
91	92	93	94	95

Figure 7. West End Walls (SU-5)

Hallway West Wall			
> 2m			
5	6	7	8
1	2	3	4

Hallway North Wall											
> 2m											
20	21	22	23	24	25	26	Doorway	27	28	29	30
9	10	11	12	13	14	15		16	17	18	19

South Wall West End													
> 2m													
58	57	56	55	54	53	52	51	50	49	48	47	46	45
44	43	42	41	40	39	38	37	36	35	34	33	32	31

South Wall East End													
> 2m													
86	85	84	83	82	81	80	79	78	77	76	75	74	73
72	71	70	69	68	67	66	65	64	63	62	61	60	59

Figure 8. Hallway Walls (SU-6)

Garage West Wall						
> 2m						
8	9	10	11	12	13	14
1	2	3	4	5	6	7

Garage North Wall														
> 2m														
30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

Figure 9. Garage Walls (SU-7)

East End Garage North Wall			
> 2m			
5	6	7	8
1	2	3	4

East End Garage East Wall								
> 2m								
18	19	20	21	22	23	24	25	26
9	10	11	12	13	14	15	16	17

East End Garage South Wall			
> 2m			
31	32	33	34
27	28	29	30

Figure 10. East End Garage Walls (SU-8)

APPENDIX A

DECOMMISSIONING AND DEMOLITION OUTPUT SUMMARY REPORT FOR URANIUM 238

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DandD Building Occupancy Scenario

DandD Version: 2.4.0
Run Date/Time: 1/9/2018 1:47:56 PM
Site Name: Picatinny
Description: U-238 Revised resuspension factor
FileName:C:\Users\passigm\DandD_Docs\U-238 Revised.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages of sampled values used for behavioral and metabolic type parameters
Averages of sampled values not used for derived behavioral or metabolic parameters

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

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Site Specific Value equating to 25 mrem/yr when applying the indoor resuspension factor of 1E-6 m-1		Value 1.40E+03

Chain Data:

Number of chains: **1**

Chain No. 1: **238U**
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	1	1.63E+12					6.88E-08	3.20E-05	4.76E-14	4.76E-17
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)
238U	1.40E+03
234Th	0.00E+00
234mPa	0.00E+00
234Pa	0.00E+00
234U	0.00E+00
230Th	0.00E+00
226Ra	0.00E+00
222Rn	0.00E+00
218Po	0.00E+00
214Pb	0.00E+00
218At	0.00E+00
214Bi	0.00E+00
214Po	0.00E+00
210Pb	0.00E+00
210Bi	0.00E+00
210Po	0.00E+00

Model Parameters:

General Parameters:

Parameter Name	Description	Distribution
To:Time In Building		CONSTANT(hr/week)

	The time in the building during the occupancy period	
Behavioral category: Default value used		Value 4.50E+01
Tto:Occupancy Period	The duration of the occupancy exposure period	CONSTANT(days)
Behavioral category: 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)
Metabolic category: Default value used		Value 1.40E+00
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Physical category: Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)
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)
Behavioral category: Default value used		
Tstart:Start Time	The start time of the scenario in days	CONSTANT(days)
Program Control category: Default value used		Value 0.00E+00
Tend:End Time	The ending time of the scenario in days	CONSTANT(days)
Program Control category: Default value used		Value 3.65E+02
dt:Time Step Size	The time step size	CONSTANT(days)
Program Control category: 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)
Program Control category: 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)
Behavioral category: 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)
Behavioral category: 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)
Behavioral category: 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)
Behavioral category: Default value used		
Fl:Loose Fraction	Fraction of surface contamination available for resuspension and ingestion	CONSTANT(none)
Physical category: Default value used		Value 1.00E-01
Rfo:Loose Resuspension Factor	Resuspension factor for loose contamination	CONTINUOUS LOGARITHMIC(1/m)
Physical category: 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)	
Behavioral category: Default value used		Value	1.10E-04

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 2.50E+01 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 2.50E+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)
238U	1.40E+03
234Th	1.27E+03
234mPa	1.26E+03
234Pa	2.53E+00
234U	1.64E-03
230Th	4.55E-09
226Ra	4.55E-13
222Rn	4.37E-13
218Po	4.37E-13
214Pb	4.37E-13
218At	8.75E-17
214Bi	4.37E-13
214Po	4.37E-13
210Pb	0.00E+00
210Bi	4.23E-14
210Po	4.90E-14

Pathway Dose from All Nuclides (mrem)

	External	Inhalation	

All Pathways Dose			Secondary Ingestion
2.50E+01	4.95E-02	2.45E+01	4.33E-01

Radionuclide Dose through All Active Pathways (mrem)

Nuclide	All Pathways Dose
238U	2.49E+01
234Th	4.14E-02
234mPa	2.71E-02
234Pa	6.55E-03
234U	3.27E-05
230Th	2.22E-10
226Ra	1.28E-15
222Rn	2.42E-19
218Po	5.45E-21
214Pb	1.50E-16
218At	0.00E+00
214Bi	8.68E-16
214Po	4.99E-20
210Pb	0.00E+00
210Bi	1.60E-18
210Po	1.76E-16
All Nuclides	2.50E+01

Dose from Each Nuclide through Each Active Pathway (mrem)

Nuclide	External	Inhalation	Secondary Ingestion
238U	1.08E-03	2.45E+01	4.13E-01
234Th	1.48E-02	6.55E-03	2.01E-02
234mPa	2.71E-02	0.00E+00	0.00E+00
234Pa	6.55E-03	3.04E-07	6.35E-06
234U	1.72E-09	3.21E-05	5.40E-07
230Th	4.79E-15	2.19E-10	2.89E-12
226Ra	4.11E-18	5.76E-16	6.99E-16
222Rn	2.42E-19	0.00E+00	0.00E+00
218Po	5.45E-21	0.00E+00	0.00E+00
214Pb	1.49E-16	5.04E-19	3.17E-19
218At	0.00E+00	0.00E+00	0.00E+00
214Bi	8.67E-16	4.25E-19	1.43E-19
214Po	4.99E-20	0.00E+00	0.00E+00
210Pb	0.00E+00	0.00E+00	0.00E+00

210Bi	6.23E-20	1.22E-18	3.14E-19
210Po	5.70E-22	6.79E-17	1.08E-16

APPENDIX B

INSTRUMENT CALIBRATIONS

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GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2360 SERIAL# 193682

Owner: GI

DATE: 11/29/17 LOCATION: Griffin Inst

TECH: E.M. Glenn DATE LAST CAL EXPIRES: 11/07/17

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114512 CAL. DUE: 11/13/18

[x] Audio Response [x] Geotropism CABLE LENGTH: 39"

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: ( ) Yes (•) No BATTERY CHECK: Sat

HV (+/-10%)	AS FOUND HV	AS LEFT HV	WINDOW SETTINGS:	A.F.	A.L.
500 V:	500	A.F.	BT (3.5 mV +/- 1 mV):	3.5	A.F.
1000 V:	1000	A.F.	BW (30 mV +/-3 mV):	30	A.F.
1500 V:	1500	A.F.	AT (120 mV +/-10 mV):	120	A.F.

RATE METER / SCALER

SCALE	RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100		0.0%	A.F.					
	250	250		0.0%	A.F.		251	0.4%	A.F.	
	400	400		0.0%	A.F.					
x1 or x10	1000	1000		0.0%	A.F.					
	2500	2500		0.0%	A.F.					
	4000	4000		0.0%	A.F.					
x10 or x100	10K	10	K	0.0%	A.F.					
	25K	25	K	0.0%	A.F.					
	40K	40	K	0.0%	A.F.					
x100 or x1000	100K	100	K	0.0%	A.F.					
	250K	250	K	0.0%	A.F.					
	400K	400	K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

Overload Light: (•) Adjusted / Verified ( ) Not Adj.

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 11/29/18

INSTRUMENT MARRIED WITH 43-93 # PR260691

Performed/Reviewed by: E.M. Glenn Date: 11/29/2017 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-93 PROBE # PR260691

Owner: GI

DATE: 11/29/17
TECH: E.M. Glenn

LOCATION: Griffin Inst
DATE LAST CAL EXPIRES: 11/07/17

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: DUAL

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2360 SERIAL #: 193682 CAL. DUE: 11/29/18

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
P2-149	Tc99 SS	21,949 dpm	02/01/17	12,070 cpm
P2-152	Th230	22,166 dpm	02/01/17	11,190 cpm
2696-00	Pu239	18,500 dpm	12/02/09	9,370 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm

Efficiencies from last cal.:

Condition: (●) Sat ( ) Unsat

Pu: 22.90% Th: 18.76% Sr: 30.57%

Tc ss: 14.62% C14: Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier	Tc-99 Source Response Nickel (CPM)			Pu-239 Source Response (CPM)			Background (CPM)		Tc-99 Source Response Stainless Steel (CPM)		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
775 / N/A				4249	497	22.96%	1	210	11	3080	13.08%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
6.3%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	4249		3080	4647	2603	
AF 4 pi eff:	22.96%		13.08%	20.96%	30.01%	
AF 2 pi eff:	*45.34%*		*23.78%*	*41.52%*	*42.93%*	

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

GRIFFIN INSTRUMENTS

PROBE #: PR260691
Date: 11/29/17

PLATEAU AND SET POINT DATA

HV / Vernier	Tc-99 Source Response SS (CPM)			Pu-239 Source Response (CPM)			Background (CPM)		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
725	13	1874	8.0%	3961	323	21.4%	1	125	4.8%	<1%
750	14	2501	10.6%	4080	365	22.0%	1	176	4.4%	<1%
775	6	2966	12.7%	4230	491	22.9%	2	186	6.7%	<1%
800				4353	817	23.5%	4	279	11.0%	

Alpha / Beta Bkg (cpm) 2 198

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
775 / N/A	CPM:	4222		3054	4709		2711
	4 pi AL Efficiencies:	22.81%		13.01%	21.24%		31.52%
	2 pi AL Efficiencies:	*45.04%*		*23.66%*	*42.06%*		*45.08%*

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 11/29/18

INSTRUMENT MARRIED WITH 2360 # 193682

Performed/Reviewed by: E.M. Glenn Date: 11/29/2017 Entered by: Initials

2 pi efficiencies denoted in Italics.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2360 SERIAL# 193654

Owner: GI

DATE: 11/29/17 LOCATION: Griffin Inst

TECH: E.M. Glenn DATE LAST CAL EXPIRES: 11/07/17

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114512 CAL. DUE: 11/13/18

[x] Audio Response [x] Geotropism CABLE LENGTH: 39"

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: ( ) Yes (•) No BATTERY CHECK: Sat

HV (+/-10%)	AS FOUND HV	AS LEFT HV	WINDOW SETTINGS:	A.F.	A.L.
500 V:	500	A.F.	BT (3.5 mV +/- 1 mV):	3.5	A.F.
1000 V:	1000	A.F.	BW (30 mV +/-3 mV):	30	A.F.
1500 V:	1500	A.F.	AT (120 mV +/-10 mV):	120	A.F.

RATE METER / SCALER

SCALE	RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100		0.0%	A.F.					
	250	250		0.0%	A.F.		250	0.0%	A.F.	
	400	400		0.0%	A.F.					
x1 or x10	1000	1000		0.0%	A.F.					
	2500	2500		0.0%	A.F.					
	4000	4000		0.0%	A.F.					
x10 or x100	10K	10	K	0.0%	A.F.					
	25K	25	K	0.0%	A.F.					
	40K	40	K	0.0%	A.F.					
x100 or x1000	100K	100	K	0.0%	A.F.					
	250K	250	K	0.0%	A.F.					
	400K	400	K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

Overload Light: (•) Adjusted / Verified ( ) Not Adj.

