FINAL STATUS SURVEY REPORT
BUILDING 235/236 INTERIOR

MALLINCKRODT, INC.
COLUMBIUM- TANTULUM PROJECT- PHASE 1

DECEMBER 2003

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C-T PROJECT – PHASE I

FINAL STATUS SURVEY REPORT

Buildings 235 & 236 Interior

Survey Units 23501, 23502, & 23601

Revision 0

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1. INTRODUCTION

1.1 PURPOSE

1.1.1. This Final Status Survey Report (FSSR) is being submitted by Mallinckrodt, Inc. to the U.S. Nuclear Regulatory Commission (NRC) for the floors and walls of Buildings 235 and 236 on the Mallinckrodt St. Louis site (designated as Survey Units (SU) 23501, 23502, and 23601). This report is being provided in accordance with the Mallinckrodt C-T Project, Phase I Decommissioning Plan (D Plan). This Final Status Survey (FSS) was performed in accordance with Field Instruction CT-FI-007[1] to demonstrate that the established guidelines for unrestricted release have been met. The results of the FSS are presented in this FSSR as justification for release of this survey unit from License STB-401 for unrestricted use.

1.2. HISTORICAL BACKGROUND

1.2.1. From 1942 to 1961 Mallinckrodt was involved in radiological activities outside of the scope of this report which terminated in 1977. Mallinckrodt's facilities have either been released from the applicable license or are being remediated by the US Army Corps of Engineers in the affected areas. License STB-401 was issued to

[1] CT-FI-007, *Final Status Survey Guide for Survey Unit 23501 & 23601.*

Mallinckrodt in 1961 by the Atomic Energy Commission (AEC) (later the Nuclear Regulatory Commission (NRC)) to allow extraction of columbium and tantalum (C-T) from natural ores and tin slag, since the ores and byproducts of processing contain uranium and thorium isotopes. Mallinckrodt has not performed C-T extraction since 1987. On July 12, 1993, NRC amended License STB-401 to possession-only for D&D and license termination.

2. SCOPE OF FINAL STATUS SURVEY (FSS)

2.1. DEFINITION AND CLASSIFICATION OF SURVEY UNIT (SU)

2.1.1. The affected interior surfaces of Buildings 235 and 236 have been designated as three survey units (SU). SU-23501 consists of the interior floor and walls of building 235, rooms 101 and 102. SU-23502 consists of the ground rods in building 235, room 101. SU-23601 consists of the interior floor and walls of building 236. SU-23501 and SU-23601 are each classified as Class 2. SU-23502 are classified as Class 1.

2.1.2. Table 2.1 below contains the description provided in Appendix A of the D Plan for the areas referenced by this FSSR.

Table 2.1[2]

Survey Area Descriptions

Area	Building	Location / Surface
71	235	East Room - Interior Walls: One new 36" mandoor located on southeast corner installed for accessing new hydrogenation room. Several new penetrations in wall to accommodate piping modifications. This work was performed in 1998.
72	235	East Room - Floor: Epoxy coating applied in July 1998.
73	235	East Room - Ceiling
74	235	West Room - Interior Walls: New dryer room installed in 1998 at southwest corner of main room. Room is approximately 29' 6" long and 20' deep with 18' ceilings. New 8" masonry walls on east side and north side with4' double doors for each room. South walls of each room have old brick exposed and have been coated with one coat of epoxy paint. West room drier is also old brick with epoxy coating. New vault installed in 1996-1997 approximately 44' long and 24' 9" deep with 16' ceiling. There is a 2' 8" chase between west wall of vault and old brick interior wall leaving brick exposed.
75	235	West Room - Floor: Epoxy coating installed 7-98
76	235	West Room - Expansion Joint: Sealed with epoxy when new floor coating was installed.
77	235	West Room - Ground Rod Holes
84	236	Interior Walls/Ledges: New offices, locker rooms, showers and security office constructed inside of building within 2 floors. All walls are studded and drywalled covering inside brick surfaces. Areas where old brick is exposed are as follows: North wall approximately 35' long by 10' high. West wall approximately 36' long by 10' high. Men's shower area east wall south approximately 18' long by 7' 6" high. Upper level janitors room east wall north side, approximately 8' long by 10' high. All building modifications were performed in 2000. All exposed brick wall coated with one layer of epoxy paint.
85	236	Floor: An area of 48' by 25' of concrete was removed in 2000 for constructionof the locker room and offices. This area is 18' south of north wall. It consists of new sewer ties for locker room, showers and restrooms. Floor is tile except for showers which are epoxy coated or ceramic tile.

2.1.3. A summary report for each survey unit listing all the surfaces and fixed apparatus assigned to SU-23501, SU-23502, and SU-23601 is presented in Appendix 1. A drawing of each survey unit showing the location of key fixed apparatus items is presented in Appendix 2, Figure 2.1.

2.2. IDENTIFICATION OF THE RADIOLOGICAL CONTAMINANTS

2.2.1. The radionuclides on the St. Louis site under license STB-401 are the uranium and thorium series. Both series are assumed to be in radioactive equilibrium and to exist in a uranium-to-thorium ratio of two to one.[3]

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[2] Appendix A of D Plan

[3] Mallinckrodt C-T Project D Plan Appendix D

2.3. REFERENCE BACKGROUND LEVELS

2.3.1. When the initial characterization (CH) surveys were performed from 1992 through 1996, beta backgrounds were determined for several matrix materials. Where additional background measurements were required for the FSS, they were taken on unaffected surfaces nearby or offsite. All background levels were determined by taking direct readings on the specified matrix on unaffected surfaces using the same methods and type equipment as were used for the FSS. Natural background levels for the contaminants of interest in the survey units are presented in Table 2.2.

Table 2.2
Background Reference Data

Matrix	Mean ($Dpm_p/100cm^2$)[4]	Standard Deviation ($Dpm_p/100cm^2$)
Brick	192.4	16.0
Concrete	35.4	20.1
Concrete Block	96.1	21.7
Metal	24.0	15.7

2.4. RELEASE CRITERIA

2.4.1. Table 2.3 displays the Derived Concentration Guideline (DCGLw) for measurements on building surfaces and fixed equipment. This value is the primary release criterion from the D Plan and is applied net of background to building surfaces such as floors and walls. It also applies to items of installed apparatus such as I-beams and expansion joints.

2.4.2. To limit the dose from residual materials as much as possible an Administrative Release Guideline (ARG)[5] was developed and was used during the FSS as if it were the DCGLw with certain exceptions.[6]

Table 2.3
Building Surface and Installed Apparatus Release Criteria

Criterion	($Dpm_p/100\ cm^2$)
DCGLw	13,000
ARG	2,600

[4] $Dpm_p/100\ cm^2$ refers to the disintegrations per minute per 100 cm^2 for the combined nuclide series.
[5] NEXTEP Tech Memo 0211, *Recommendation for an Administrative Release Guideline for the Mallinckrodt C-T Project,* A.H. Thatcher, CHP.
[6] *Final Status Survey Design Guide (Phase I)*, Section 3.2, covers the rules governing use of the ARG.

2.4.3. Elevated Measurements Criterion (EMC).

2.4.3.1. The magnitude by which the concentration of radioactivity within a small area can exceed the DCGLw while maintaining compliance with the release criterion is defined as the area factor. It is calculated as the ratio of two composite dose factors and is presented graphically in Appendix C of the D Plan as a function of area. The area curve has been reduced to a calculation in the CT Design Guide[7]. Using the derived equation from the Design Guide a localized release limit for elevated concentrations was defined as:

Equation 1

$$DCGL_{EMC} = 23.4 * DCGLw * A_0^{-0.6721}$$

Where A_0 is the area, in square meters containing the elevated level of radioactivity.

2.4.3.2. The smaller the area of contamination the higher the permissible value for $DCGL_{EMC}$ up to a maximum of 10 times[8] the DCGLw.

2.4.3.3. The area factor was also applied to the ARG to produce an administrative release guideline, ARG_{EMC}, for elevated concentrations above the ARG. Equation 1 was used substituting ARG for DCGLw in the same manner.

2.5. SURVEY INSTRUMENTS

2.5.1. The instrumentation utilized to generate FSS data was maintained, calibrated, and tested according to the requirements of the D Plan. All procedures, responsibilities, and schedules for calibrating and testing equipment have been documented.

2.5.2. Maintenance information and use limitations provided in the vendor documentation of the instruments used during this FSS were adhered to. Measuring and analyzing equipment were tested and calibrated before initial use and were recalibrated periodically and whenever previous calibrations were invalidated. Field and laboratory equipment specifically used for obtaining final radiological survey data were calibrated based on standards traceable to NIST. Minimum frequencies for calibrating equipment have been established and documented.

2.5.3. Measuring equipment were tested at least once on each day the equipment was used for FSS. Test results were recorded in tabular or graphic form and compared to predetermined, acceptable performance ranges. Equipment not conforming to

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[7] *Final Status Survey Plan Design Guide (Phase I)*, Section 5.4.

[8] D Plan, Appendix C.

the performance criteria was promptly removed from service and any data gathered in the interim evaluated for quality until the deficiencies were resolved.

2.5.4. All calibration and source check records were completed, reviewed, signed-off and retained in accordance with the Mallinckrodt Quality Assurance Program. The original Calibration Sheets for the instruments used in this FSS are provided in Appendix 3 along with a calibration summary report from the C-T Radiation Database showing the normalized sensitivity calculated for each instrument at each calibration cycle.

2.5.5. L2221/AB-100 – The primary instrument used for the detection of surface radioactivity was the AB-100 scintillation detector configured for beta detection. The AB-100 detector houses a ZnS/BC-408 organic scintillator and is paired with the Ludlum 2221 scaler/ratemeter for fixed and scan surveys. The window of the AB-100 was modified to increase the thickness of the mylar to 7-9 mg/cm^2 for the purpose of alpha attenuation[9]. The detector window was unshielded (open) for a time period during counting at each sample location, and shielded (closed) for the same time period at the same location[10]. The difference in the two readings is attributable to beta emissions above 80 KeV in energy.[11] The sensitivity of the AB-100 was derived from experiments by Lucas and Colyott which were reported in Attachment 3 to the D Plan.[12] The actual instruments used were calibrated and normalized to the reference instrument tested by Lucas and Colyott as prescribed in CT-QA-6.1[13] .

2.5.6. L2241-2/AB-100 – The AB-100 detector mentioned above paired with the Ludlum 2241-2 scaler/ratemeter was used in the same way for direct and/or scan beta measurements.

2.5.7. L43-89 – The Ludlum 43-89 scintillation detector is a newer design that is functionally and physically equivalent to the AB-100. It has a slightly higher efficiency as a rule, and it may be paired on the same ratemeters and scalers.

2.5.8. L3030 – The Ludlum Model 3030 alpha/beta scaler houses ZnS(Ag) and plastic scintillators and was used to count removable contamination collected on paper swipes. Smear papers were counted in the laboratory and results were reported in βpm/100 cm^2. Removable contamination measurements were not compared with the release criteria for purposes of releasing the survey unit, but only to confirm that the removable fraction was less than 20% of the DCGLw.

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[9] As specified in Appendix D of the D Plan. Measurements taken with only the mylar covering the probe were "open window" measurements.

[10] The "closed window" reading was taken with a 1/8" soft Aluminum plate covering the face of the detector. It is sufficient to exclude β rays from the U and Th series.

[11] Internal Conversion Electrons (ICE) will also be included in this number but are a second order effect and may be ignored.

[12] *Energy Dependent Calibrations for the Bicron Model AB-100 Beta Ray Survey Probe*, A. Lucas, CHP and L. Colyott, Phd., submitted as Attachment 3 to the Mallinckrodt Phase I Decommissioning Plan.

[13] CT-QA-6.1 - *Calibration and Control of Measuring and Survey Equipment.*

2.6. LOWER LIMITS OF DETECTION (LLD) AND DETECTION THRESHOLDS

2.6.1. The terminology adopted to reflect an instruments' measurement (detection) capability is the lower limit of detection (LLD) or the minimum detectable activity (MDA). It refers to the intrinsic detection capability of the entire measurement process. The LLD, or MDA, is the lowest level of radioactivity that will yield a net count, above system blank, that will be detected with at least 95% probability with no greater than a 5% probability of falsely concluding that a blank observation represents a real signal. It is desirable to express the MDA as minimum detectable areal density (MDAD) or minimum detectable concentration (MDC) in units comparable to a regulatory limit with which a measurement may be compared. For a more detailed discussion regarding LLD and equations involved in calculation of LLD, refer to CT-QA-6.1.[14]

2.6.2. The LLD requirements for the FSS have been developed in accordance with MARSSIM[15] Chapter 4 guidelines. They are contained in the Design Guide and are listed in Table 2.4.

Table 2.4
MDC Requirements for CT FSS

Measurement Type	MDC Requirement[16]
Direct Beta	50% of ARG
Class 1 Beta Scans	ARG_{EMC}
Class 2 or 3 Beta Scans	ARG

2.6.3. The MDCs for the instruments used in the FSS were calculated according to Appendix D of the D Plan. A comparison of the MDCs calculated for the AB-100[17] with the requirement for this FSS is provided in Table 2.5.

2.6.4. Action thresholds based upon the release criteria were calculated for each instrument in both direct and scan modes of operation. All thresholds were based on the ARG and are presented in Table 2.5. Details of the MDC calculations and derivation of the action thresholds are provided in NEXTEP Tech Memo 0230.[18]

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[14] CT-QA-6.1, Ibid.
[15] NUREG 1575, *Multi Agency Radiation Survey and Site Investigation Manual.*
[16] Requirements are stated in terms of the ARG which may be adjusted upward (not to exceed the DCGLw) by the area factor or paint attenuation factor as described in Section 3.2 of the Design Guide.
[17] The MDC for the L43-89 is comparable to the AB-100 detector.
[18] NEXTEP Tech Memo 0230, *Technical Basis Document for Mallinckrodt Final Status Surveys*, A.H. Thatcher CHP (included with FSSR 235 Roof).

Table 2.5
LLD and Action Thresholds[19]

Measurement	Units	Calculated Value	Required Value	Required Value
BETA DIRECT			*Class 1*	*Class 2*
MDC	$Dpm_p/100\ cm^2$	100	1,300	1,300
Tinv[20]	cpm		2,900	2,900
BETA SCAN				
MDC	$Dpm_p/100\ cm^2$	760	1,300	2,600
Tinv	cpm		2,000	2,000

2.7. INSTRUMENT SENSITIVITY, BACKSCATTER AND PAINT ATTENUATION

2.7.1. Beta direct measurements taken in the field were converted to $dpm_p/100\ cm^2$ of the parent nuclide series in accordance with Section 9 of the Design Guide using the following equation:

Equation 2

$$AD = \frac{Co - Cc}{PAF * S_i * S_b(m) * t}$$

Where:

AD	=	Areal Density in $dpm_p/100\ cm^2$ for the parent nuclides
Co	=	Counts measured in the open window configuration
Cc	=	Counts measured in the closed window configuration
PAF	=	Paint attenuation factor derived from the number of coats ofpaint applied to the surface since C-T operations ceased.
S_i	=	Normalized Instrument sensitivity without backscatter.
$S_b(m)$	=	Backscatter factor (a function of matrix)
t	=	Integration time in minutes

2.7.2. There were six painted surfaces in building 235 and five in building 236 which were covered with one coat of paint. The paint attenuation factor (PAF) was equal to 0.357 for these surfaces[21]. All other surfaces in building 235 had a PAF equal to 1.

[19] All Values given are net of background.
[20] Investigation Threshold
[21] NEXTEP Tech Memo 0212: *Paint Attenuation Factor Calculations*, B.P. Anderson.

2.7.3. Justification and calculations for separation of backscatter (as a function of the matrix) and instrument sensitivity were presented in Nextep Tech Memo 0215.[22] Reference backscatter coefficients for several matrix materials were generated using an MCNP model and are described in Nextep Tech Memo 0213.[23] These coefficients were stored in the Matrix table in the Database and were used in the calculations according to the matrix material upon which the measurement was taken.

3. SURVEY METHODS

3.1. SURVEY PROCEDURES

3.1.1. The FSS conformed to the procedures and plans listed in Table 3.1. The primary guidance for the FSS is contained in the Design Guide and the FI.

Table 3.1

Survey Procedures and Documents
CT Decommissioning Plan (Phase I)
CT Decommissioning Project, Final Status Survey Design Guide (Phase I)
CT-FI-007, Final Status Survey Guide for Survey Units 23501 and 23601
CT-QA-6.1: Calibration and Operation of Measuring and Survey Equipment
CT-RP-66: Operation of Scalers, Rate Meters, and Contamination Detectors
CT-RP-39: Performance of Radiation and Contamination Surveys
CT-RP-40: Survey Documentation and Review

3.1.2. All FSS data recorded in the field was submitted to the Quality Assurance Coordinator for processing and review. The data collection forms and annotated drawings were signed by the technician taking the data and reviewed by the Radiation Protection, Health & Safety (RPHS) Manager or designee overseeing the survey. After data entry and review, QA approved the data sheets and filed them with the permanent Mallinckrodt records. The QA checklist[24] developed for quality verification of FSS data was used as a guide to data verification.

3.1.3. All the data generated by the surveys were entered into the CT Radiation Database (RDB) and analyzed as outlined in Section 4.4 of the D Plan.

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[22] NEXTEP Tech Memo 0215: *Separation of Backscatter & Derivation of Instrument Sensitivity*, A.H. Thatcher CHP (included with FSSR 2501).

[23] NEXTEP Tech Memo 0213: *Beta Backscatter Factors for Several Materials at the Mallinckrodt Site,* N. Zhang and D. Wilson (included with FSSR 2501).

[24] NEXTEP Tech Memo 0206, *QA Data Verification for MI CT Final Status Survey Data*, B. Anderson, (included with FSSR 2501).

3.2. SURVEY MEASUREMENTS

3.2.1. Beta Measurements:

3.2.1.1. *Direct* – A systematic grid of direct measurements were obtained on the floor and wall surfaces as described in the FI. Bias measurements were taken on building surfaces and fixed apparatus at locations determined by the surveyor and to more fully characterize the fixed apparatus.

3.2.1.2. *Scans* - Beta scans were performed using the same instruments used for the direct beta measurements. Beta Scans were performed on the floor and wall surfaces. Scans were performed at a scan rate of less than one detector width per second with a probe height less than one inch from the surface being scanned.

3.2.2. Removable Contamination Measurements:

3.2.2.1. *Swipes* - Removable contamination samples were collected at 100% of all regular grid locations on the floor and walls of SU-23501 and as bias data on the floor and walls of SU-23601 where the original surfaces were exposed. The swipes were counted in the laboratory and recorded in the database. Sampling of removable contamination was performed to confirm the assumption, used in derivation of the DCGLw, that the removable fraction measures less than 20% of the DCGLw[25].

3.3. MEASUREMENT LOCATIONS

3.3.1. Statistical Grid Data Points

3.3.1.1. The *Visual Sample Plan*© (VSP)[26] software was used to develop a MARSSIM grid for each survey unit. The minimum number of points required and their spacing were calculated in accordance with the statistical guidance given in MARSSIM Sections 5.5.2.2 and 5.5.2.5.

3.3.1.2. VSP users the Data Quality Objective (DQO) input values to calculate the number of measurement points, N, required to satisfy MARSSIM statistical guidance. The calculations include 20% excess to allow for inaccessible locations. A summary of all the input parameters used with VSP for this report is presented in Table 3.2.

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[25] Section 3.3 of the C-T Design Guide.

[26] NEXTEP Tech Memo 0008, *Verification and Validation of Applicable Portions of VSP Software,* A. H. Thatcher, CHP.

Table 3.2
VSP Inputs for Building 235/236 Interior

DQO	Value
Type I error rate	5%
Type II error rate	5%
Width of Gray Region	200 $Dpm_p/100cm^2$
Level (ARG)	2,600
Estimated Std Deviation	200 $Dpm_p/100cm^2$
Excess % sample points	20%

3.3.1.3. The number N for SU-23501 and SU-23601 was 29.[27] A rectangular grid was used for both survey units. The maximum grid interval spacing, L, was calculated from the total area of each survey unit, A, and the required number of data points, N, according to the following equation:

Equation 3

$$L \leq \sqrt{\frac{A}{N}}$$

3.3.1.4. Table 3.3 presents the calculated values for L and N for this FSS.

Table 3.3
SU-23501 and SU 23601 Calculated Grid Point Separation

Survey Unit	Class	N	A (ft^2)	L (ft)
SU-23501	2	29	22,538	27.9
SU-23601	2	29	9,025	17.6

3.3.2. Bias Measurement Locations

3.3.2.1. Bias direct measurements were taken at the discretion of the HP technician performing the survey.

3.3.2.2. Bias surveys were also taken at hot spot locations identified by scans as directed in the Hot Spot Protocol[28].