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 11/29/18

INSTRUMENT MARRIED WITH 43-93 # PR200115

Performed/Reviewed by: E.M. Glenn Date: 11/29/2017 Entered by: _____ Initials

Calibrations performed to ANSI N323A-1997 standards

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-93 PROBE # PR200115

Owner: GI

DATE: 11/29/17
TECH: E.M. Glenn

LOCATION: Griffin Inst
DATE LAST CAL EXPIRES: 11/07/17

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: DUAL

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2360 SERIAL #: 193654 CAL. DUE: 11/29/18

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
P2-149	Tc99 SS	21,949 dpm	02/01/17	12,070 cpm
P2-152	Th230	22,166 dpm	02/01/17	11,190 cpm
2696-00	Pu239	18,500 dpm	12/02/09	9,370 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm

Efficiencies from last cal.:

Condition: (●) Sat ( ) Unsat

Pu: 24.38% Th: 19.74% Sr: 31.11%

Tc ss: 14.70% C14: Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
700 / N/A				4457	576	24.09%	0	184	19	2909	12.42%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
8.1%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	4457		2909	4803	2552	
AF 4 pi eff:	24.09%		12.42%	21.67%	29.70%	
AF 2 pi eff:	*47.57%*		*22.58%*	*42.92%*	*42.48%*	

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

GRIFFIN INSTRUMENTS

PROBE #: **PR200115**
Date: 11/29/17

PLATEAU AND SET POINT DATA

HV / Vernier:	Tc-99 Source Response SS (CPM):			Pu-239 Source Response (CPM)			Background (CPM):		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
650	16	1447	6.3%	4049	312	21.9%	1	66	5.7%	<1%
675	13	1855	7.9%	4341	354	23.4%	3	124	5.0%	<1%
700	13	2787	12.0%	4445	526	24.0%	0	156	7.7%	<1%
725				4443	804	24.0%	0	213	11.7%	

Alpha / Beta Bkg (cpm) 2 158

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
700 / N/A	CPM:	4446		3004	4836		2670
	4 pi AL Efficiencies:	24.02%		12.97%	21.81%		31.51%
	2 pi AL Efficiencies:	*47.43%*		*23.58%*	*43.20%*		*45.06%*

REMARKS:

Does Instrument Meet Final Acceptance Criteria? (●) Yes ( ) No

Calibration Sticker Attached? (●) Yes ( ) No

Date Instrument is Due For Next Calibration: 11/29/18

INSTRUMENT MARRIED WITH 2360 # 193654

Performed/Reviewed by: E.M. Glenn Date: 11/29/2017 Entered by: _____ Initials

2 pi efficiencies denoted in italics.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2360 SERIAL# 278624

Owner: GI

DATE: 07/23/19 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 07/10/19

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: 500-2 SERIAL #: 284951 CAL. DUE: 10/03/19

[x] Audio Response [x] Geotropism CABLE LENGTH: 39"

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: (•) Yes ( ) No BATTERY CHECK: Sat

HV (+/-10%)	AS FOUND HV	AS LEFT HV	WINDOW SETTINGS:	A.F.	A.L.
500 V:	500	A.F.	BT (3.5 mV +/- 1 mV):	3.5	A.F.
1000 V:	1000	A.F.	BW (30 mV +/-3 mV):	30	A.F.
1500 V:	1500	A.F.	AT (120 mV +/-10 mV):	110	120

RATE METER

SCALER

SCALE	RATE CPM	AS FOUND	% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100	0.0%	A.F.					
	250	250	0.0%	A.F.		250	0.0%	A.F.	
	400	400	0.0%	A.F.					
x1 or x10	1000	1000	0.0%	A.F.					
	2500	2500	0.0%	A.F.					
	4000	4000	0.0%	A.F.					
x10 or x100	10K	10 K	0.0%	A.F.					
	25K	25 K	0.0%	A.F.					
	40K	40 K	0.0%	A.F.					
x100 or x1000	100K	100 K	0.0%	A.F.					
	250K	250 K	0.0%	A.F.					
	400K	400 K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

Overload Light: (•) Adjusted / Verified ( ) Not Adj.

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 07/23/20

INSTRUMENT MARRIED WITH 43-93 #PR311200

Performed/Reviewed by: Joanne Glenn Date: 7/23/2019 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-93 PROBE # PR311200

Owner: GI

DATE: 07/23/19 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 07/10/19

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: dual

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2360 SERIAL #: 278624 CAL. DUE: 07/23/20

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
P2-149	Tc99 SS	21,949 dpm	02/01/17	12,070 cpm
P2-152	Th230	22,166 dpm	02/01/17	11,190 cpm
Q5-679	Pu239	20,819 dpm	06/01/18	10,510 cpm
AL-8203	Sr90	30,720 dpm	05/31/18	19,920 cpm

Condition: (●) Sat ( ) Unsat

Efficiencies from last cal.:

Pu: 23.51% Th: 20.68% Sr: 33.48%

Tc ss: 16.08% C14: Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
650 / N/A				4942	490	23.74%	0	164	0	3770	16.43%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
6.2%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	4942		3770	4507	9955	
AF 4 pi eff:	23.74%		16.43%	20.33%	32.78%	
AF 2 pi eff:	*47.02%*		*29.88%*	*40.28%*	*50.55%*	

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

GRIFFIN INSTRUMENTS

PROBE #: **PR311200**
Date: 07/23/19

PLATEAU AND SET POINT DATA

HV / Vernier:	Tc-99 Source Response SS (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
N/A										

Alpha / Beta Bkg (cpm) 0 164

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
650 / N/A	CPM:	4942		3770	4507		9955
	4 pi AL Efficiencies:	23.74%		16.43%	20.33%		32.78%
	2 pi AL Efficiencies:	*47.02%*		*29.88%*	*40.28%*		*50.55%*

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 07/23/20

INSTRUMENT MARRIED WITH 2360 #278624

Performed/Reviewed by: Joanne Glenn Date: 7/23/2019 Entered by: ____ Initials

2 pi efficiencies denoted in italics.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 3030E SERIAL# 327699

Owner: C&C ENVIRONMENTAL

DATE: 09/20/19 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 10/04/19

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

CABLE LENGTH: 39" ( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: 500-2 SERIAL #: 341331 CAL. DUE: 09/03/20

MODEL: SERIAL #: CAL DUE:

Condition: (•) Sat ( ) Unsat

AF Mechanical Zero: 0

AL Mechanical Zero: 0

Scaler Function Check	As Found	As Left	
Beta Channel Window (4-50 mV):	4.4-53	4-50	
Alpha Channel Window (175 mV, 120 for 3030):	112	120	
Alpha Counts w/Pulser @ 10,000 CPM:	9,960	9965	% Error: 0.4%
Beta Counts w/Pulser @ 10,000 CPM:	9,944	9966	% Error: 0.6%

HIGH VOLTAGE POWER SUPLY CAL. (2929 only)

1 KV Reading (R-5 on HV Board):	1.018	1.0
Max HV (1500 V +):	(•) Sat	( ) Unsat

REMARKS: Verified internal battery sat.

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 09/20/20

INSTRUMENT MARRIED WITH 43-10-1 #PR360356

Performed/Reviewed by: Joanne Glenn Date: 9/20/2019 Entered by: GP Initials

Calibrations performed to ANSI N323A-1997 standards.

Ludlum Measurements,Inc.
Model 3030 Parameters

9/20/2019
8:43:57 AM

Header 1: John Q Public
Header 2: Serial#327699
Header 3: PR360356
Header 4: Room 7 EastWall
Header 5: More Comments?
Header 6: More Comments?

Calibration Due Date: 9/20/2020

Model 3030 Date: 9/20/2019
Model 3030 Time: 8:43:14 AM

Count Time Switch (min): 1.0
User PC Time (min): 1.0

Alpha Alarm: 999999
Beta Alarm: 999999
Alpha + Beta Alarm: 999999

High Voltage (VDC): 875

Loss of Count Time (min): 30.0

Count Mode: SCALER

Alpha Efficiency %: 37.8
Beta Efficiency %: 22.8

Background Subtract: OFF
Alpha Background: 0.0
Beta Background: 58.0

Crosstalk Correction: OFF
Alpha to Beta Crosstalk %: 2.5
Beta to Alpha Crosstalk %: 0.0

Show Parameters during startup: Enabled

Daily QC Check: OFF
Update Efficiency/Background Subtract from QC: SUB
Override QC Count Time: ON

Last Alpha Efficiency %: 39.6
Last Beta Efficiency %: 32.3

Standard Alpha Efficiency %: 40
Standard Beta Efficiency %: 32

Allowable Alpha QC Efficiency ± %: 15
Allowable Beta QC Efficiency ± %: 15

Alpha Source Size (dpm): 397000
Alpha Source Size (Bq): 6616.67
Alpha Source Size (µCi): 0.17882882883

Beta Source Size (dpm): 227000
Beta Source Size (Bq): 3783.33
Beta Source Size (µCi): 0.10225225225

Alpha QC Count Time (min): 1.0
Beta QC Count Time (min): 1.0
Background QC Count Time (min): 1.0

Last Alpha QC Background: 0.0
Last Beta QC Background: 35.0

Alpha Background Upper Limit (cpm): 3.0
Alpha Background Lower Limit (cpm): 0.0
Beta Background Upper Limit (cpm): 80.0
Beta Background Lower Limit (cpm): 0.0

Next Sample Number: 0001
User-defined Comment: AAAAAAAAAA
Logging Mode: Off
Recycle Mode: OFF
Printer Mode: OFF

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-10-1 PROBE # PR360356

Owner: C&C ENVIRONMENTAL

DATE: 09/20/19
TECH: Joanne Glenn
LOCATION: Griffin Inst
DATE LAST CAL EXPIRES: 10/04/19

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: **INPUT SENSITIVITY:**

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 3030E **SERIAL #:** 327699 **CAL. DUE:** 09/20/20

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
P2-149	Tc99 SS	21,949 dpm	02/01/17	12,070 cpm
P2-152	Th230	22,166 dpm	02/01/17	11,190 cpm
2696-00	Pu239	18,500 dpm	12/02/09	9,370 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm
PX-726	C14	48,780 dpm	01/21/08	18,660 cpm

Condition: (●) Sat ( ) Unsat

Efficiencies from last cal.:

Pu: 37.35% Th: 34.85% Sr: 40.56%

Tc ss: 23.36% C14: 13.63% Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
875 / N/A				6997	205	37.82%	1	127	0	5071	22.52%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
1.1%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	6997		5071	7586	3109	6106
AF 4 pi eff:	37.82%		22.52%	34.22%	39.09%	12.26%
AF 2 pi eff:	*74.66%*		*40.96%*	*67.78%*	*55.91%*	32.04%

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

Ludlum Measurements, Inc.
Model 3030 Plateau Data

9/20/2019
8:41:41 AM

Header 1: John Q Public
Header 2: Serial#327699
Header 3: PR360356
Header 4: Room 7 EastWall
Header 5: More Comments?
Header 6: More Comments?

Calibration Due Date: 9/20/2020

Model 3030 Date: 9/20/2019
Model 3030 Time: 7:30:14 AM

User PC Time: 1.0

Alpha Isotope: Pu239, 2696-00, 12/2/09
Alpha Source Size (dpm): 18500
Alpha Source Size (Bq): 308.33
Alpha Source Size (µCi): 0.008333333

Beta Isotope: Tc99, P2-149, 2/1/17
Beta Source Size (dpm): 21949
Beta Source Size (Bq): 365.82
Beta Source Size (µCi): 0.009886937

Starting High Voltage: 700
Starting High Voltage: 950
High Voltage Increment: 25

Plateau Count Mode: SCALER
Source Count Time (min): 1.0
Background Count Time (min): 1.0

	ALPHA				BETA				
HV	Source (Beta)	Background	Eff	CrossTalk	Source (Alpha)	Background	Eff	Crosstalk
700	4935 (643)	0	26.7%	12.9%	1080 (0)	5	4.9%	0.0%
725	5554 (449)	1	30.0%	7.8%	1780 (0)	17	8.0%	0.0%
750	6182 (307)	0	33.4%	4.6%	2385 (0)	22	10.8%	0.0%
775	6549 (256)	0	35.4%	3.4%	3086 (0)	32	13.9%	0.0%
800	6733 (230)	0	36.4%	2.6%	3585 (1)	55	16.1%	0.0%
825	6918 (254)	1	37.4%	3.0%	4078 (0)	46	18.4%	0.0%
850	7074 (215)	0	38.2%	2.5%	4679 (0)	41	21.1%	0.0%
→875	7000 (231)	0	37.8%	2.5%	5066 (0)	58	22.8%	0.0%
900	6905 (215)	0	37.3%	2.2%	5504 (0)	65	24.8%	0.0%
925	7044 (935)	0	38.1%	11.8%	5545 (2)	104	24.8%	0.0%
950	7245 (1075)	1	39.2%	0.6%	6793 (1)	1032	26.2%	0.0%

GRIFFIN INSTRUMENTS

PROBE #: **PR360356**
Date: 09/20/19

PLATEAU AND SET POINT DATA

HV / Vernier:	Tc-99 Source Response SS (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
See Attached										

Alpha / Beta Bkg (cpm) 0 58

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
875 / N/A	CPM:	7000		5066	7724	5847	3140
4 pi AL Efficiencies:		37.84%		22.82%	34.85%	11.87%	40.40%
2 pi AL Efficiencies:		*74.71%*		*41.49%*	*69.03%*	*31.02%*	*57.78%*

REMARKS: Cleaned around mylar due to high background as found. Re-plateaued.

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 09/20/20

INSTRUMENT MARRIED WITH 3030E #327699

Performed/Reviewed by: Joanne Glenn JG Date: 9/20/2019 Entered by: JG Initials

2 pi efficiencies denoted in italics.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-89 PROBE # PR170449

Owner: SOLUTIENT TECHNOL 1942

DATE: 07/17/10
TECH: Joanne Glenn

LOCATION: Griffin Inst
DATE LAST CAL EXPIRES: 02/13/10

REASON FOR CALIBRATION:

(•) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: dual

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2224 SERIAL #: 163741 CAL. DUE: 07/17/11

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
00TC470-0654	Tc99 SS	17,300 dpm	06/15/09	10,800 cpm
94TH470-1593	Th230	16,700 dpm	06/16/09	8,170 cpm
2696-00	Pu239	18,500 dpm	12/02/09	9,370 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm

Condition: (•) Sat ( ) Unsat

Efficiencies from last cal.:

Pu: Th: 16.09% Sr:

Tc ss: 8.23% C14: Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier	Tc-99 Source Response Nickel (CPM)			Pu-239 Source Response (CPM)			Background (CPM)		Tc-99 Source Response Stainless Steel (CPM)		
	A ch	B ch	Net Eff	A ch	B ch	Net Eff	A ch	B ch	A ch	B ch	Net Eff
675				3508	596	18.96%	0	274	5	1785	8.73%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
8.4%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	3508		1785	2945	2653	
AF 4 pi eff:	18.96%		8.73%	17.63%	25.01%	
AF 2 pi eff:	*37.44%*		*13.99%*	*36.05%*	*35.77%*	

Is as found efficiency within 20% of the efficiency from the last cal? ( ) Yes (•) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10% then the technician may N/A the plateau section and go directly to remarks

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2224 SERIAL# 163741

1940

Owner: SOLUTIENT TECHNOLOGIES

DATE: 07/17/10 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 02/13/10

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 42386 CAL. DUE: 04/21/11

☑ Audio Response ☑ Geotropism CABLE LENGTH: 39"

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: (•) Yes ( ) No BATTERY CHECK: Sat

HV (+/-10%)	AS FOUND HV	AS LEFT HV	WINDOW SETTINGS:	A.F.	A.L.
500 V:	500	A.F.	BT (3.5 mV +/- 1 mV):	3.5	A.F.
1000 V:	1000	A.F.	BW (30 mV +/-3 mV):	30	A.F.
1500 V:	1500	A.F.	AT (120 mV +/-10 mV):	110	120

RATE METER

SCALER

SCALE	RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100		0.0%	A.F.					
	250	250		0.0%	A.F.		250	0.0%	A.F.	
	400	400		0.0%	A.F.					
x1 or x10	1000	1000		0.0%	A.F.					
	2500	2500		0.0%	A.F.					
	4000	4000		0.0%	A.F.					
x10 or x100	10K	10	K	0.0%	A.F.					
	25K	25	K	0.0%	A.F.					
	40K	40	K	0.0%	A.F.					
x100 or x1000	100K	100	K	0.0%	A.F.					
	250K	250	K	0.0%	A.F.					
	400K	400	K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

Overload Light: (•) Adjusted ( ) Not Adj.

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 07/17/11

INSTRUMENT MARRIED WITH 43-89 # PR170449

Performed/Reviewed by: Joanne Glenn Date: 7/17/2010 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards

GRIFFIN INSTRUMENTS

PROBE #: **PR170449**
Date 07/17/10

PLATEAU AND SET POINT DATA

HV / Vernier	Tc-99 Source Response SS (CPM)			Pu-239 Source Response (CPM)			Background (CPM)		Net A to B Xtalk: <10%	B to A Xtalk <1%
	A ch	B ch	Net Eff	A ch	B ch	Net Eff	A ch	B ch		
N/A										

Alpha / Beta Bkg (cpm) 0 274

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
675	CPM:	3508		1785	2945		2653
	4 pi AL Efficiencies:	18.96%		8.73%	17.63%		25.01%
	2 pi AL Efficiencies:	*37.36%*		*13.99%*	*36.05%*		*35.77%*

REMARKS: As found data off scale - replaced mylar

Does Instrument Meet Final Acceptance Criteria? (•) Yes ( ) No

Calibration Sticker Attached? (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 07/17/11

INSTRUMENT MARRIED WITH 2224 # 163741

Performed/Reviewed by: [signature] Date: 7/17/2010 Entered by: [signature] Initials

2 pi efficiencies denoted in italics.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2224 SERIAL# 221460

1919

Owner: SOLUTIENT TECHNOLOGIES

DATE: 03/02/10 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 02/13/10

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114512 CAL. DUE: 09/05/10

☑ Audio Response ☑ Geotropism CABLE LENGTH: 39"

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: ( ) Yes (•) No BATTERY CHECK: Sat

HV (+/-10%)	AS FOUND HV	AS LEFT HV	WINDOW SETTINGS:	A.F.	A.L.
500 V:	500	A.F.	BT (3.5 mV +/- 1 mV):	3.5	A.F.
1000 V:	1000	A.F.	BW (30 mV +/-3 mV):	29	30
1500 V:	1500	A.F.	AT (120 mV +/-10 mV):	120	A.F.

RATE METER

SCALER

SCALE	RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100		0.0%	A.F.					
	250	250		0.0%	A.F.		250	0.0%	A.F.	
	400	400		0.0%	A.F.					
x1 or x10	1000	1000		0.0%	A.F.					
	2500	2500		0.0%	A.F.					
	4000	4000		0.0%	A.F.					
x10 or x100	10K	10	K	0.0%	A.F.					
	25K	25	K	0.0%	A.F.					
	40K	40	K	0.0%	A.F.					
x100 or x1000	100K	100	K	0.0%	A.F.					
	250K	250	K	0.0%	A.F.					
	400K	400	K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

Overload Light: ( ) Adjusted (•) Not Adj

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 03/02/11

INSTRUMENT MARRIED WITH 43-93 # PR244555

Performed/Reviewed by: Joanne Glenn Date: 3/2/2010 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-93 PROBE # PR244555

Owner: SOLUTIENT TECHNOL

DATE: 03/02/10
TECH: Joanne Glenn
LOCATION: Griffin Inst
DATE LAST CAL EXPIRES: 02/13/10

REASON FOR CALIBRATION:

(•) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: dual

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2224 SERIAL #: 221460 CAL. DUE: 03/02/11

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
00TC470-0654	Tc99 SS	17,300 dpm	06/15/09	10,800 cpm
94TH470-1593	Th230	16,700 dpm	06/16/09	8,170 cpm
2696-00	Pu239	18,500 dpm	12/02/09	9,370 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm

Condition: (•) Sat ( ) Unsat

Efficiencies from last cal.:

Pu: Th: 18 38% Sr:

Tc ss: 12 00% C14: Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier	Tc-99 Source Response Nickel (CPM)			Pu-239 Source Response (CPM)			Background (CPM)		Tc-99 Source Response Stainless Steel (CPM)		
	A ch	B ch	Net Eff	A ch	B ch	Net Eff	A ch	B ch	A ch	B ch	Net Eff
675 / N/A				4287	564	23 16%	2	276	18	2551	13 15%

Net A to B Xtalk: <10%	B to A Xtalk <1%
6 3%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	4287		2551	3651	3619	
AF 4 pi eff:	23.16%		13.15%	21.85%	34.86%	
AF 2 pi eff:	*45.73%*		*21.06%*	*44.66%*	*49.86%*	

Is as found efficiency within 20% of the efficiency from the last cal? (•) Yes ( ) No (See Remarks)

Note If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10% then the technician may N/A the plateau section and go directly to remarks

GRIFFIN INSTRUMENTS

PROBE #: PR244555
Date: 03/02/10

PLATEAU AND SET POINT DATA

HV / Vernier	Tc-99 Source Response SS (CPM)			Pu-239 Source Response (CPM)			Background (CPM)		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff	A ch.	B ch.	Net Eff	A ch.	B ch.		
N/A										

Alpha / Beta Bkg (cpm) 2 276

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
675 / N/A	CPM:	4287		2551	3651		3619
	4 pi AL Efficiencies:	23.16%		13.15%	21.85%		34.86%
	2 pi AL Efficiencies:	*45.63%*		*21.06%*	*44.66%*		*49.86%*

REMARKS:

Does Instrument Meet Final Acceptance Criteria? (•) Yes ( ) No

Calibration Sticker Attached? (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 03/02/11

INSTRUMENT MARRIED WITH 221460 # 2224

Performed/Reviewed by: Jerome Ghen Date: 3/2/2010 Entered by: _____ Initials

2 pi efficiencies denoted in italics.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2221 SERIAL# 176942 1135

Owner: SOLUTIENT TECHNOLOGIES

DATE: 07/17/10 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 03/28/10

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 42386 CAL DUE: 04/21/11

MODEL: SERIAL #: CAL DUE:

☑ Fast/Slow Switch working properly ☑ Audio Response ☑ Geotropism CABLE LENGTH 6'

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: (•) Yes ( ) No BATT. CHECK >4.8V: 6.3 V

HV (+/-10%)	AS FOUND HV	AS LEFT HV
600 V:	594	596
1200 V:	1175	1197
1800 V:	1770	1789

AF INPUT SENSITIVITY (mV): 4 AL INPUT SENSITIVITY (mV): A.F.

RATE METER

SCALER

SCALE	RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100		0.0%	A.F.					
	250	250		0.0%	A.F.		250	0.0%	A.F.	
	400	400		0.0%	A.F.					
x1 or x10	1000	1000		0.0%	A.F.					
	2500	2500		0.0%	A.F.					
	4000	4000		0.0%	A.F.					
x10 or x100	10K	10	K	0.0%	A.F.					
	25K	25	K	0.0%	A.F.					
	40K	40	K	0.0%	A.F.					
x100 or x1000	100K	100	K	0.0%	A.F.					
	250K	250	K	0.0%	A.F.					
	400K	400	K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

LOG SCALE

SCALE	RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR
Log	200	200		0.0%	A.F.	
	2000	2000		0.0%	A.F.	
	20K	20	K	0.0%	A.F.	
	200K	195	K	2.5%	A.F.	

Is the As Found Data Within 20% of the Set Point?: (•) Yes ( ) No

GRIFFIN INSTRUMENTS

SERIAL # 176942

07/17/10

Audio Divide:	(•) Sat ( ) Unsat	Push Buttons:	(•) Sat ( ) Unsat
Lamp:	(•) Sat ( ) Unsat	Scaler/Digital:	(•) Sat ( ) Unsat

Remarks:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 07/17/11

INSTRUMENT MARRIED WITH #

Performed/Reviewed by: Joanne Ghent Date: 7/17/2010 Entered by: JG Initials

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-37 PROBE # RN015934

Owner: SOLUTIENT TECHNOL 1167

DATE: 07/17/10 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 03/28/10

REASON FOR CALIBRATION:

(•) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 6' INPUT SENSITIVITY: 4 mV

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2221 SERIAL #: 176942 CAL. DUE: 07/17/11

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
00TC470-0654	Tc99 SS	17,300 dpm	06/15/09	10,800 cpm
94TH470-1593	Th230	16,700 dpm	06/16/09	8,170 cpm
2696-00	Pu239	18,500 dpm	12/02/09	9,370 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm
PX 726	C14	48,780 dpm	01/21/08	18,660 cpm

Condition: (•) Sat ( ) Unsat

Efficiencies from last cal.:

Pu: 24.58% Th: 20.52% Sr: 41.34%

Tc ss: 21.25% C14: Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
1250 a / 1750 b				4397		23.74%	5	875		5668	27.71%

Net A to B Xtalk: <10% | B to A Xtalk: <1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	4397		5668	3673	4662	8345
AF 4 pi eff:	23.74%		27.71%	21.96%	39.81%	15.31%
AF 2 pi eff:	*46.87%*		*44.38%*	*44.90%*	*56.94%*	*40.03%*

Is as found efficiency within 20% of the efficiency from the last cal? (•) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10% then the technician may N/A the plateau section and go directly to remarks

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APPENDIX C

SCAN MINIMUM DETECTABLE CONCENTRATIONS FOR RADIOLOGICAL CONTAMINANTS OF CONCERN AT PICATINNY ARSENAL BUILDING 315

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SCAN MINIMUM DETECTABLE CONCENTRATRATIONS FOR RADIOLOGICAL CONTAMINANTS OF CONCERN AT PICATINNY ARSENAL BUILDING 315

NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC 1998), and NUREG-1575, MARSSIM (DOD 2000), provide methodology for calculation of MDCs. The following details the approach for calculating site-specific MDCs for U-238 for use in the survey process at the Building 315. The MDCs provided in this appendix were calculated using specific instrument and background data gathered at building 315 during surveys in August 2010, May 2018 and November 2019.

The steps utilized for calculating MDCs for Building 315 follow the approach detailed in NUREG-1507. The steps include:

1. Calculating the minimum detectable count rate (MDCR) by selecting a given level of performance, scan speed, and background level of the detector; and
2. Selecting a surveyor efficiency, if applicable.