[27] Since SU-23502 is made up of two ground rods and one ground rod hole, no grid spacing was calculated. Instead, readings were taken on each rod and on the ground rod hole.

[28] CT-FI-002, *Final Status Survey Guide for Survey Units 235NES & 236NSW.*

3.4. REFERENCE COORDINATE SYSTEM

3.4.1. A unified reference system was prescribed for the location of all data points taken on all building surfaces and on the surface of installed apparatus. A description of the reference coordinate system is provided below.

3.4.2. A data point's unique location is specified by a combination of the following data elements: building, room, surface ID, X, and Y. The surface ID refers to the four walls, floor, ceiling and roof as shown in Table 3.2. X and Y are distances from the origin measured as shown in the table. An example of X and Y axes for floors and walls is presented in Appendix 2, Figure 3.1

Table 3.2
Coordinate System Locators

Location	Identifier	X	Y
North Wall	N	Feet right from leftmost edge of the wall surface	Feet up from floor or the lowest point in the room
South Wall	S		
East Wall	E		
West Wall	W		
Floor	F	Feet east from western most edge of the surface	Feet North of southernmost edge
Ceiling	C		
Roof	R		

3.4.3. The surface ID for a roof applies only in the case when measurements are being made on the exterior surface of a building. In this unique case the "room" assigned has the special number "999".

3.4.4. Systematic grid data points which fell on external surfaces of installed apparatus were located with the primary coordinate system. The ID code of the apparatus was recorded in the remarks. For example: Let Q2 be identified as a large air conditioning unit located on the roof. Any systematic grid measurement points for the roof surface which landed on the air conditioner would have been identified using the X and Y coordinates from the southwest corner of the roof. "Q2 – A/C unit" would be noted in the remarks. The surface ID would be "R".

3.4.5. All bias data points taken on installed apparatus were numbered and located on the drawings provided. This number was recorded as the X coordinate on the data sheet and amplifying information was entered in the remarks section.

3.5. DATA EVALUATION

3.5.1. All of the direct, swipe and scan data were entered into the CT Radiation Database (RDB) for easy access and analysis. The direct beta measurements are the primary means for documenting the survey unit and justifying its release. Therefore, a special report was programmed to perform all the tests specified in Section 4.4.8 of the D Plan and to provide a clear report of the results for

evaluation. The calculations in this report have been validated and verified as described in NEXTEP Tech Memo 0231[29].

3.5.2. The purpose of the screening software is to compare each direct beta reading taken in the survey unit with specified threshold levels, to apply the statistical tests called for in MARSSIM when appropriate, and to present the results in a clear and useful manner so that an analyst can accurately assess the action to be taken or declare that the survey unit meets the requirements for release.

3.5.3. Some of the screening tests apply to each record in the survey unit and failure of one data point results in failure of the survey unit. Other tests do not apply to each survey record but generate a single PASS/FAIL verdict for the entire data set. The tests are described in the following paragraphs[30]. An abbreviated summary of these tests is presented in Table 3.5.

3.5.4. *Background Screen.*

3.5.4.1. For each MATRIX code in the database, calculate the mean background reading, its standard deviation, and its minimum value. Calculate and store the Background Threshold, T_{bk}, with its matrix code according to the following equation:

Equation 4

$$T_{bk}(m) = \overline{BK}(m) + 2 * \sigma_{bk}(m)$$

3.5.4.2. T_{bk} is equal to the mean of the background readings $\left(\overline{BK}\right)$ for a given matrix plus two times its standard deviation (2σ).

3.5.4.3. Compare each data point in the filtered survey unit with T_{bk}. If the survey reading > T_{bk} the data point fails the test. One data point failure implies failure of the background screen test for the survey unit.

3.5.5. *Min/Max Test.*

3.5.5.1. Find the maximum direct survey result, in $dpm_p/100cm^2$, for the survey data set.

3.5.5.2. Find the minimum background reading among all the background data points having MATRIX codes that match those in the data set.

3.5.5.3. If the difference between these two values is greater than DCGLw[31] the MIN/MAX test fails for the survey unit.

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[29] NEXTEP Tech Memo 0231, *Validation and Verification of the C-T Database Analysis Report,* B. Anderson, (included with FSSR 2501).

[30] A more detailed explanation is provided in the Design Guide.

[31] Normally, the ARG is used as $DCGL_w$ wherever the Threshold Comparison Test Report (TCTR) is run.

3.5.6. *DCGLw Screen.*

3.5.6.1. For each matrix code calculate and store a DCGLw Threshold (T_d). T_d is calculated by adding the value of DCGLw to T_{bk}.

Equation 5

$$T_d(m) = T_{bk} + DCGLw$$

3.5.6.2. Compare each data point in the survey unit with T_d. If the survey reading > T_d the data point fails the test. One data point failure implies failure of the DCGLw screen test for the survey unit.

3.5.7. *EMC Screen.*

3.5.7.1. For each matrix code calculate and store an EMC Threshold (T_e). T_e is calculated by adding the value of EMC to T_{bk}. The EMC value selected is normally dependent upon the area involved. However, if no specific area was known, the EMC was normally set to 13,000 $dpm_p/100\ cm^2$.[32]

3.5.7.2. Compare each data point in the filtered survey unit with T_e. If the survey reading > T_e the data point fails the test. One data point failure implies failure of the EMC test for the survey unit.

3.5.8. *DCGL Average Test.*

3.5.8.1. For each matrix material in the survey unit, calculate the mean activity density, (in $dpm_p/100cm^{2)}$, in the survey data set. Subtract from this value, the mean value of background activity for the same matrix. If the remainder is greater than DCGLw for any matrix in the survey unit, the test fails.

Equation 6

$$\overline{AD}(m) - \overline{BK}(m) > DCGLw$$

3.5.9. *Statistical Tests.*

3.5.9.1. The statistical tests prescribed by MARSSIM operate only on the data points of MEASUREMENT TYPE = RG (Regular Grid) and PG (Post-Remediation Grid). The program narrows the filter to include only these points before proceeding.

3.5.9.2. The Wilcoxon Rank Sum Test[33] is applicable for survey units with measurements on a single matrix type or on matrices with similar

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[32] Since the ARG was normally used in place of the DCGLw, the value for DCGLw (13,000 $dpm_p/100\ cm^2$) was normally used as the EMC threshold for the TCTR.

[33] Described in Appendix I of MARSSIM.

background characteristics. Where more than one matrix was present, the Sign Test for Paired Data[34] was used.

3.5.10. The output of the Threshold Comparison Test Report (TCTR) was used for analysis of the data for buildings 235 and 236 floors and walls and the results are presented in Appendix 4. The TCTR is divided into eight sections which are briefly described in the following paragraphs to assist the unfamiliar reader.

3.5.10.1. General: date, survey unit number, class, and grid information.

3.5.10.2. Survey Unit Table: building surface included, affected fixed apparatus, and total surface area of the survey unit.

3.5.10.3. Initialization Data: On startup of the analysis report program, the analyst must tell the program which parameters to use while running the tests described in this section. The *Initialization Data* section of the report output displays the options that were chosen for the run. The measurement types listed are those chosen by the analyst to be included in the report. The date range chosen is also listed. The default value is "All Dates". Values for DCGLw (ARG) and $DCGL_{EMC}$ are also specified at the start of the run and are listed in this section. If remediated data points are included in the run, it will be noted in this section. Normally they will be excluded.

3.5.10.4. Survey Unit Test Status: Lists Pass/Fail status of all tests and gives a high level summary of key activity levels in the SU.

3.5.10.5. Points that failed tests: Lists all points that failed each specified threshold test (EMC, DCGL, and Background).

3.5.10.6. Points that passed all the tests: This includes the remainder of all the points in the data set. These data points have passed all the tests.

3.5.10.7. Summary of background data used in the calculations. This table includes the matrix materials included in the survey and the thresholds calculated for each of the tests discussed in this section.

3.5.10.8. Statistical Test Results: This page lists the results of the Sign Test for Paired Data or the Wilcoxon Rank Sum test, whichever is selected. If the Test Status line reads Pass then the survey unit passes the Sign Test for Paired Data. The Data Summary section lists the number of background points and the number of survey points used from the data set. If the operator selects the option to show all data, a table of all data points used in the test is printed out.

[34] Described in NEXTEP Tech Memo 0231, Ibid.

Table 3.5
Threshold Screening Tests

Test	Test Criteria for PASS
Min/Max	Difference between minimum background measurement and maximum survey value less than DCGLw
Background	All samples must be less than the background threshold[a]
$DCGL_w$	All samples must be no more than $DCGL_w$ + the background threshold
$DCGL_{avg}$	The average of all net survey values must be less than $DCGL_w$
EMC	All samples must be less than $DCGL_{EMC}$ + the background threshold
Sign Test for Paired Data	The Sign Test for Paired Data is described in detail in NUREG 1505[35]
Wilcoxon Rank Sum Test	This statistical test is described in detail in MARSSIM, Appendix I.

[a] The background threshold is equal to the mean background value plus twice σ_{BK}.

3.5.11. Provided all additional considerations such as scan data, swipes, sampling of removable contamination or sludge from traps, etc. indicate that the survey unit meets the release criteria, the release of the survey unit can be determined from the test report according to Table 3.6.

Table 3.6
Requirements for SU Release[36]

Test	Class 1	Class 2	Class 3
Min/Max	not required[a]	not required[a]	PASS
Background	not required	not required	PASS
$DCGL_w$	not required	PASS	PASS
$DCGL_{avg}$	PASS	PASS	PASS
EMC	PASS	PASS	PASS
Sign Test for Paired Data	PASS	PASS	PASS

[a] Class 1 or 2 survey units which pass Min/Max may be released without further consideration.

[35] NUREG 1505, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys.*

[36] See MARSSIM, Chapter 8, Table 8.2

4. FSS RESULTS AND DISCUSSION

4.1. CHARACTERIZATION DATA

4.1.1. The characterization data taken in SU-23501 from 1992 to 1996 were very limited. Since the data on file in the characterization report were all taken with an HP-210 instrument they could not be normalized to the AB-100 calibration standards and therefore are not included in the data set. The characterization data taken in SU-23601 from 1992 to 1996 were taken with an AB-100 and were numerous. Those data were included in the data set as RG and CH data. CH data was treated as bias.