The scan MDCs for structure surfaces may be calculated as follows:

The observation interval (i) is defined as the width of the probe divided by the time that 25 percent of the probe is over a 4"×4" area of interest (scan speed).

$$i = \text{(probe width)} / \text{(scan speed)}$$

or

$$i = \frac{w}{s}$$

where:

i = observation interval (second)
w = probe width (inches)

The observable background count (b_i) is defined as is the number of background counts that occur during an observation interval.

$$b_i = (\mathrm{B}) \times (i/60)$$

where:

B = background count rate (cpm)

The minimum detectable number of net source counts in the interval is given by s_i. Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts by the detectability value associated with the desired performance (d'), as shown in the following equations:

$$s_i = d' \sqrt{b_i}$$

or

$$s_i = d' \sqrt{B(\frac{i}{60})}$$

where:

s_i = minimum detectable number of net source counts
d' = index of detectability
B = background count rate (cpm)

The MDCR is defined as the increase above background recognizable during a survey in a given period of time. The variable, *d*', is defined as the index of sensitivity and is dependent on the selected decision errors for Type I (alpha) and Type II (beta) errors. A true positive error (1–β) of 95 percent and a false positive error (alpha) of 60 percent were selected to be consistent with NUREG-1507. The value of 1.38 was obtained from Table 6.1 in NUREG-1507 (Table 6.5 in MARSSIM).

$$\text{MDCR} = s_i \times (60/i) = \text{cpm}$$

Finally, the scan MDCs for structure surfaces may be calculated:

$$MDC = \frac{MDCR}{\left(\sqrt{p}\right)(\varepsilon_s)(\varepsilon_i)\left(\frac{probe\ area}{100\ cm^2}\right)}$$

where:

MCDR = minimum detectable count rate
ε_s = surface efficiency
ε_i = instrument efficiency
p = surveyor efficiency

The static MDC for structure surfaces may be calculated as follows:

$$MDC = \frac{\left(3 + 3.29\sqrt{(B)(T_g)(1+\frac{T_g}{T_b})}\right)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{probe\ area}{100\ cm^2}\right)(T_g)}$$

where:

B = background count rate (cpm)
ε_s = surface efficiency
ε_i = instrument efficiency
T_g = measurement count time (minutes)
T_b = background count time (minutes)

LUDLUM MODEL 2360 WITH 43-93 DETECTOR SN 260691

The beta static MDC for the 43-93 can be calculated as follows:

where:

B = 226 cpm
T_b = 2 minutes
T_g = 2 minutes
ε_s = 0.5
ε_i = 0.451 cpm/dpm
probe area = 100 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(226)(2)(1+\frac{2}{2})}\right)}{(2)(0.5)(0.451)\left(\frac{100}{100\ cm^2}\right)} = 226\ dpm/100\ cm^2$$

The beta scan MDC for the 43-93 can be calculated as follows:

where:

w = 2.8 inches
s = 2 inch/second

$$i = \frac{2.8}{2} = 1.4 \text{ seconds}$$

where:

d' = 1.38
B = 226 cpm
i = 1.4 seconds

$$MDCR = 1.38\left(\sqrt{(226)\frac{1.4}{60}}\right)(\frac{60}{1.4}) = 137 \text{ cpm}$$

where:

MCDR = 137 cpm
ε_s = 0.5
ε_i = 0.451
p = 0.5
probe area = 100 cm^2

$$MDC = \frac{137}{\left(\sqrt{0.5}\right)(0.5)(0.451)\left(\frac{100}{100\ cm^2}\right)} = 860\ dpm/100\ cm^2$$

LUDLUM MODEL 2360 WITH 43-93 DETECTOR SN 200115

The beta static MDC for the 43-93 can be calculated as follows:

where:

B = 204 cpm
T_b = 2 minutes
T_g = 2 minutes
ε_s = 0.5
ε_i = 0.451 cpm/dpm
probe area = 100 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(204)(2)(1+\frac{2}{2})}\right)}{(2)(0.5)(0.451)\left(\frac{100}{100\ cm^2}\right)} = 215\ dpm/100\ cm^2$$

The beta scan MDC for the 43-93 can be calculated as follows:

where:

w = 2.8 inches
s = 2 inch/second

$$i = \frac{2.8}{2} = 1.4 \text{ seconds}$$

where:

d' = 1.38
B = 204 cpm
i = 1.4 seconds

$$MDCR = 1.38\left(\sqrt{(204)\frac{1.4}{60}}\right)(\frac{60}{1.4}) = 130 \text{ cpm}$$

where:

MCDR = 130 cpm
ε_s = 0.5
ε_i = 0.451
p = 0.5
probe area = 100 cm^2

$$MDC = \frac{130}{\left(\sqrt{0.5}\right)(0.5)(0.451)\left(\frac{100}{100\ cm^2}\right)} = 816\ dpm/100\ cm^2$$

LUDLUM MODEL 2360 WITH 43-93 DETECTOR SN 311200

The beta static MDC for the 43-93 can be calculated as follows:

where:

B = 252 cpm
T_b = 2 minutes
T_g = 2 minutes
ε_s = 0.5
ε_i = 0.506 cpm/dpm
probe area = 100 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(252)(2)(1+\frac{2}{2})}\right)}{(2)(0.5)(0.506)\left(\frac{100}{100\ cm^2}\right)} = 213\ dpm/100\ cm^2$$

The beta scan MDC for the 43-93 can be calculated as follows:

where:

w = 2.8 inches
s = 2 inch/second

$$i = \frac{2.8}{2} = 1.4 \text{ seconds}$$

where:

d' = 1.38
B = 252 cpm
i = 1.4 seconds

$$MDCR = 1.38\left(\sqrt{(252)\frac{1.4}{60}}\right)(\frac{60}{1.4}) = 145 \text{ cpm}$$

where:

MCDR = 145 cpm
ε_s = 0.5
ε_i = 0.506
p = 0.5
probe area = 100 cm^2

$$MDC = \frac{145}{\left(\sqrt{0.5}\right)(0.5)(0.506)\left(\frac{100}{100\ cm^2}\right)} = 811\ dpm/100\ cm^2$$

LUDLUM MODEL 2360 WITH 43-93 DETECTOR SN 311200

The beta static MDC for the 43-93 can be calculated as follows:

where:

B = 246 cpm
T_b = 2 minutes
T_g = 2 minutes
ε_s = 0.5
ε_i = 0.506 cpm/dpm
probe area = 100 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(246)(2)(1+\frac{2}{2})}\right)}{(2)(0.5)(0.506)\left(\frac{100}{100\ cm^2}\right)} = 210\ dpm/100\ \ cm^2$$

The beta scan MDC for the 43-93 can be calculated as follows:

where:

w = 2.8 inches
s = 2 inch/second

$$i = \frac{2.8}{2} = 1.4 \text{ seconds}$$

where:

d' = 1.38
B = 246 cpm
i = 1.4 seconds

$$MDCR = 1.38\left(\sqrt{(246)\frac{1.4}{60}}\right)(\frac{60}{1.4}) = 143 \text{ cpm}$$

where:

MCDR = 143 cpm
ε_s = 0.5
ε_i = 0.506
p = 0.5
probe area = 100 cm^2

$$MDC = \frac{143}{\left(\sqrt{0.5}\right)(0.5)(0.506)\left(\frac{100}{100\ cm^2}\right)} = 800\ dpm/100\ \ cm^2$$

LUDLUM MODEL 2224 WITH 43-89 DETECTOR SN 170449

The beta static MDC for the 43-89 can be calculated as follows:

where:

B = 280 cpm
T_b = 1 minutes
T_g = 1 minutes
ε_s = 0.5
ε_i = 0.358 cpm/dpm
probe area = 125 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(280)(1)(1+\frac{1}{1})}\right)}{(1)(0.5)(0.358)\left(\frac{125}{100\ cm^2}\right)} = 362\ dpm/100\ \ cm^2$$

The beta scan MDC for the 43-89 can be calculated as follows:

where:

w = 3 inches
s = 2 inch/second

$$i = \frac{3}{2} = 1.5 \text{ seconds}$$

where:

d' = 1.38
B = 280 cpm
i = 1.5 seconds

$$MDCR = 1.38\left(\sqrt{(280)\frac{1.5}{60}}\right)(\frac{60}{1.5}) = 147 \text{ cpm}$$

where:

MCDR = 147 cpm
ε_s = 0.5
ε_i = 0.358
p = 0.5
probe area = 125 cm^2

$$MDC = \frac{147}{\left(\sqrt{0.5}\right)(0.5)(0.358)\left(\frac{125}{100\ cm^2}\right)} = 930\ dpm/100\ \ cm^2$$

LUDLUM MODEL 2224 WITH 43-89 DETECTOR SN 170449

The beta static MDC for the 43-89 can be calculated as follows:

where:

B = 290 cpm
T_b = 1 minutes
T_g = 1 minutes
ε_s = 0.5
ε_i = 0.358 cpm/dpm
probe area = 125 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(290)(1)(1+\frac{1}{1})}\right)}{(1)(0.5)(0.358)\left(\frac{125}{100\ cm^2}\right)} = 368\ dpm/100\ \ cm^2$$

The beta scan MDC for the 43-89 can be calculated as follows:

where:

w = 3 inches
s = 2 inch/second

$$i = \frac{3}{2} = 1.5 \text{ seconds}$$

where:

d' = 1.38
B = 290 cpm
i = 1.5 seconds

$$MDCR = 1.38\left(\sqrt{(290)\frac{1.5}{60}}\right)(\frac{60}{1.5}) = 149 \text{ cpm}$$

where:

MCDR = 149 cpm
ε_s = 0.5
ε_i = 0.358
p = 0.5
probe area = 125 cm^2

$$MDC = \frac{149}{\left(\sqrt{0.5}\right)(0.5)(0.358)\left(\frac{125}{100\ cm^2}\right)} = 943\ dpm/100\ \ cm^2$$

LUDLUM MODEL 2360 WITH 43-93 DETECTOR SN 244555

The beta static MDC for the 43-93 can be calculated as follows:

where:

B = 280 cpm
T_b = 1 minutes
T_g = 1 minutes
ε_s = 0.5
ε_i = 0.499 cpm/dpm
probe area = 100 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(280)(1)(1+\frac{1}{1})}\right)}{(1)(0.5)(0.499)\left(\frac{100}{100\ cm^2}\right)} = 324\ dpm/100\ cm^2$$

The beta scan MDC for the 43-93 can be calculated as follows:

where:

w = 2.8 inches
s = 2 inch/second

$$i = \frac{2.8}{2} = 1.4 \text{ seconds}$$

where:

d' = 1.38
B = 280 cpm
i = 1.4 seconds

$$MDCR = 1.38\left(\sqrt{(280)\frac{1.4}{60}}\right)(\frac{60}{1.4}) = 153 \text{ cpm}$$

where:

MCDR = 153 cpm
ε_s = 0.5
ε_i = 0.499
p = 0.5
probe area = 100 cm^2

$$MDC = \frac{153}{\left(\sqrt{0.5}\right)(0.5)(0.499)\left(\frac{100}{100\ cm^2}\right)} = 868\ dpm/100\ cm^2$$

LUDLUM MODEL 2221 WITH 43-37 DETECTOR SN 244555

The beta static MDC for the 43-37 can be calculated as follows:

where:

B = 1409 cpm
T_b = 1 minutes
T_g = 1 minutes
ε_s = 0.5
ε_i = 0.569 cpm/dpm
probe area = 100 cm^2

$$MDC = \frac{\left(3 + 3.29\sqrt{(1409)(1)(1+\frac{1}{1})}\right)}{(1)(0.5)(0..569)\left(\frac{584}{100\ cm^2}\right)} = 107\ dpm/100\ \ cm^2$$

The beta scan MDC for the 43-37 can be calculated as follows:

where:

w = 6.26 inches
s = 3 inch/second

$$i = \frac{6.26}{3} = 2.1 \text{ seconds}$$

where:

d' = 1.38
B = 1409 cpm
i = 2.1 seconds

$$MDCR = 1.38\left(\sqrt{(1409)\frac{2.1}{60}}\right)(\frac{60}{2.1}) = 277 \text{ cpm}$$

where:

MCDR = 277 cpm
ε_s = 0.5
ε_i = 0.569
p = 0.5
probe area = 584 cm^2

$$MDC = \frac{277}{\left(\sqrt{0.5}\right)(0.5)(0.569)\left(\frac{584}{100\ cm^2}\right)} = 236\ dpm/100\ \ cm^2$$

COMPUTATION OF SMEAR DETECTION LIMITS WITH A LUDLUM MODEL 3030E SCALER AND LUDLUM MODEL 43-10-1 DETECTOR

LUDLUM MODEL 3030E SN 327699 WITH 43-10-1 DETECTOR SN PR360356

$$MDC = \frac{(3 + 3.29\sqrt{(B)T_{S+B}(1 + \frac{T_{S+B}}{T_B})})}{KT_{S+B}}$$

NUREG-1507 (equation 3-11)

$$K = (total\ efficiency)(\frac{probe\ area}{100})$$

$$\varepsilon_t = \varepsilon_i \times \varepsilon_s$$

where:

B = background count rate
T_{S+B} = sample count time
T_B = background count time
K = proportionality constant
ε_t = total efficiency
ε_s = surface efficiency
ε_i = instrument efficiency
ε_t = 0.31
probe area = 100 cm^2

$$K = (0.31)\left(\frac{100cm^2}{100}\right) = 0.31\ cm^2$$

where:

B = 65.8 cpm (beta)
T_{S+B} = 2 minute sample count times
T_B = 10 minutes

Beta count, 10-minute background count time:

$$MDC = \frac{(3 + 3.29\sqrt{65.8(2)(1 + \frac{2}{10})})}{0.31(2)} = 71.5\ dpm/100\ cm^2$$

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APPENDIX D

RESULTS OF RADIOLOGICAL SURVEYS

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Table D-1. Structure Surface Total Activity Measurement Data for Building 315 Ventilation

Table D-1a. Ventilation

Statistic	Sample Type	Alpha Activity (dpm/100 cm^2)	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Biased	70	117	0.05
Median	Biased	46	28	0.01
Standard Deviation	Biased	94	171	0.08
Number of Samples	Biased	9	9	--
Maximum	Biased	314	457	0.20
Range	Biased	303	457	0.20

Table D-1b. Ventilation

Survey ID	Sample Type	Location	Description	Instrument Efficiency		Surface Efficiency		Alpha Radiation			Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
				Alpha	Beta	Alpha	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Biased	Met Lab	Inlet to blower	0.403	0.506	0.25	0.50	5.5	0.83	46	253.0	246	28	0.01	2,240
2	Biased	Met Lab	Transition outlet HEPA	0.403	0.506	0.25	0.50	4.5	0.83	36	233.0	246	0	0.00	2,240
3	Biased	Met Lab	Transtion inlet HEPA	0.403	0.506	0.25	0.50	7.5	0.83	66	335.0	246	352	0.16	2,240
4	Biased	Met Lab	Inside HEPA Housing	0.403	0.506	0.25	0.50	32.5	0.83	314	361.5	246	457	0.20	2,240
5	Biased	Met Lab	Overhead Floor work area	0.403	0.506	0.25	0.50	2.0	0.83	12	249.5	246	14	0.01	2,240
6	Biased	Met Lab	Overhead Floor work area	0.403	0.506	0.25	0.50	2.5	0.83	17	281.0	246	138	0.06	2,240
7	Biased	Met Lab	Overhead Floor work area	0.403	0.506	0.25	0.50	5.5	0.83	46	261.5	246	61	0.03	2,240
8	Biased	Old DU Shop	HEPA Housing Inlet	0.403	0.506	0.25	0.50	8.5	0.83	76	204.0	246	0	0.00	2,240
9	Biased	Old DU Shop	Blower Inlet	0.403	0.506	0.25	0.50	2.5	0.83	17	245.5	246	0	0.00	2,240

Notes:

The instruments used were Ludlum Model 2360 serial # 278624 coupled with Ludlum Model 43-93 serial # 311200 (100 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily pre and post instrument checks were performed.

Beta MDC = 210 dpm/100 cm^2, alpha MDC= 45 dpm/100 cm^2.

Instrument background was determined by collecting three, 1-minute background measurements and averaging the results.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{100\ cm^2}{100\ cm^2}\right)}$$

Table D-2. Structure Surface Total Activity Measurement Data for Building 315 Impacted Area Drains

Table D-2a. Drains

Statistic	Sample Type	Alpha Activity (dpm/100 cm^2)	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Biased	212	340	0.15
Median	Biased	43	318	0.14
Standard Deviation	Biased	276	325	0.15
Number of Samples	Biased	5	5	--
Maximum	Biased	653	833	0.37
Range	Biased	640	833	0.37

Table D-2b. Drains

Survey ID	Sample Type	Description	Instrument Efficiency		Surface Efficiency		Alpha Radiation			Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Alpha	Beta	Alpha	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Biased	Met Lab floor Drain	0.403	0.506	0.25	0.50	67.5	1.67	653	462.5	252	833	0.37	2,240
2	Biased	Met Lab Pipe Drain	0.403	0.506	0.25	0.50	33.5	1.67	316	363.0	252	439	0.20	2,240
3	Biased	Garage Sink Drain	0.403	0.506	0.25	0.50	3.0	1.67	13	332.5	252	318	0.14	2,240
4	Biased	Garage Sink Drain Cover	0.403	0.506	0.25	0.50	5.0	1.67	33	216.0	252	0	0.00	2,240
5	Biased	Old DU Machine Shop	0.403	0.506	0.25	0.50	6.0	1.67	43	279.5	252	109	0.05	2,240

Notes:

The instruments used were Ludlum Model 2360 serial # 278624 coupled with Ludlum Model 43-93 serial # 311200 (100 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily pre and post instrument checks were performed.

Beta MDC = 213 dpm/100 cm^2, alpha MDC= 57 dpm/100 cm^2.

Instrument background was determined by collecting three, 1-minute background measurements and averaging the results.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{100\ cm^2}{100\ cm^2}\right)}$$

Table D-3. Structure Surface Total Activity Measurement Data for Metallography Laboratory (SU-1)

Table D-3a. Metallography Laboratory SU-1

Statistic	Measurement Type	Alpha Activity (dpm/100 cm^2)	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	19	104	0.05
Median	Systematic	14	47	0.02
Standard Deviation	Systematic	24	115	0.05
Number of Measurements	Systematic	19	19	--
Maximum	Systematic	97	335	0.15
Range	Systematic	97	335	0.15

Table D-3b. Metallography Laboratory SU-1

Survey ID	Sample Type	Description	Instrument Efficiency		Surface Efficiency		Alpha Radiation			Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Alpha	Beta	Alpha	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	North Wall	0.432	0.451	0.25	0.50	0.5	1.00	0	200.5	204	0	0.00	2,240
2	Systematic	North Wall	0.432	0.451	0.25	0.50	2.0	1.00	9	214.5	204	47	0.02	2,240
3	Systematic	North Wall	0.432	0.451	0.25	0.50	0.5	1.00	0	192.0	204	0	0.00	2,240
4	Systematic	Door	0.432	0.451	0.25	0.50	3.0	1.00	19	214.5	204	47	0.02	2,240
5	Biased	North Wall	0.432	0.451	0.25	0.50	2.0	1.00	9	212.5	204	38	0.02	2,240
6	Systematic	West Wall	0.432	0.451	0.25	0.50	2.0	1.00	9	207.5	204	16	0.01	2,240
7	Systematic	Floor	0.432	0.451	0.25	0.50	3.0	1.00	19	249.0	204	200	0.09	2,240
8	Systematic	Floor	0.432	0.451	0.25	0.50	5.0	1.00	37	261.5	204	255	0.11	2,240
9	Systematic	Floor	0.432	0.451	0.25	0.50	5.0	1.00	37	255.5	204	229	0.10	2,240
10	Systematic	Floor	0.432	0.451	0.25	0.50	6.5	1.00	51	279.5	204	335	0.15	2,240
11	Systematic	East Wall	0.432	0.451	0.25	0.50	1.0	1.00	0	203.5	204	0	0.00	2,240
12	Systematic	Floor	0.432	0.451	0.25	0.50	2.0	1.00	9	218.5	204	64	0.03	2,240
13	Systematic	Floor	0.432	0.451	0.25	0.50	3.5	1.00	23	241.5	204	166	0.07	2,240
14	Systematic	Floor	0.432	0.451	0.25	0.50	11.5	1.00	97	267.5	204	282	0.13	2,240
15	Systematic	Floor	0.432	0.451	0.25	0.50	3.0	1.00	19	237.0	204	146	0.07	2,240
16	Systematic	Floor	0.432	0.451	0.25	0.50	1.0	1.00	0	204.0	204	0	0.00	2,240
17	Systematic	South Wall	0.432	0.451	0.25	0.50	1.0	1.00	0	248.0	204	195	0.09	2,240
18	Systematic	South Wall	0.432	0.451	0.25	0.50	2.5	1.00	14	190.5	204	0	0.00	2,240
19	Systematic	South Wall	0.432	0.451	0.25	0.50	3.0	1.00	19	194.0	204	0	0.00	2,240
20	Systematic	South Wall	0.432	0.451	0.25	0.50	2.0	1.00	9	182.5	204	0	0.00	2,240
21	Biased	Floor	0.432	0.451	0.25	0.50	48.0	1.00	435	664.0	204	2,042	0.91	2,240
22	Biased	Floor	0.432	0.451	0.25	0.50	60.0	1.00	546	933.0	204	3,236	1.44	2,240
22a	Biased	Floor	0.432	0.451	0.25	0.50	86.0	1.00	787	702.0	204	2,210	0.99	2,240
23	Biased	Floor	0.432	0.451	0.25	0.50	69.0	1.00	630	617.0	204	1,833	0.82	2,240
24	Biased	Lower wall	0.432	0.451	0.25	0.50	75.0	1.00	685	698.0	204	2,193	0.98	2,240

Notes:

The instruments used were Ludlum Model 2360 serial # 193654 coupled with Ludlum Model 43-93 serial # 200115 (100 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily pre and post instrument checks were performed.

Beta MDC = 226 dpm/100 cm^2, alpha MDC= 55 dpm/100 cm^2.

Instrument background was determined by collecting three, 1-minute background measurements and averaging the results.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

Location 22a was a resurvey of location 22 after the area was wiped down and dried.

A Sign Test was not required for this survey unit.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{100\ cm^2}{100\ cm^2}\right)}$$

Table D-4. Structure Surface Total Activity Measurement Data for Building 315 Class 3 Floor (SU-2)

Table D-4a. Class 3 Floor SU-2

Statistic	Measurement Type	Alpha Activity (dpm/100 cm^2)	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Random	5	199	0.09
Median	Random	3	216	0.10
Standard Deviation	Random	6	199	0.09
Number of Measurements	Random	20	20	--
Maximum	Random	18	514	0.23
Range	Random	18	514	0.23

Table D-4b. Class 3 Floor SU-2

Survey ID	Sample Type	Description	Instrument Efficiency		Surface Efficiency		Alpha Radiation			Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Alpha	Beta	Alpha	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Random	Floor	0.403	0.506	0.25	0.50	0.5	1.67	0	205.0	252	0	0.00	2,240
2	Random	Floor	0.403	0.506	0.25	0.50	0.5	1.67	0	224.5	252	0	0.00	2,240
3	Random	Floor	0.403	0.506	0.25	0.50	3.0	1.67	13	332.5	252	318	0.14	2,240
4	Random	Floor	0.403	0.506	0.25	0.50	3.5	1.67	18	342.5	252	358	0.16	2,240
5	Random	Floor	0.403	0.506	0.25	0.50	1.0	1.67	0	321.5	252	275	0.12	2,240
6	Random	Floor	0.403	0.506	0.25	0.50	1.5	1.67	0	322.0	252	277	0.12	2,240
7	Random	Floor	0.403	0.506	0.25	0.50	1.5	1.67	0	336.0	252	332	0.15	2,240
8	Random	Floor	0.403	0.506	0.25	0.50	1.0	1.67	0	364.5	252	445	0.20	2,240
9	Random	Floor	0.403	0.506	0.25	0.50	0.5	1.67	0	351.5	252	394	0.18	2,240
10	Random	Floor	0.403	0.506	0.25	0.50	0.5	1.67	0	351.0	252	392	0.17	2,240
11	Random	Floor	0.403	0.506	0.25	0.50	3.0	1.67	13	379.0	252	502	0.22	2,240
12	Random	Floor	0.403	0.506	0.25	0.50	2.0	1.67	3	382.0	252	514	0.23	2,240
13	Random	Floor	0.403	0.506	0.25	0.50	2.0	1.67	3	241.0	252	0	0.00	2,240
14	Random	Floor	0.403	0.506	0.25	0.50	2.0	1.67	3	251.0	252	0	0.00	2,240
15	Random	Floor	0.403	0.506	0.25	0.50	3.0	1.67	13	291.5	252	156	0.07	2,240
16	Random	Floor	0.403	0.506	0.25	0.50	2.5	1.67	8	238.0	252	0	0.00	2,240
17	Random	Floor	0.403	0.506	0.25	0.50	2.0	1.67	3	225.0	252	0	0.00	2,240
18	Random	Floor	0.403	0.506	0.25	0.50	1.5	1.67	0	221.5	252	0	0.00	2,240
19	Random	Floor	0.403	0.506	0.25	0.50	2.5	1.67	8	252.5	252	2	0.00	2,240
20	Random	Floor	0.403	0.506	0.25	0.50	2.0	1.67	3	253.0	252	4	0.00	2,240

Notes:

The instruments used were Ludlum Model 2360 serial # 278624 coupled with Ludlum Model 43-93 serial # 311200 (100 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily pre and post instrument checks were performed.