4.2. SURVEY UNIT 23501

4.2.1. SU-23501 was surveyed in June 2003. Measurements were taken on the floor and walls.

4.2.2. Direct Beta Measurements on Building Surfaces

4.2.2.1. 33 direct beta measurements were taken on the floor and wall surfaces of the survey unit. 33 of these were included in the systematic grid. Diagrams of each surface in SU-23501 are presented in Appendix 2, Figures 4.1 – 4.2.

4.2.2.2. A summary of the direct measurement results is presented in Table 4.1 and shows that the maximum activity measured, net of background, was 390 $dpm_p/100cm^2$. The average value for the survey unit was 76 $dpm_p/100cm^2$.

Table 4.1
SU-23501 Direct Measurements Summary
(Building Surfaces)

Matrix	Points	Avg Net Activity ($Dpm_p/100cm^2$)	Max Net Activity ($Dpm_p/100cm^2$)
Brick	8	130.4	389.9
Concrete	18	42.8	286.7
Concrete Block	6	118.6	381.3
Metal	1	-10.9	-10.9

4.2.3. Direct Beta Measurements on Installed Apparatus

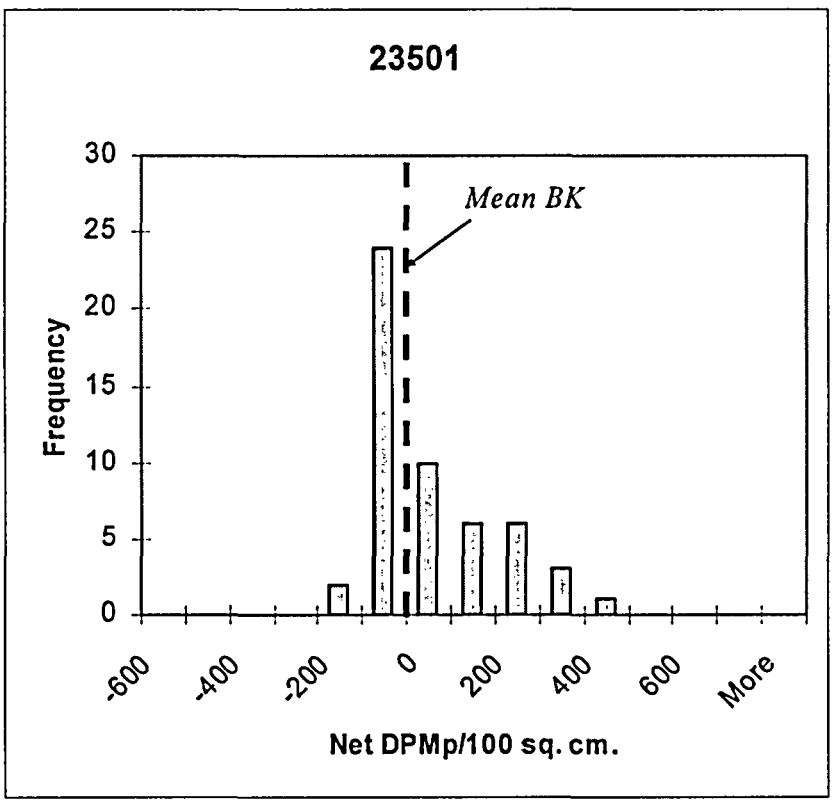
4.2.3.1. All 3 items of installed apparatus which are listed in Appendix 1 were surveyed by direct beta measurements. A summary of the measurements taken is provided in Table 4.2 sorted by matrix material. The values observed ranged from -161 to 434 $dpm_p/100cm^2$. All values were less than the ARG. The data confirm that negligible residual radioactivity was measured on the 3 items of installed apparatus in SU-23501.

Table 4.2
SU-23501 Fixed Equipment Direct Measurements Summary

Matrix	Points	Avg Net Activity (Dpmp/100cm^2)	Max Net Activity (Dpmp/100cm^2)
Concrete	9	116.5	433.5
Metal	10	-21.4	-4.7

4.2.4. Direct Beta Analysis and Threshold Tests

4.2.4.1. A histogram of the net activity values found in SU-23501 is provided in Figure 4.1. The distribution appears to have a single mode with the majority of the data centered at approximately 0 $dpm_p/100cm^2$. This is consistent with a normal distribution of background radioactivity with residual contamination just above background levels but well below the ARG.



Histogram of Net Direct Beta Measurements
Figure 4.1

4.2.4.2. All the direct measurements in the survey unit were analyzed using the Threshold Comparison Test Report and the results are presented in Appendix 4 for SU-23501. The TCTR report contains a complete listing of all the beta direct measurements taken in the Final Status Survey within SU-23501 sorted by activity. The summary pages indicate that all

tests described in the D Plan passed except background. All the tests required for release of Class 2 survey units were passed. A comparison of test results and requirements for release of the survey unit is presented in Table 4.3.

Table 4.3
TCTR Results for SU-2501

Test	Class 2	SU-23501
Min/Max	not required[a]	P
Background	not required	F
$DCGL_w$	PASS	P
$DCGL_{avg}$	PASS	P
EMC	PASS	P
Wilcoxon Rank Sum Test	PASS	P

[a] Class 2 survey units which pass Min/Max may be released without further consideration.

4.2.4.3. As the histogram in Figure 4.1 shows, the survey unit has some radioactivity above background, but well below the ARG. These results are consistent with a passing of all tests except background for this survey unit.

4.2.5. Measurements of removable contamination

4.2.5.1. Swipes were taken at each location where a direct grid measurement was performed. The results of these measurements are presented in Table 4.4.

Table 4.4
SU-23501 Removable Contamination Summary

Surface	Points	Avg Net Beta ($\beta pm/100cm^2$)	Max Net Beta ($\beta pm/100cm^2$)	Avg Net Activity[a] ($Dpm_p/100cm^2$)	Max Net Activity ($Dpm_p/100cm^2$)
N	5	7.8	14	1.6	2.9
E	4	9.8	31	2.0	6.5
S	5	-1.0	14	-0.2	2.9
W	6	15.3	42	3.2	8.8
F	13	14.5	36	3.0	7.5

[a] Activity was converted to $dpm_p/100\ cm^2$ from $\beta pm/100\ cm^2$ using an approximate figure of 4.8 betas per disintegration.

4.2.5.2. The results show that removable contamination averages near zero $dpm_p/100cm^2$ and varies between –4.0 and +8.8 $dpm_p/100cm^2$. The data confirm that virtually no removable contamination is present within SU-23501.

4.2.6. Beta Scan Measurements

4.2.6.1. Beta scans were performed on about 15% of the surface of the interior walls and floor. Diagrams of the areas surveyed are presented in Appendix 2, Figures 4.3 and 4.4.

4.2.6.2. The scan threshold used for these surveys was 2,000 cpm (net of background) which corresponds to the ARG of 2,600 $dpm_p/100cm^2$. The calculation of threshold count rate and MDC for scans is presented in NEXTEP Tech Memo 0230[37].

4.2.6.3. All scans performed on the floor surfaces were taken on brick, concrete or concrete block. The average background value used for analysis of the brick, concrete, and concrete block data was obtained from the average of all the open window, direct beta readings (in cpm) taken in the survey unit, by matrix. This value was 356 cpm for brick, 260 cpm for concrete, and 313 cpm for concrete block. The average of all open window survey readings taken in the background data set was 552 cpm, 331 cpm, and 412 cpm for brick, concrete, and concrete block respectively.

4.2.6.4. During the surveys the maximum and average gross count rates were recorded for each area scanned. The beta scan data are summarized for SU-23501 and presented in Table 4.5.

Table 4.5
SU-23501 Scan Measurements Summary

Matrix	Areas	Maximum (cpm)	Average (cpm)	Max Net (cpm)	Avg Net (cpm)
Brick	6	280	183	-76	-173
Concrete	26	500	156	240	-105
Concrete Block	2	240	190	-73	-123

4.2.6.5. The maximum net scan value of 240 cpm is well below the scan threshold of 2000 cpm. No beta scan data were observed in SU-23501 above the scan threshold.

[37] NEXTEP Tech Memo 0230, ibid.

4.3. SURVEY UNIT 23502

4.3.1. SU-23502 exists to cover item 77 in Appendix A of the D Plan (see Table 2.1). This item came from a diagram in Volume 2 of the Characterization Report[38] which showed a 50,000 cpm NaI scan reading taken in the SW corner of the west bay of Building 235. The text below the diagram says, "the 50K reading was recorded near a hole in concrete for grounding rod". A copy of the diagram is reproduced in Appendix 2, Figure 4.6 of this report and shows the measurement to be near or among a large group of 55 gallon drums.

4.3.2. Although two other ground rods were identified in room 101 of B235 (see Figure 2.1) the original ground rod hole has been obliterated probably by new construction which created the two dryer rooms shown in Figure 4.7.

4.3.3. Direct beta measurements were taken on the ground rods in Room 101 of Building 235 in October 2003. In November 2003 beta scans were performed in and around the dryer rooms in search of contamination which might be related to the high scan reading obtained near the ground rod hole in that area in 1994.

4.3.4. Direct Beta Measurements on Ground Rods

4.3.4.1. Direct beta measurements were taken on two ground rods located in room 101 of Building 235 on the south and east walls. A summary of the direct measurement results is presented in Table 4.6 and shows that the maximum activity measured, net of background, was 38.7 $dpm_p/100cm^2$. The average value for the rods was 9.3 $dpm_p/100cm^2$. All measurements were well below the ARG.

Table 4.6
SU-23502 (Ground Rods) Direct Measurements Summary

Matrix	Points	Avg Net Activity ($Dpm_p/100cm^2$)	Max Net Activity ($Dpm_p/100cm^2$)
Metal	2	9.3	38.7

4.3.5. Beta Scans

4.3.5.1. The floors of the east and west dryer rooms in room 101 of Building 235 were scanned with a beta detector. About 75% of the floor surface of both rooms was scanned with special attention given to the SW corner of the building. No measurements in these rooms were obtained in excess of 200 cpm, well below the beta scan threshold of 2,000 cpm. A diagram of the areas scanned in the dryer rooms is presented in Figure 4.7.

[38] *Radiological Data Set for the Mallinckrodt Chemical C-T Plant,* Revised October, 1998

4.3.6. No scan or direct measurements were obtained in SU-23502 above the release criteria or scan investigation threshold.

4.4. SURVEY UNIT 23601

4.4.1. SU-23601 was surveyed during the Characterization program from 1992 to 1996 and some additional survey work was performed in June 2003. Because adequate characterization data exist, no direct measurements were added to the data set from SU-23601. Smears were collected from the floor and walls at accessible points. Due to extensive remodeling of Building 236 since C-T operations ceased, few areas from the original C-T building configuration are accessible today due to new interior brick walls which cover the drywall construction.