Beta MDC = 213 dpm/100 cm^2, alpha MDC= 57 dpm/100 cm^2.

Instrument background was determined by collecting three, 1-minute background measurements and averaging the results.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

A Sign Test was not required for this survey unit.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{100\ cm^2}{100\ cm^2}\right)}$$

Table D-5. Structure Surface Total Activity Measurement Data for DU Machine Shop Floor (SU-3)

Table D-5a. Structure Total Activity Measurement Data Summary for DU Machine Shop Floor

Statistic	Measurement Type	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	610	0.27
Median	Systematic	242	0.11
Standard Deviation	Systematic	941	0.42
Number of Measurements	Systematic	35	--
Maximum	Systematic *	4,419	1.97
Range	Systematic *	4,419	1.97

Table D-5b. DU Machine Shop Floor Data

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	Floor	0.358	0.50	390.0	280	492	0.22	2,240
2	Systematic	Floor	0.358	0.50	404.0	280	555	0.25	2,240
3	Systematic	Floor	0.358	0.50	372.0	280	412	0.18	2,240
4	Systematic	Floor	0.358	0.50	388.0	280	483	0.22	2,240
5	Systematic	Floor	0.358	0.50	420.0	280	626	0.28	2,240
6	Systematic	Floor	0.358	0.50	424.0	280	644	0.29	2,240
7	Systematic	Floor	0.358	0.50	268.0	280	0	0.00	2,240
8	Systematic	Floor	0.358	0.50	334.0	280	242	0.11	2,240
9	Systematic	Floor	0.358	0.50	302.0	280	98	0.04	2,240
10 *	Systematic	Floor	0.358	0.50	1,268.0	280	4,419	**1.97**	2,240
11	Systematic	Floor	0.358	0.50	286.0	280	27	0.01	2,240
12	Systematic	Floor	0.358	0.50	334.0	280	242	0.11	2,240
13	Systematic	Floor	0.358	0.50	290.0	280	45	0.02	2,240
14	Systematic	Floor	0.358	0.50	268.0	280	0	0.00	2,240
15	Systematic	Floor	0.358	0.50	446.0	280	743	0.33	2,240
16	Systematic	Floor	0.358	0.50	364.0	280	376	0.17	2,240
17*	Systematic	Floor	0.358	0.50	892.0	280	2,737	**1.22**	2,240
18	Systematic	Floor	0.358	0.50	684.0	280	1,807	0.81	2,240
19	Systematic	Floor	0.358	0.50	292.0	280	54	0.02	2,240
20	Systematic	Floor	0.358	0.50	584.0	280	1,360	0.61	2,240
21	Systematic	Floor	0.358	0.50	314.0	280	152	0.07	2,240
22	Systematic	Floor	0.358	0.50	320.0	280	179	0.08	2,240
23	Systematic	Floor	0.358	0.50	314.0	280	152	0.07	2,240
24	Systematic	Floor	0.358	0.50	376.0	280	429	0.19	2,240
25	Systematic	Floor	0.358	0.50	758.0	280	2,138	0.95	2,240
26	Systematic	Floor	0.358	0.50	310.0	280	134	0.06	2,240
27	Systematic	Floor	0.358	0.50	676.0	280	1,771	0.79	2,240
28	Systematic	Floor	0.358	0.50	394.0	280	510	0.23	2,240
29	Systematic	Floor	0.358	0.50	280.0	280	0	0.00	2,240

Table D-5. Structure Surface Total Activity Measurement Data for DU Machine Shop Floor (SU-3)

Table D-5b. DU Machine Shop Floor Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
30	Systematic	Floor	0.358	0.50	286.0	280	27	0.01	2,240
31	Systematic	Floor	0.358	0.50	244.0	280	0	0.00	2,240
32	Systematic	Floor	0.358	0.50	360.0	280	358	0.16	2,240
33	Systematic	Floor	0.358	0.50	282.0	280	9	0.00	2,240
34	Systematic	Floor	0.358	0.50	308.0	280	125	0.06	2,240
35	Systematic	Floor	0.358	0.50	278.0	280	0	0.00	2,240

Notes:

* Location 10 and 17 were remediated and scanned to confirm the contamination was successfully removed. These initial Elevated Readings are included in the Sign Test for SU-3

The instruments used were Ludlum Model 2224 serial # 163741 coupled with Ludlum Model 43-89 serial # 170449 (125 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily instrument checks were performed.

Beta MDC = 362 dpm/100 cm^2, alpha MDC= 74 dpm/100 cm^2.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{125\ cm^2}{100\ cm^2}\right)}$$

Table D-6. Structure Surface Total Activity Measurement Data for DU Machine Shop Walls up to 2 Meters (SU-4)

Table D-6a. Structure Total Activity Measurement Data Summary for DU Machine Shop Walls

Statistic	Measurement Type	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	5	0.00
Median	Systematic	0	0.00
Standard Deviation	Systematic	25	0.01
Number of Measurements	Systematic	41	--
Maximum	Systematic	125	0.06
Range	Systematic	125	0.06

Table D-6b.DU Machine Shop Wall Data

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	West Wall	0.358	0.50	214	280	0	0.00	2,240
2	Systematic	West Wall	0.358	0.50	244	280	0	0.00	2,240
3	Systematic	West Wall	0.358	0.50	230	280	0	0.00	2,240
4	Systematic	West Wall	0.358	0.50	214	280	0	0.00	2,240
5	Systematic	West Wall	0.358	0.50	210	280	0	0.00	2,240
6	Systematic	West Wall	0.358	0.50	210	280	0	0.00	2,240
7	Systematic	West Wall	0.358	0.50	242	280	0	0.00	2,240
8	Systematic	West Wall	0.358	0.50	186	280	0	0.00	2,240
9	Systematic	West Wall	0.358	0.50	226	280	0	0.00	2,240
10	Systematic	West Wall	0.358	0.50	248	280	0	0.00	2,240
11	Systematic	West Wall	0.358	0.50	252	280	0	0.00	2,240
12	Systematic	West Wall	0.358	0.50	234	280	0	0.00	2,240
13	Systematic	North Wall	0.358	0.50	196	280	0	0.00	2,240
14	Systematic	North Wall	0.358	0.50	234	280	0	0.00	2,240
15	Systematic	North Wall	0.358	0.50	276	280	0	0.00	2,240
16	Systematic	North Wall	0.358	0.50	234	280	0	0.00	2,240
17	Systematic	North Wall	0.358	0.50	240	280	0	0.00	2,240
18	Systematic	North Wall	0.358	0.50	262	280	0	0.00	2,240
19	Systematic	North Wall	0.358	0.50	280	280	0	0.00	2,240
20	Systematic	North Wall	0.358	0.50	302	280	98	0.04	2,240
21	Systematic	North Wall	0.358	0.50	308	280	125	0.06	2,240
22	Systematic	North Wall	0.358	0.50	280	280	0	0.00	2,240
23	Systematic	East Wall	0.358	0.50	190	280	0	0.00	2,240
24	Systematic	East Wall	0.358	0.50	206	280	0	0.00	2,240
25	Systematic	East Wall	0.358	0.50	226	280	0	0.00	2,240
26	Systematic	East Wall	0.358	0.50	232	280	0	0.00	2,240
27	Systematic	East Wall	0.358	0.50	218	280	0	0.00	2,240
28	Systematic	East Wall	0.358	0.50	226	280	0	0.00	2,240
29	Systematic	East Wall	0.358	0.50	248	280	0	0.00	2,240
30	Systematic	East Wall	0.358	0.50	184	280	0	0.00	2,240
31	Systematic	East Wall	0.358	0.50	236	280	0	0.00	2,240
32	Systematic	East Wall	0.358	0.50	190	280	0	0.00	2,240
33	Systematic	South Wall	0.358	0.50	188	280	0	0.00	2,240

Table D-6. Structure Surface Total Activity Measurement Data for DU Machine Shop Walls up to 2 Meters (SU-4)

Table D-6b.DU Machine Shop Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
34	Systematic	South Wall	0.358	0.50	262	280	0	0.00	2,240
35	Systematic	South Wall	0.358	0.50	230	280	0	0.00	2,240
36	Systematic	South Wall	0.358	0.50	256	280	0	0.00	2,240
37	Systematic	South Wall	0.358	0.50	260	280	0	0.00	2,240
38	Systematic	South Wall	0.358	0.50	194	280	0	0.00	2,240
39	Systematic	South Wall	0.358	0.50	230	280	0	0.00	2,240
40	Systematic	South Wall	0.358	0.50	216	280	0	0.00	2,240
41	Systematic	South Wall	0.358	0.50	198	280	0	0.00	2,240

Notes:

The instruments used were Ludlum Model 2224 serial # 163741 coupled with Ludlum Model 43-89 serial # 170449 (125 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily instrument checks were performed.

Beta MDC = 362 dpm/100 cm^2, alpha MDC= 74 dpm/100 cm^2.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

A Sign Test was not required for this survey unit.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{125\ cm^2}{100\ cm^2}\right)}$$

Table D-7. Structure Surface Total Activity Measurement Data for West End Walls up to 2 Meters (SU-5)

Table D-7a. Structure Total Activity Measurement Data Summary for West End Walls

Statistic	Measurement Type	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	199	0.09
Median	Systematic	74	0.03
Standard Deviation	Systematic	233	0.10
Number of Measurements	Systematic	100	--
Maximum	Systematic	991	0.44
Range	Systematic	991	0.44

Table D-7b. West End Wall Data

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	West Wall	0.358	0.50	426	290	607	0.27	2,240
2	Systematic	West Wall	0.358	0.50	370	290	356	0.16	2,240
3	Systematic	West Wall	0.358	0.50	262	290	0	0.00	2,240
4	Systematic	West Wall	0.358	0.50	302	290	52	0.02	2,240
5	Systematic	West Wall	0.358	0.50	268	290	0	0.00	2,240
6	Systematic	West Wall	0.358	0.50	374	290	374	0.17	2,240
7	Systematic	West Wall	0.358	0.50	386	290	428	0.19	2,240
8	Systematic	West Wall	0.358	0.50	254	290	0	0.00	2,240
9	Systematic	West Wall	0.358	0.50	308	290	79	0.04	2,240
10	Systematic	West Wall	0.358	0.50	274	290	0	0.00	2,240
11	Systematic	West Wall	0.358	0.50	352	290	276	0.12	2,240
12	Systematic	West Wall	0.358	0.50	430	290	624	0.28	2,240
13	Systematic	West Wall	0.358	0.50	242	290	0	0.00	2,240
14	Systematic	West Wall	0.358	0.50	306	290	70	0.03	2,240
15	Systematic	West Wall	0.358	0.50	282	290	0	0.00	2,240
16	Systematic	West Wall	0.358	0.50	388	290	437	0.19	2,240
17	Systematic	West Wall	0.358	0.50	376	290	383	0.17	2,240
18	Systematic	West Wall	0.358	0.50	242	290	0	0.00	2,240
19	Systematic	North Wall	0.358	0.50	388	290	437	0.19	2,240
20	Systematic	North Wall	0.358	0.50	400	290	490	0.22	2,240
21	Systematic	North Wall	0.358	0.50	420	290	580	0.26	2,240
22	Systematic	North Wall	0.358	0.50	288	290	0	0.00	2,240
23	Systematic	North Wall	0.358	0.50	396	290	472	0.21	2,240
24	Systematic	North Wall	0.358	0.50	466	290	785	0.35	2,240
25	Systematic	North Wall	0.358	0.50	392	290	454	0.20	2,240
26	Systematic	North Wall	0.358	0.50	362	290	320	0.14	2,240
27	Systematic	North Wall	0.358	0.50	354	290	284	0.13	2,240
28	Systematic	North Wall	0.358	0.50	324	290	150	0.07	2,240
29	Systematic	North Wall	0.358	0.50	254	290	0	0.00	2,240
30	Systematic	North Wall	0.358	0.50	228	290	0	0.00	2,240
31	Systematic	North Wall	0.358	0.50	380	290	401	0.18	2,240
32	Systematic	North Wall	0.358	0.50	394	290	463	0.21	2,240
33	Systematic	North Wall	0.358	0.50	308	290	79	0.04	2,240

Table D-7. Structure Surface Total Activity Measurement Data for West End Walls up to 2 Meters (SU-5)