4.4.2. Direct Beta Measurements on Building Surfaces

4.4.2.1. 145 direct beta measurements were taken on the floor and wall surfaces of the survey unit. 120 of these were included in the systematic grid. A diagram of the surfaces in SU-23601 is presented in Appendix 2, Figure 4.8.

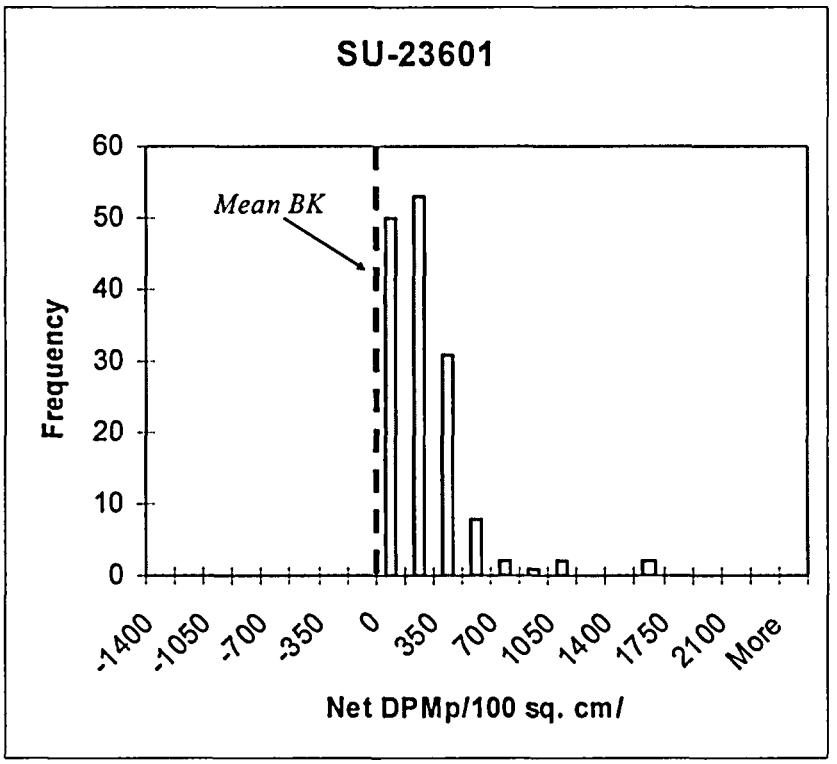
4.4.2.2. A summary of the direct measurement results is presented in Table 4.7 and shows that the maximum activity measured, net of background, was 1,681 $dpm_p/100cm^2$. The average value for the survey unit was 303 $dpm_p/100cm^2$. All measurements were well below the ARG.

Table 4.7
SU-23601 Direct Measurements Summary
(Building Surfaces)

Matrix	Points	Avg Net Activity ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
Brick	78	337.0	1681.4
Concrete	56	301.0	1604.3
Concrete Block	2	328.0	364.0
Gypsum Board	10	109.6	205.6
Metal	3	74.0	153.8

4.4.3. Direct Beta Measurement Distribution and Threshold Tests

4.4.3.1. A histogram of the net activity values found in SU-23601 is provided in Figure 4.2. The distribution appears to have a single mode with the majority of the data centered close to 260 $dpm_p/100cm^2$. There are some data which lie outside of this distribution. This is consistent with a normal distribution of background radioactivity with a small amount of residual radioactivity above background. All measurements were well below the ARG.



Histogram of Net Direct Beta Measurements
Figure 4.2

4.4.3.2. All the direct measurements in the survey unit were analyzed using the Threshold Comparison Test Report and the results are presented in Appendix 4 for SU-23601. The TCTR report contains a complete listing of all the beta direct measurements taken in the Final Status Survey within SU-23601 sorted by activity. The summary pages indicate that all tests described in the D Plan passed except background. All the tests required for release of Class 2 survey units were passed. A comparison of test results and requirements for release of the survey unit is presented in Table 4.8.

Table 4.8
Requirements for SU Release

Test	Class 2	SU-23501
Min/Max	not required[a]	P
Background	not required	F
$DCGL_w$	PASS	P
$DCGL_{avg}$	PASS	P
EMC	PASS	P
Wilcoxon Rank Sum Test	PASS	P

[a] Class 2 survey units which pass Min/Max may be released without further consideration.

4.4.3.3. As the histogram in Figure 4.2 shows, the survey unit has some radioactivity above background, but well below the ARG. These results are consistent with passing all tests except background for this survey unit.

4.4.4. Measurements of removable contamination

4.4.4.1. Swipes were taken at accessible locations on exposed areas of the floor and walls to supplant the smear samples that would normally coincide with the direct grid measurement locations. The results of the measurements are presented in Table 4.9.

Table 4.9
SU-23601 Removable Contamination Summary

Surface	Points	Avg Net Beta ($\beta pm/100cm^2$)	Max Net Beta ($\beta pm/100cm^2$)	Avg Net Activity[a] ($Dpm_p/100cm^2$)	Max Net Activity ($Dpm_p/100cm^2$)
E	2	-10.0	11.0	-2.1	2.3
F	5	-0.6	36.0	-0.1	7.5
N	1	-11.0	-11.0	-2.3	-2.3
S	1	-28.0	-28.0	-5.8	-5.8
W	2	-22.0	-19.0	-4.6	-4.0

[a] Activity was converted to $dpm_p/100\ cm^2$ from $\beta pm/100\ cm^2$ using an approximate figure of 4.8 betas per disintegration.

4.4.4.2. The results show that removable contamination averages near zero $dpm_p/100cm^2$ and varies between –6.5 and +7.5 $dpm_p/100cm^2$. The data confirm that virtually no removable contamination is present within SU-23601.

4.4.5. Beta Scan Measurements

4.4.5.1. Beta scans were performed on about 15% of the floor surface and on about 10% of the wall surfaces. A diagram of the areas surveyed in SU-23601 is presented in Appendix 2, Figure 4.9.

4.4.5.2. The scan threshold used for these surveys was 2,000 cpm (net of background) which corresponds to the ARG of 2,600 $dpm_p/100cm^2$. The calculation of threshold count rate and MDC for scans is presented in NEXTEP Tech Memo 0230[39].

4.4.5.3. All scans performed on the wall and floor surfaces were taken on brick and concrete respectively. The average background value used for analysis of the brick and concrete raw data was obtained from the average of all the open window, direct beta readings (in cpm) taken in the background data set, by matrix. This value was 552 cpm for brick and 331 cpm for concrete. The average of all open window survey readings taken in the survey unit was 742 cpm and 636 cpm for brick and concrete respectively.

4.4.5.4. During the surveys the maximum and average gross count rates were recorded for each area scanned. The beta scan data are summarized for SU-23601 and presented in Table 4.10.

Table 4.10
SU-23601 Scan Measurements Summary

Matrix	Areas	Maximum (cpm)	Average (cpm)	Max Net (cpm)	Avg Net (cpm)
Brick	7	360	191.4	-192.2	-360.8
Concrete	2	130	100.0	-201.2	-231.2

4.4.5.5. The maximum net scan value of -192 cpm is well below the scan threshold of 2000 cpm. No beta scan data were observed in SU-23601 above the scan threshold.

5. CONCLUSIONS

5.1. SU-23501 passed all the tests described in the D Plan except background. All the tests required for release of a Class 2 Survey unit were passed. (Par. 4.2.4.2)

5.2. No significant residual radioactivity was measured on the 3 items of installed apparatus in SU-23501. (Par. 4.2.3.1)

5.3. Virtually no removable contamination is present within SU-23501. (Par. 4.2.5.2)

[39] NEXTEP Tech Memo 0230, Ibid.

5.4. No beta scan data were observed in SU-23501 above the scan threshold of 2,000 cpm. (Par. 4.2.6.5)

5.5. All direct beta measurements taken on the ground rods (SU-23502) were well below the ARG. (Par. 4.3.4.1)

5.6. SU-23601 passed all the tests described in the D Plan except background. All the tests required for release of a Class 2 Survey unit were passed. (Par. 4.4.3.2)

5.7. Virtually no removable contamination is present within SU-23601. (Par. 4.4.4.2)

5.8. No beta scan data were observed in SU-23601 above the scan threshold of 2,000 cpm. (Par. 4.4.5.5)

5.9. Within the scope of this survey, Survey Units 23501, 23502, and 23601 meet all the requirements of the D Plan and MARSSIM for unconditional release.

6. RECOMMENDATIONS

6.1. Survey Units 23501, 23502, and 23601 should be released from the license.

Appendix 1
Building Survey Unit Listing for
Buildings 235 & 236 Interior

Building Survey Unit Listing

SurfaceCode	*Xmax*	*Ymax*	*Area (sq.ft.)*	*Paint (Coats)*	*Description*
SurveyUnitID: 23501					***Class:*** 2
Room 101					
F	78.7	81.3	6,398	1.0	
N	78.7	23.0	1,809	1.0	
S	78.7	23.0	1,809	1.0	
E	81.3	23.0	1,871	1.0	
W	81.3	23.0	1,871	1.0	
Q1				0.0	I Beams
Q3				0.0	Expansion Joint
Summary for Room 101 (7 detail records)				*13,758*	**Sq. Feet**
Room 102					
F	39.6	81.3	3,218	1.0	
N	39.6	23.0	910	0.0	
S	39.6	23.0	910	0.0	
E	81.3	23.0	1,871	0.0	
W	81.3	23.0	1,871	0.0	
Q1				0.0	Green Iron I Beams
Summary for Room 102 (6 detail records)				*8,780*	**Sq. Feet**
TOTAL for Survey Unit 23501				*22,538*	Sq. Feet

Building Survey Unit Listing

SurfaceCode	*Xmax*	*Ymax*	*Area (sq.ft.)*	*Paint (Coats)*	*Description*

SurveyUnitID: 23502 ***Class:*** 1

Room 101

Q4				0.0	Ground Rods (3)

Summary for Room 101 (1 detail record) *0* **Sq. Feet**

TOTAL for Survey Unit 23502 *0* Sq. Feet

Building Survey Unit Listing

SurfaceCode	*Xmax*	*Ymax*	*Area (sq.ft.)*	*Paint (Coats)*	*Description*
SurveyUnitID: 23601					***Class:*** 2
Room 101					
F	41.5	81.3	3,375	1.0	
N	41.5	23.0	955	1.0	3.5' of brick above drywall is affected
S	41.5	23.0	955	1.0	3.5' of brick above drywall is affected
E	81.3	23.0	1,871	1.0	3.5' of brick above drywall is affected
W	81.3	23.0	1,871	1.0	3.5' of brick above drywall is affected
Summary for Room 101 (5 detail records)				*9,025* Sq. Feet	
TOTAL for Survey Unit 23601				*9,025* Sq. Feet	

APPENDIX 2
Figures

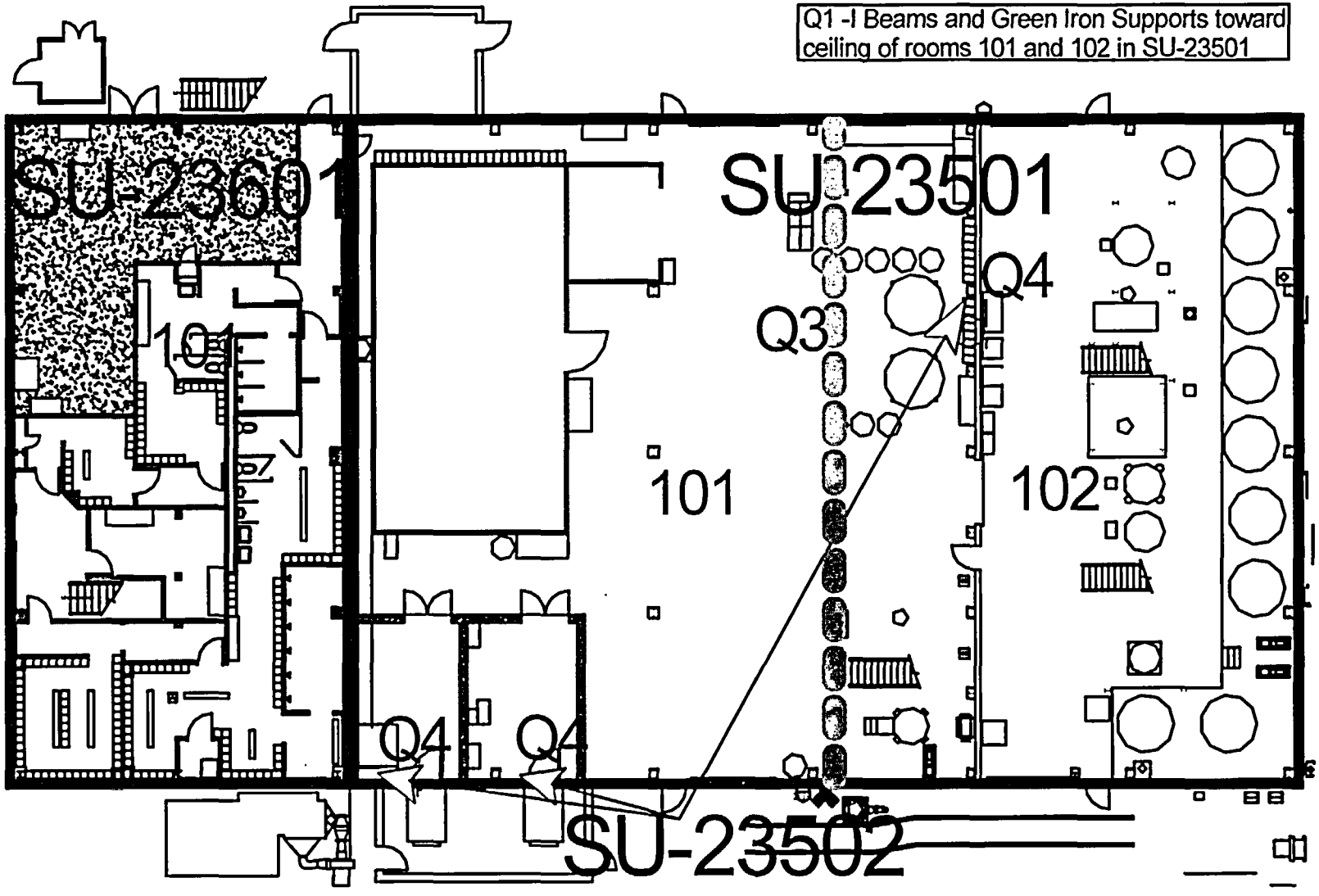


Figure 2.1
SU-23501 & SU-23601

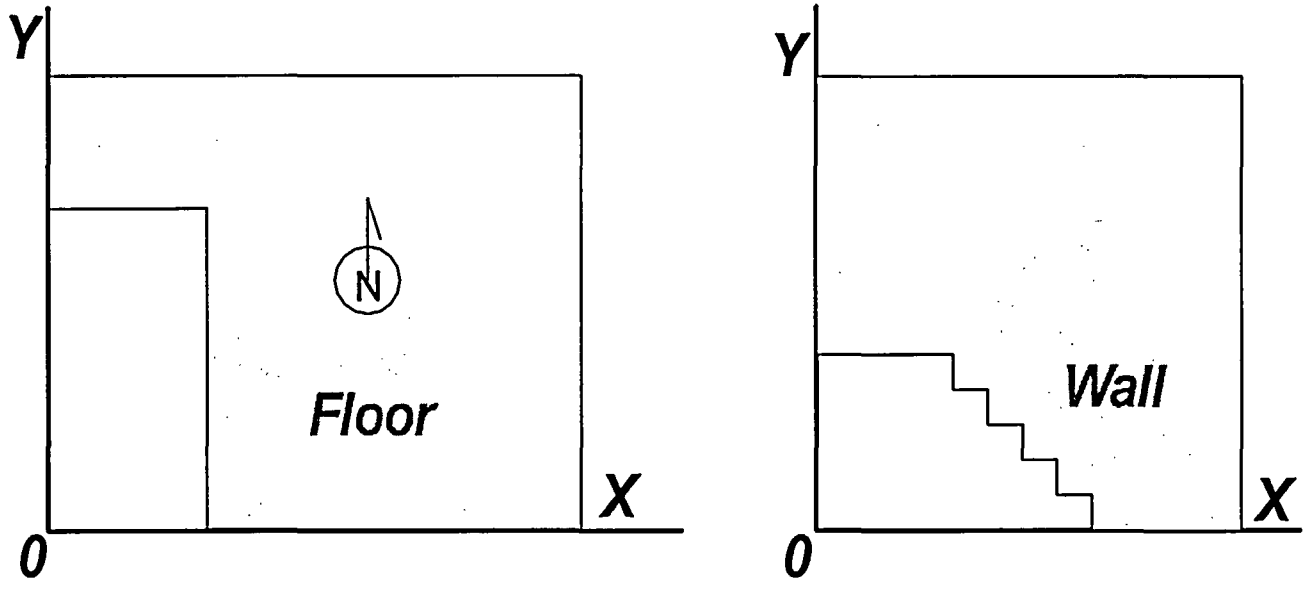
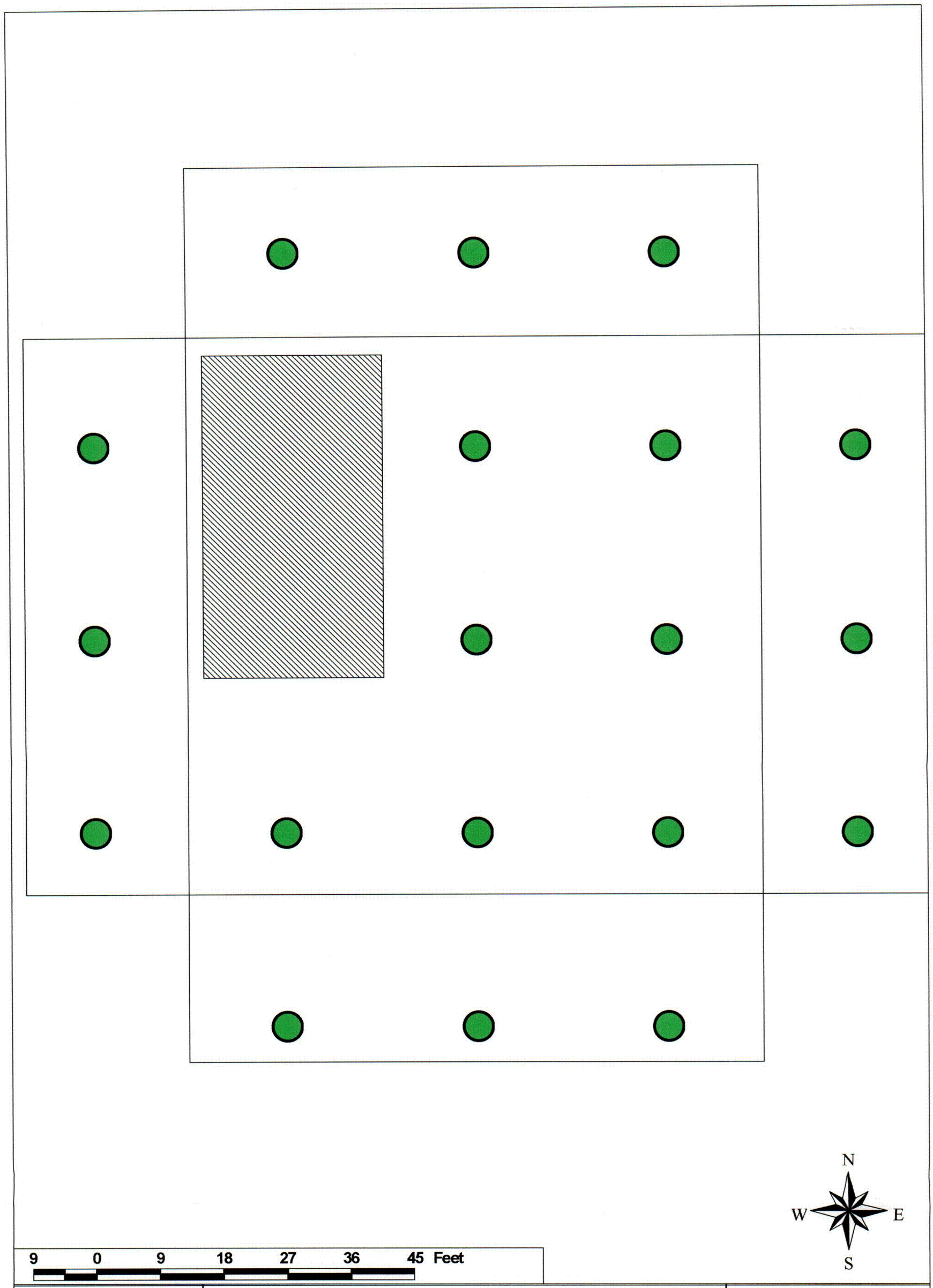
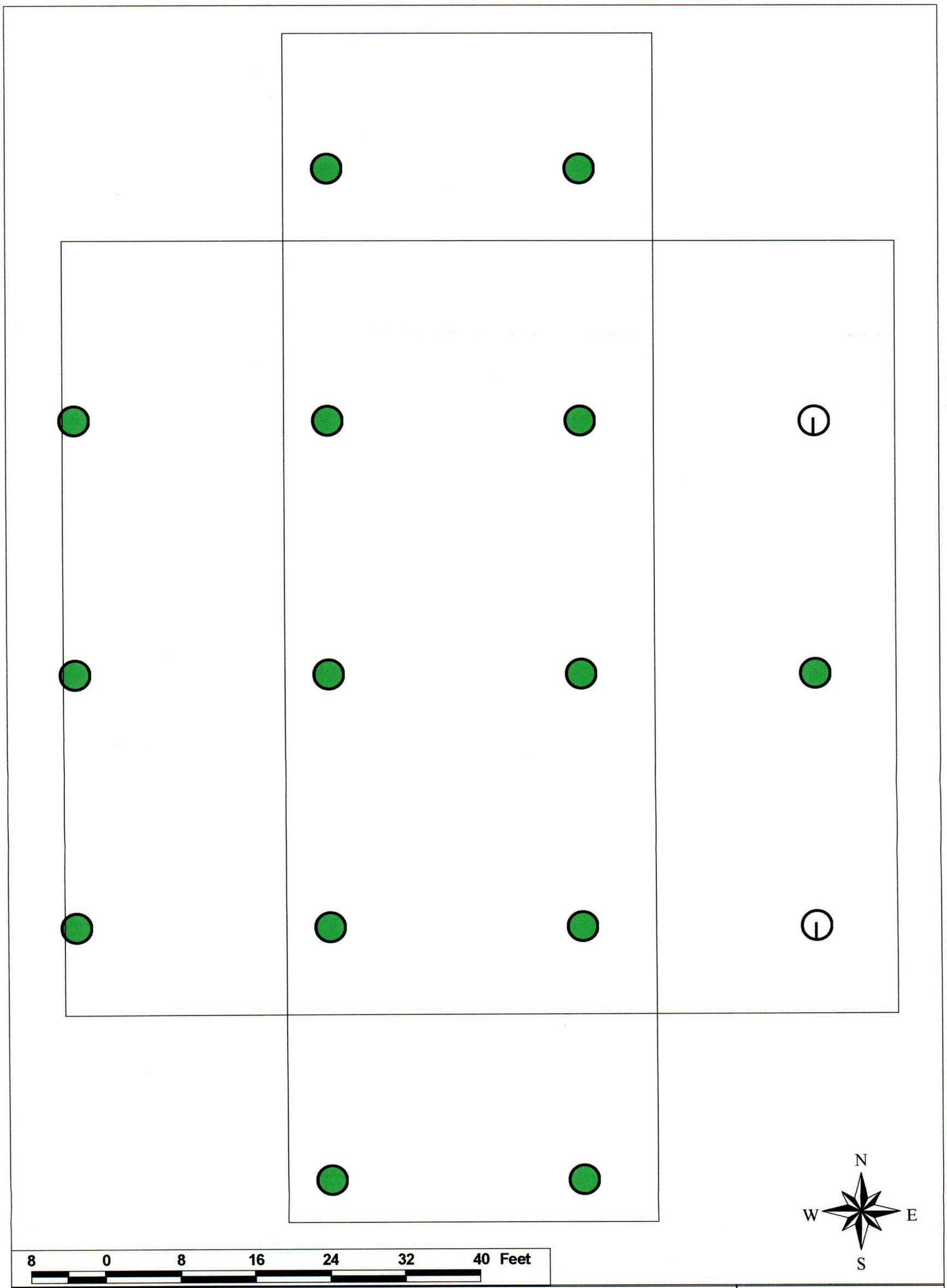