Table D-7b. West End Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
34	Systematic	North Wall	0.358	0.50	322	290	141	0.06	2,240
35	Systematic	North Wall	0.358	0.50	226	290	0	0.00	2,240
36	Systematic	North Wall	0.358	0.50	330	290	177	0.08	2,240
37	Systematic	North Wall	0.358	0.50	512	290	991	0.44	2,240
38	Systematic	North Wall	0.358	0.50	318	290	123	0.06	2,240
39	Systematic	North Wall	0.358	0.50	344	290	240	0.11	2,240
40	Systematic	North Wall	0.358	0.50	254	290	0	0.00	2,240
41	Systematic	North Wall	0.358	0.50	354	290	284	0.13	2,240
42	Systematic	North Wall	0.358	0.50	292	290	7	0.00	2,240
43	Systematic	North Wall	0.358	0.50	416	290	562	0.25	2,240
44	Systematic	North Wall	0.358	0.50	236	290	0	0.00	2,240
45	Systematic	North Wall	0.358	0.50	444	290	687	0.31	2,240
46	Systematic	North Wall	0.358	0.50	398	290	481	0.21	2,240
47	Systematic	North Wall	0.358	0.50	302	290	52	0.02	2,240
48	Systematic	North Wall	0.358	0.50	366	290	338	0.15	2,240
49	Systematic	North Wall	0.358	0.50	422	290	589	0.26	2,240
50	Systematic	North Wall	0.358	0.50	378	290	392	0.17	2,240
51	Systematic	North Wall	0.358	0.50	370	290	356	0.16	2,240
52	Systematic	North Wall	0.358	0.50	286	290	0	0.00	2,240
53	Systematic	East Wall	0.358	0.50	298	290	34	0.02	2,240
54	Systematic	East Wall	0.358	0.50	254	290	0	0.00	2,240
55	Systematic	East Wall	0.358	0.50	278	290	0	0.00	2,240
56	Systematic	East Wall	0.358	0.50	352	290	276	0.12	2,240
57	Systematic	East Wall	0.358	0.50	350	290	267	0.12	2,240
58	Systematic	East Wall	0.358	0.50	234	290	0	0.00	2,240
59	Systematic	East Wall	0.358	0.50	354	290	284	0.13	2,240
60	Systematic	East Wall	0.358	0.50	258	290	0	0.00	2,240
61	Systematic	East Wall	0.358	0.50	298	290	34	0.02	2,240
62	Systematic	East Wall	0.358	0.50	230	290	0	0.00	2,240
63	Systematic	East Wall	0.358	0.50	294	290	16	0.01	2,240
64	Systematic	East Wall	0.358	0.50	234	290	0	0.00	2,240
65	Systematic	East Wall	0.358	0.50	250	290	0	0.00	2,240
66	Systematic	East Wall	0.358	0.50	248	290	0	0.00	2,240
67	Systematic	South Wall	0.358	0.50	232	290	0	0.00	2,240
68	Systematic	South Wall	0.358	0.50	226	290	0	0.00	2,240
69	Systematic	South Wall	0.358	0.50	198	290	0	0.00	2,240
70	Systematic	South Wall	0.358	0.50	258	290	0	0.00	2,240
71	Systematic	South Wall	0.358	0.50	230	290	0	0.00	2,240
72	Systematic	South Wall	0.358	0.50	294	290	16	0.01	2,240
73	Systematic	South Wall	0.358	0.50	246	290	0	0.00	2,240
74	Systematic	South Wall	0.358	0.50	268	290	0	0.00	2,240
75	Systematic	South Wall	0.358	0.50	302	290	52	0.02	2,240
76	Systematic	South Wall	0.358	0.50	276	290	0	0.00	2,240
77	Systematic	South Wall	0.358	0.50	306	290	70	0.03	2,240

Table D-7. Structure Surface Total Activity Measurement Data for West End Walls up to 2 Meters (SU-5)

Table D-7b. West End Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
78	Systematic	South Wall	0.358	0.50	224	290	0	0.00	2,240
79	Systematic	South Wall	0.358	0.50	196	290	0	0.00	2,240
80	Systematic	South Wall	0.358	0.50	226	290	0	0.00	2,240
81	Systematic	South Wall	0.358	0.50	262	290	0	0.00	2,240
82	Systematic	South Wall	0.358	0.50	198	290	0	0.00	2,240
83	Systematic	Small East Wall	0.358	0.50	446	290	696	0.31	2,240
84	Systematic	Small East Wall	0.358	0.50	358	290	302	0.13	2,240
85	Systematic	Small East Wall	0.358	0.50	384	290	419	0.19	2,240
86	Systematic	Small East Wall	0.358	0.50	348	290	258	0.12	2,240
87	Systematic	Small East Wall	0.358	0.50	300	290	43	0.02	2,240
88	Systematic	Small East Wall	0.358	0.50	434	290	642	0.29	2,240
89	Systematic	Small East Wall	0.358	0.50	308	290	79	0.04	2,240
90	Systematic	Small East Wall	0.358	0.50	256	290	0	0.00	2,240
91	Systematic	Small South Wall	0.358	0.50	340	290	222	0.10	2,240
92	Systematic	Small South Wall	0.358	0.50	408	290	526	0.23	2,240
93	Systematic	Small South Wall	0.358	0.50	352	290	276	0.12	2,240
94	Systematic	Small South Wall	0.358	0.50	292	290	7	0.00	2,240
95	Systematic	Small South Wall	0.358	0.50	346	290	249	0.11	2,240
96	Systematic	Small South Wall	0.358	0.50	356	290	293	0.13	2,240
97	Systematic	Small South Wall	0.358	0.50	368	290	347	0.15	2,240
98	Systematic	Small South Wall	0.358	0.50	390	290	446	0.20	2,240
99	Systematic	Small South Wall	0.358	0.50	300	290	43	0.02	2,240
100	Systematic	Small South Wall	0.358	0.50	282	290	0	0.00	2,240

Notes:

The instruments used were Ludlum Model 2224 serial # 163741 coupled with Ludlum Model 43-89 serial # 170449 (125 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily instrument checks were performed.

Beta MDC = 368 dpm/100 cm^2, alpha MDC= 77 dpm/100 cm^2.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

A Sign Test was not required for this survey unit.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{125\ cm^2}{100\ cm^2}\right)}$$

Table D-8. Structure Surface Total Activity Measurement Data for Hallway Walls up to 2 Meters (SU-6)

Table D-8a. Structure Total Activity Measurement Data Summary for West End Walls

Statistic	Measurement Type	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	23	0.01
Median	Systematic	0	0.00
Standard Deviation	Systematic	64	0.03
Number of Measurements	Systematic	86	--
Maximum	Systematic	365	0.16
Range	Systematic	365	0.16

Table D-8b. Hallway Wall Data

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	West Wall	0.358	0.50	230	290	0	0.00	2,240
2	Systematic	West Wall	0.358	0.50	202	290	0	0.00	2,240
3	Systematic	West Wall	0.358	0.50	226	290	0	0.00	2,240
4	Systematic	West Wall	0.358	0.50	254	290	0	0.00	2,240
5	Systematic	West Wall	0.358	0.50	226	290	0	0.00	2,240
6	Systematic	West Wall	0.358	0.50	232	290	0	0.00	2,240
7	Systematic	West Wall	0.358	0.50	282	290	0	0.00	2,240
8	Systematic	West Wall	0.358	0.50	272	290	0	0.00	2,240
9	Systematic	North Wall	0.358	0.50	254	290	0	0.00	2,240
10	Systematic	North Wall	0.358	0.50	242	290	0	0.00	2,240
11	Systematic	North Wall	0.358	0.50	216	290	0	0.00	2,240
12	Systematic	North Wall	0.358	0.50	212	290	0	0.00	2,240
13	Systematic	North Wall	0.358	0.50	310	290	88	0.04	2,240
14	Systematic	North Wall	0.358	0.50	242	290	0	0.00	2,240
15	Systematic	North Wall	0.358	0.50	260	290	0	0.00	2,240
16	Systematic	North Wall	0.358	0.50	294	290	16	0.01	2,240
17	Systematic	North Wall	0.358	0.50	242	290	0	0.00	2,240
18	Systematic	North Wall	0.358	0.50	258	290	0	0.00	2,240
19	Systematic	North Wall	0.358	0.50	232	290	0	0.00	2,240
20	Systematic	North Wall	0.358	0.50	372	290	365	0.16	2,240
21	Systematic	North Wall	0.358	0.50	266	290	0	0.00	2,240
22	Systematic	North Wall	0.358	0.50	236	290	0	0.00	2,240
23	Systematic	North Wall	0.358	0.50	230	290	0	0.00	2,240
24	Systematic	North Wall	0.358	0.50	258	290	0	0.00	2,240
25	Systematic	North Wall	0.358	0.50	330	290	177	0.08	2,240
26	Systematic	North Wall	0.358	0.50	236	290	0	0.00	2,240
27	Systematic	North Wall	0.358	0.50	230	290	0	0.00	2,240
28	Systematic	North Wall	0.358	0.50	246	290	0	0.00	2,240
29	Systematic	North Wall	0.358	0.50	240	290	0	0.00	2,240
30	Systematic	North Wall	0.358	0.50	226	290	0	0.00	2,240
31	Systematic	South Wall	0.358	0.50	248	290	0	0.00	2,240
32	Systematic	South Wall	0.358	0.50	314	290	106	0.05	2,240
33	Systematic	South Wall	0.358	0.50	282	290	0	0.00	2,240

Table D-8. Structure Surface Total Activity Measurement Data for Hallway Walls up to 2 Meters (SU-6)

Table D-8b. Hallway Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
34	Systematic	South Wall	0.358	0.50	234	290	0	0.00	2,240
35	Systematic	South Wall	0.358	0.50	286	290	0	0.00	2,240
36	Systematic	South Wall	0.358	0.50	272	290	0	0.00	2,240
37	Systematic	South Wall	0.358	0.50	348	290	258	0.12	2,240
38	Systematic	South Wall	0.358	0.50	272	290	0	0.00	2,240
39	Systematic	South Wall	0.358	0.50	270	290	0	0.00	2,240
40	Systematic	South Wall	0.358	0.50	280	290	0	0.00	2,240
41	Systematic	South Wall	0.358	0.50	312	290	97	0.04	2,240
42	Systematic	South Wall	0.358	0.50	276	290	0	0.00	2,240
43	Systematic	South Wall	0.358	0.50	226	290	0	0.00	2,240
44	Systematic	South Wall	0.358	0.50	288	290	0	0.00	2,240
45	Systematic	South Wall	0.358	0.50	306	290	70	0.03	2,240
46	Systematic	South Wall	0.358	0.50	266	290	0	0.00	2,240
47	Systematic	South Wall	0.358	0.50	226	290	0	0.00	2,240
48	Systematic	South Wall	0.358	0.50	344	290	240	0.11	2,240
49	Systematic	South Wall	0.358	0.50	306	290	70	0.03	2,240
50	Systematic	South Wall	0.358	0.50	278	290	0	0.00	2,240
51	Systematic	South Wall	0.358	0.50	280	290	0	0.00	2,240
52	Systematic	South Wall	0.358	0.50	232	290	0	0.00	2,240
53	Systematic	South Wall	0.358	0.50	214	290	0	0.00	2,240
54	Systematic	South Wall	0.358	0.50	224	290	0	0.00	2,240
55	Systematic	South Wall	0.358	0.50	238	290	0	0.00	2,240
56	Systematic	South Wall	0.358	0.50	206	290	0	0.00	2,240
57	Systematic	South Wall	0.358	0.50	290	290	0	0.00	2,240
58	Systematic	South Wall	0.358	0.50	280	290	0	0.00	2,240
59	Systematic	South Wall	0.358	0.50	270	290	0	0.00	2,240
60	Systematic	South Wall	0.358	0.50	322	290	141	0.06	2,240
61	Systematic	South Wall	0.358	0.50	300	290	43	0.02	2,240
62	Systematic	South Wall	0.358	0.50	228	290	0	0.00	2,240
63	Systematic	South Wall	0.358	0.50	258	290	0	0.00	2,240
64	Systematic	South Wall	0.358	0.50	236	290	0	0.00	2,240
65	Systematic	South Wall	0.358	0.50	260	290	0	0.00	2,240
66	Systematic	South Wall	0.358	0.50	256	290	0	0.00	2,240
67	Systematic	South Wall	0.358	0.50	272	290	0	0.00	2,240
68	Systematic	South Wall	0.358	0.50	264	290	0	0.00	2,240
69	Systematic	South Wall	0.358	0.50	274	290	0	0.00	2,240
70	Systematic	South Wall	0.358	0.50	266	290	0	0.00	2,240
71	Systematic	South Wall	0.358	0.50	204	290	0	0.00	2,240
72	Systematic	South Wall	0.358	0.50	226	290	0	0.00	2,240
73	Systematic	South Wall	0.358	0.50	326	290	159	0.07	2,240
74	Systematic	South Wall	0.358	0.50	280	290	0	0.00	2,240
75	Systematic	South Wall	0.358	0.50	232	290	0	0.00	2,240
76	Systematic	South Wall	0.358	0.50	274	290	0	0.00	2,240
77	Systematic	South Wall	0.358	0.50	204	290	0	0.00	2,240

Table D-8. Structure Surface Total Activity Measurement Data for Hallway Walls up to 2 Meters (SU-6)

Table D-8b. Hallway Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
78	Systematic	South Wall	0.358	0.50	296	290	25	0.01	2,240
79	Systematic	South Wall	0.358	0.50	272	290	0	0.00	2,240
80	Systematic	South Wall	0.358	0.50	254	290	0	0.00	2,240
81	Systematic	South Wall	0.358	0.50	238	290	0	0.00	2,240
82	Systematic	South Wall	0.358	0.50	326	290	159	0.07	2,240
83	Systematic	South Wall	0.358	0.50	226	290	0	0.00	2,240
84	Systematic	South Wall	0.358	0.50	208	290	0	0.00	2,240
85	Systematic	South Wall	0.358	0.50	252	290	0	0.00	2,240
86	Systematic	South Wall	0.358	0.50	290	290	0	0.00	2,240

Notes:

The instruments used were Ludlum Model 2224 serial # 163741 coupled with Ludlum Model 43-89 serial # 170449 (125 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily instrument checks were performed.

Beta MDC = 368 dpm/100 cm^2, alpha MDC= 77 dpm/100 cm^2.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{125\ cm^2}{100\ cm^2}\right)}$$

Table D-9. Structure Surface Total Activity Measurement Data for Garage Walls up to 2 Meters (SU-7)

Table D-9a. Structure Total Activity Measurement Data Summary for Garage Walls

Statistic	Measurement Type	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	26	0.01
Median	Systematic	0	0.00
Standard Deviation	Systematic	50	0.02
Number of Measurements	Systematic	44	--
Maximum	Systematic	177	0.08
Range	Systematic	177	0.08

Table D-9b. Garage Wall Data

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	West Wall	0.499	0.50	196	280	0	0.00	2,240
2	Systematic	West Wall	0.499	0.50	244	280	0	0.00	2,240
3	Systematic	West Wall	0.499	0.50	0	280	0	0.00	2,240
4	Systematic	West Wall	0.499	0.50	250	280	0	0.00	2,240
5	Systematic	West Wall	0.499	0.50	268	280	0	0.00	2,240
6	Systematic	West Wall	0.499	0.50	234	280	0	0.00	2,240
7	Systematic	West Wall	0.499	0.50	264	280	0	0.00	2,240
8	Systematic	West Wall	0.499	0.50	252	280	0	0.00	2,240
9	Systematic	North Wall	0.499	0.50	212	280	0	0.00	2,240
10	Systematic	North Wall	0.499	0.50	0	280	0	0.00	2,240
11	Systematic	North Wall	0.499	0.50	208	280	0	0.00	2,240
12	Systematic	North Wall	0.499	0.50	228	280	0	0.00	2,240
13	Systematic	North Wall	0.499	0.50	256	280	0	0.00	2,240
14	Systematic	North Wall	0.499	0.50	194	280	0	0.00	2,240
15	Systematic	North Wall	0.499	0.50	276	280	0	0.00	2,240
16	Systematic	North Wall	0.499	0.50	278	280	0	0.00	2,240
17	Systematic	North Wall	0.499	0.50	230	280	0	0.00	2,240
18	Systematic	North Wall	0.499	0.50	260	280	0	0.00	2,240
19	Systematic	North Wall	0.499	0.50	316	280	145	0.06	2,240
20	Systematic	North Wall	0.499	0.50	256	280	0	0.00	2,240
21	Systematic	North Wall	0.499	0.50	274	280	0	0.00	2,240
22	Systematic	North Wall	0.499	0.50	220	280	0	0.00	2,240
23	Systematic	North Wall	0.499	0.50	260	280	0	0.00	2,240
24	Systematic	North Wall	0.499	0.50	226	280	0	0.00	2,240
25	Systematic	North Wall	0.499	0.50	300	280	81	0.04	2,240
26	Systematic	North Wall	0.499	0.50	256	280	0	0.00	2,240
27	Systematic	North Wall	0.499	0.50	278	280	0	0.00	2,240
28	Systematic	North Wall	0.499	0.50	324	280	177	0.08	2,240
29	Systematic	North Wall	0.499	0.50	256	280	0	0.00	2,240
30	Systematic	North Wall	0.499	0.50	258	280	0	0.00	2,240
31	Systematic	South Wall	0.499	0.50	298	280	73	0.03	2,240
32	Systematic	South Wall	0.499	0.50	246	280	0	0.00	2,240
33	Systematic	South Wall	0.499	0.50	292	280	49	0.02	2,240

Table D-9. Structure Surface Total Activity Measurement Data for Garage Walls up to 2 Meters (SU-7)

Table D-9b. Garage Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
34	Systematic	South Wall	0.499	0.50	306	280	105	0.05	2,240
35	Systematic	South Wall	0.499	0.50	288	280	32	0.01	2,240
36	Systematic	South Wall	0.499	0.50	306	280	105	0.05	2,240
37	Systematic	South Wall	0.499	0.50	304	280	97	0.04	2,240
38	Systematic	South Wall	0.499	0.50	284	280	16	0.01	2,240
39	Systematic	South Wall	0.499	0.50	312	280	129	0.06	2,240
40	Systematic	South Wall	0.499	0.50	318	280	153	0.07	2,240
41	Systematic	South Wall	0.499	0.50	252	280	0	0.00	2,240
42	Systematic	South Wall	0.499	0.50	276	280	0	0.00	2,240
43	Systematic	South Wall	0.499	0.50	280	280	0	0.00	2,240
44	Systematic	South Wall	0.499	0.50	236	280	0	0.00	2,240

Notes:

The instruments used were Ludlum Model 2224 serial # 221460 coupled with Ludlum Model 43-93 serial # 244555 (100 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily instrument checks were performed.

Beta MDC= 324 dpm/100 cm^2, alpha MDC= 74 dpm/100 cm^2.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{100\ cm^2}{100\ cm^2}\right)}$$

Table D-10. Structure Surface Total Activity Measurement Data for East End Garage Walls up to 2 Meters (SU-8)

Table D-10a. Structure Total Activity Measurement Data Summary for Garage Walls

Statistic	Measurement Type	Beta Activity (dpm/100 cm^2)	Fraction of DCGL
Mean	Systematic	282	0.13
Median	Systematic	285	0.13
Standard Deviation	Systematic	228	0.10
Number of Measurements	Systematic	34	--
Maximum	Systematic	666	0.30
Range	Systematic	666	0.30

Table D-10b. East End Garage Wall Data

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
1	Systematic	North Wall	0.499	0.50	446	280	666	0.30	2,240
2	Systematic	North Wall	0.499	0.50	358	280	313	0.14	2,240
3	Systematic	North Wall	0.499	0.50	384	280	418	0.19	2,240
4	Systematic	North Wall	0.499	0.50	348	280	273	0.12	2,240
5	Systematic	North Wall	0.499	0.50	300	280	81	0.04	2,240
6	Systematic	North Wall	0.499	0.50	434	280	618	0.28	2,240
7	Systematic	North Wall	0.499	0.50	308	280	113	0.05	2,240
8	Systematic	North Wall	0.499	0.50	256	280	0	0.00	2,240
9	Systematic	East Wall	0.499	0.50	378	280	394	0.18	2,240
10	Systematic	East Wall	0.499	0.50	332	280	209	0.09	2,240
11	Systematic	East Wall	0.499	0.50	354	280	297	0.13	2,240
12	Systematic	East Wall	0.499	0.50	288	280	32	0.01	2,240
13	Systematic	East Wall	0.499	0.50	256	280	0	0.00	2,240
14	Systematic	East Wall	0.499	0.50	362	280	329	0.15	2,240
15	Systematic	East Wall	0.499	0.50	416	280	546	0.24	2,240
16	Systematic	East Wall	0.499	0.50	392	280	450	0.20	2,240
17	Systematic	East Wall	0.499	0.50	360	280	321	0.14	2,240
18	Systematic	East Wall	0.499	0.50	274	280	0	0.00	2,240
19	Systematic	East Wall	0.499	0.50	262	280	0	0.00	2,240
20	Systematic	East Wall	0.499	0.50	278	280	0	0.00	2,240
21	Systematic	East Wall	0.499	0.50	260	280	0	0.00	2,240
22	Systematic	East Wall	0.499	0.50	394	280	458	0.20	2,240
23	Systematic	East Wall	0.499	0.50	390	280	442	0.20	2,240
24	Systematic	East Wall	0.499	0.50	310	280	121	0.05	2,240
25	Systematic	East Wall	0.499	0.50	280	280	0	0.00	2,240
26	Systematic	East Wall	0.499	0.50	414	280	538	0.24	2,240
27	Systematic	South Wall	0.499	0.50	430	280	602	0.27	2,240
28	Systematic	South Wall	0.499	0.50	416	280	546	0.24	2,240
29	Systematic	South Wall	0.499	0.50	444	280	658	0.29	2,240

Table D-10. Structure Surface Total Activity Measurement Data for East End Garage Walls up to 2 Meters (SU-8)

Table D-10b. East End Garage Wall Data (Continued)

Survey ID	Sample Type	Description	Instrument Efficiency	Surface Efficiency	Beta Radiation			Fraction of DCGL	Beta DCGL (dpm/100 cm^2)
			Beta	Beta	Gross (cpm)	Background (cpm)	Activity (dpm/100 cm^2)		
30	Systematic	South Wall	0.499	0.50	344	280	257	0.11	2,240
31	Systematic	South Wall	0.499	0.50	278	280	0	0.00	2,240
32	Systematic	South Wall	0.499	0.50	412	280	530	0.24	2,240
33	Systematic	South Wall	0.499	0.50	310	280	121	0.05	2,240
34	Systematic	South Wall	0.499	0.50	344	280	257	0.11	2,240

Notes:

The instruments used were Ludlum Model 2224 serial # 221460 coupled with Ludlum Model 43-93 serial # 244555 (100 cm^2 scintillation detector).

The 2 pi instrument efficiency (ε_i) was determined at the time of instrument calibration, and daily instrument checks were performed.

Beta MDC = 324 dpm/100 cm^2, alpha MDC= 78 dpm/100 cm^2.

As a conservative measure, surface material background levels of radiation (from naturally occurring radioactivity in the materials themselves) were not subtracted from these direct measurements.

The activity (in dpm/100 cm^2) was determined using the following equation:

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{gross\ (cpm) - background\ (cpm)}{(\varepsilon_s)(\varepsilon_i)\left(\frac{100\ cm^2}{100\ cm^2}\right)}$$

APPENDIX E

STATISTICAL TESTS

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Surface Contamination Sign Test			
Survey Unit Description: DU Room Floor SU-3			
Beta DCGL:		**2,240 dpm/100 cm²**	
Probability for:		**Type I Error (α)**	**Type II Error (β)**
		0.05	**0.20**
Sample No.	**Beta (dpm/100cm²)**	**Beta Difference❶**	**Beta Adjusted❷**
1	492	1,748	1,748
2	555	1,685	1,685
3	412	1,828	1,828
4	483	1,757	1,757
5	626	1,614	1,614
6	644	1,596	1,596
7	0	2,240	2,240
8	242	1,998	1,998
9	98	2,142	2,142
10	4,419	-2,179	-2,179
11	27	2,213	2,213
12	242	1,998	1,998
13	45	2,195	2,195
14	0	2,240	2,240
15	743	1,497	1,497
16	376	1,864	1,864
17	2,737	-497	-497
18	1,807	433	433
19	54	2,186	2,186
20	1,360	880	880
21	152	2,088	2,088
22	179	2,061	2,061
23	152	2,088	2,088
24	429	1,811	1,811
25	2,138	102	102
26	134	2,106	2,106
27	1,771	469	469
28	510	1,730	1,730
29	0	2,240	2,240
30	27	2,213	2,213
31	0	2,240	2,240
32	358	1,882	1,882
33	9	2,231	2,231
34	125	2,115	2,115
35	0	2,240	2,240
SU Statistics		**Sign Test Statistics**	
Mean	610	***S+***	33
St. Dev.	941	***N***	35
Min. No. Samples	9	$k_{critical}$	22
		Result	***Pass***

❶ Beta Difference is equal to difference between DCGL and the beta results.

❷ Beta Adjusted removes results where the difference between DCGL and the result is zero.

S+ is the number of positive differences. If S+ is greater than $k_{critical}$, then the survey unit passes.

N is the number of non-zero differences.

$k_{critical}$ is obtain from MARSSIM Table I.3.

Location 10 and 17 were remediated and scanned to confirm contamination was removed.

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