Figure3.1
Coordinate System


N
W
E
S
9 0 9 18 27 36 45 Feet
MALLINCKRODT
NEXTEP ENVIRONMENTAL
Legend
Direct Beta Measurements (dpm p/100 cm2)
Inaccessible
Vault
Under 2000
2000 - 2600
2600 or More
Mallinckrodt C-T Project
Final Status Survey Report
Figure 4.1
Building 235, Room 101
Direct Beta Measurements
Drawn by: DCW
Date: 10/20/2003
Building: 235
Revision: 0

C01


8 0 8 16 24 32 40 Feet
N
W
E
S
MALLINCKRODT
NEXTEP
ENVIRONMENTAL
Legend
Direct Beta Measurements (dpm p/100 cm2)
Inaccessible
Under 2000
2000 - 2600
2600 or More
Mallinckrodt C-T Project
Final Status Survey Report
Figure 4.2
Building 235, Room 102
Direct Beta Measurements
Drawn by: DCW
Date: 10/20/2003
Building: 235
Revision: 0

C02

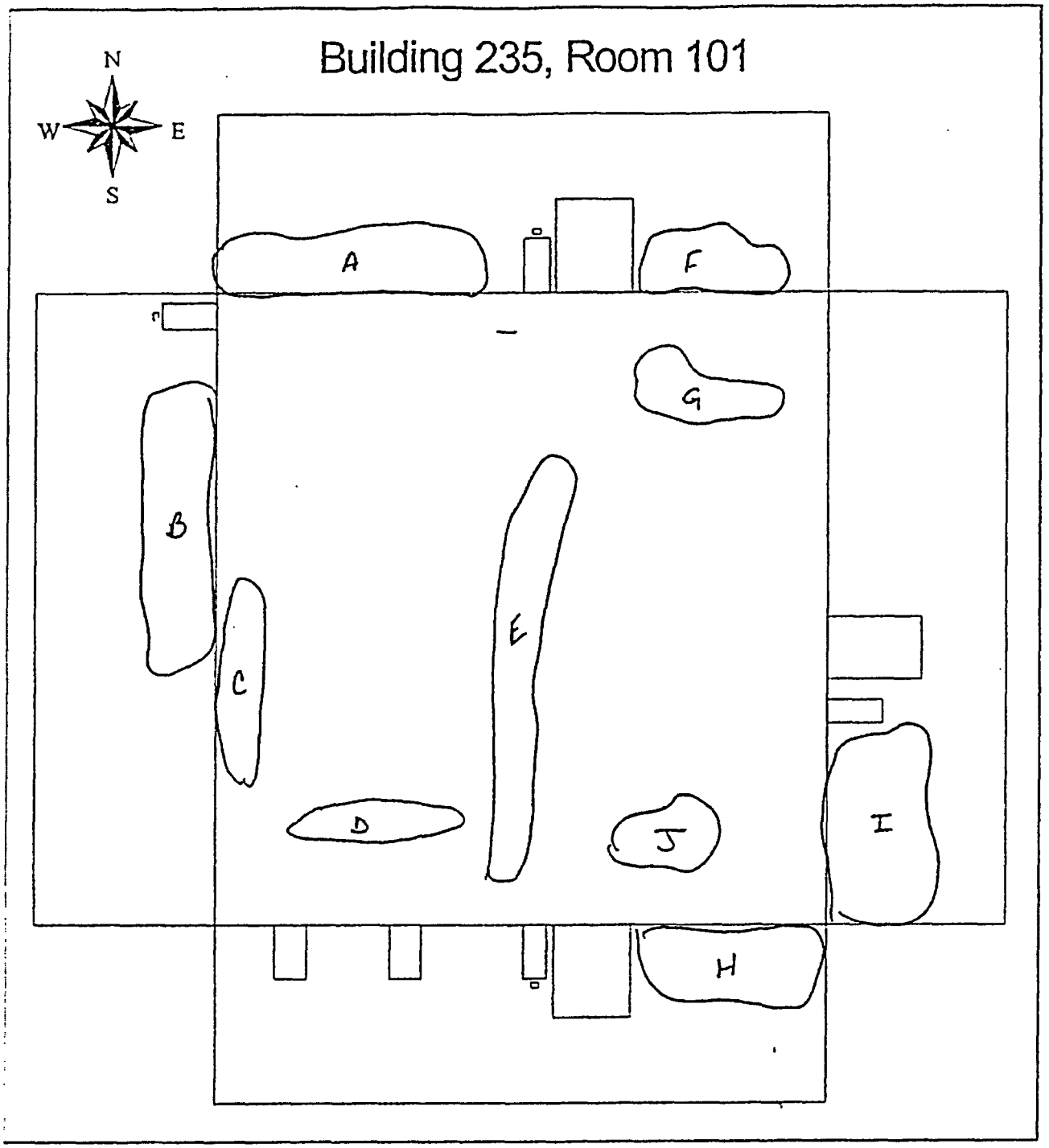


Figure 4.3
Building 235, Room 101 Scans

Building 235, Room 102

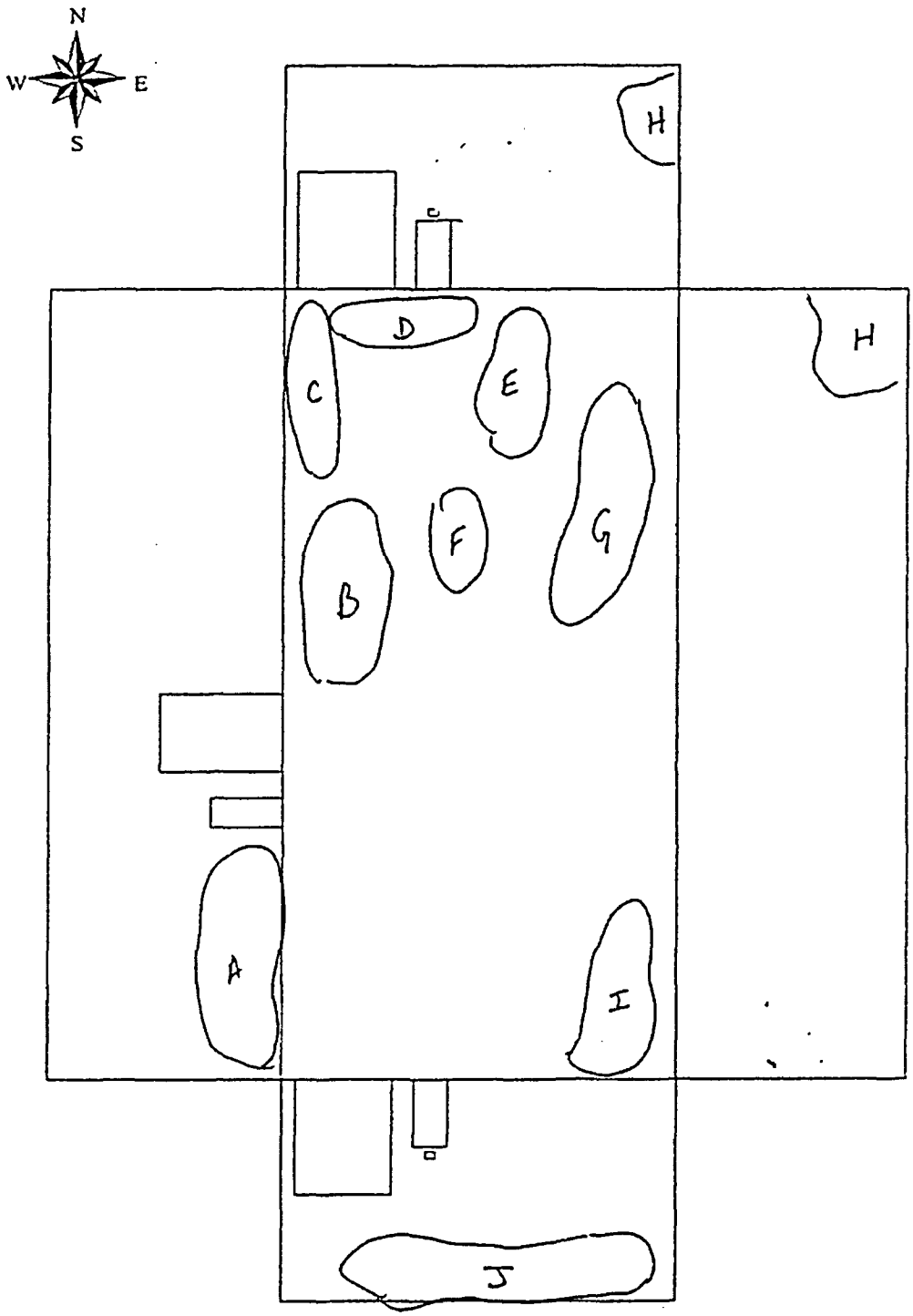


Figure 4.4
Building 235, Room 102 Scans

Burns & McDonnell SINCE 1898

011200 Form GCO-29

Client _____ Page _____ of _____

Project _____ Date _____ Made By _____

Bldg 235, W. Bay Checked By _____

Survey Unit: 23501 Preliminary _____ Final _____

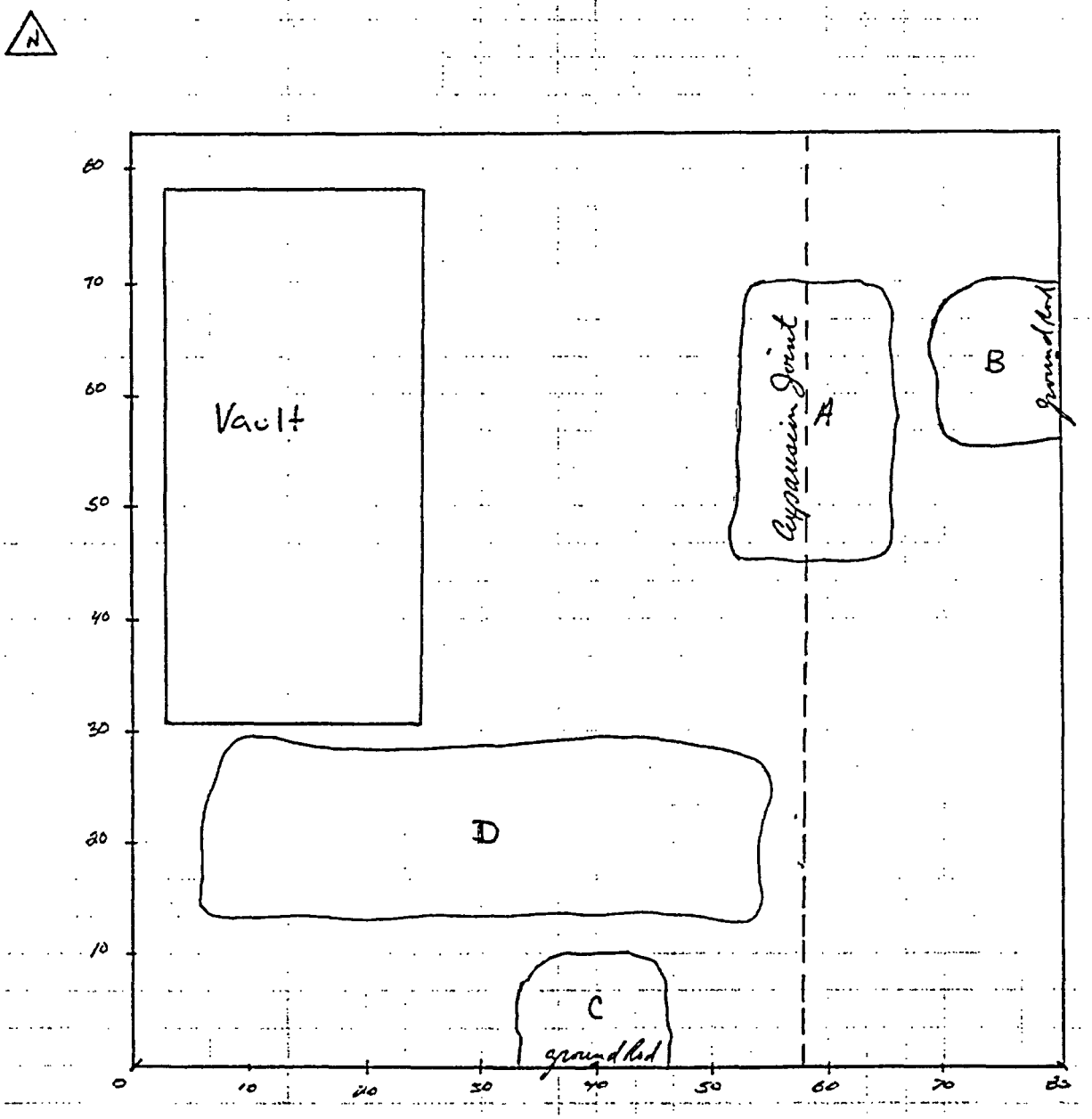


Figure 4.5
Building 235, Room 101
Expansion Joint Scans

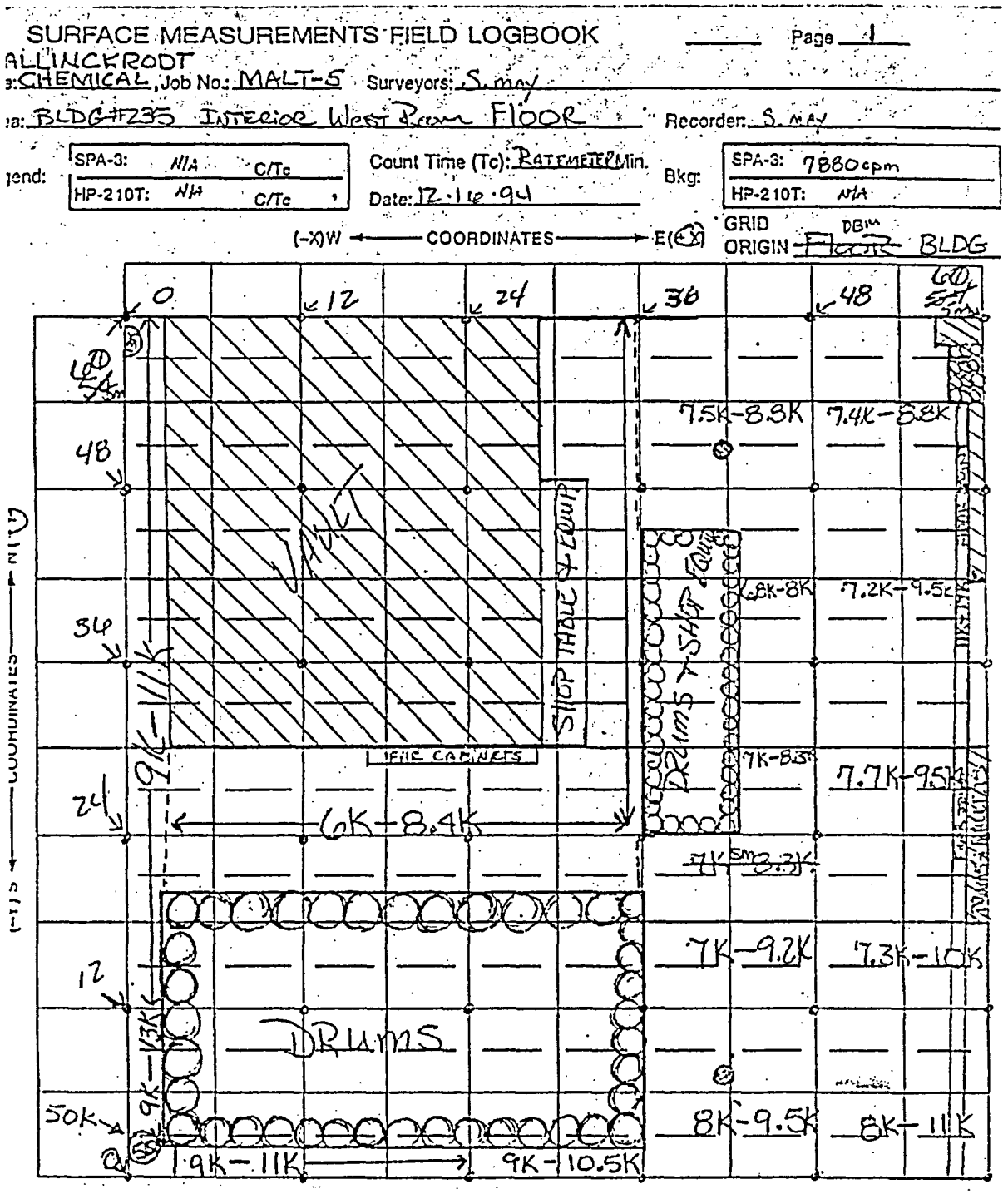


Figure 4.6
Building 235, Room 101
CH Scan Maps

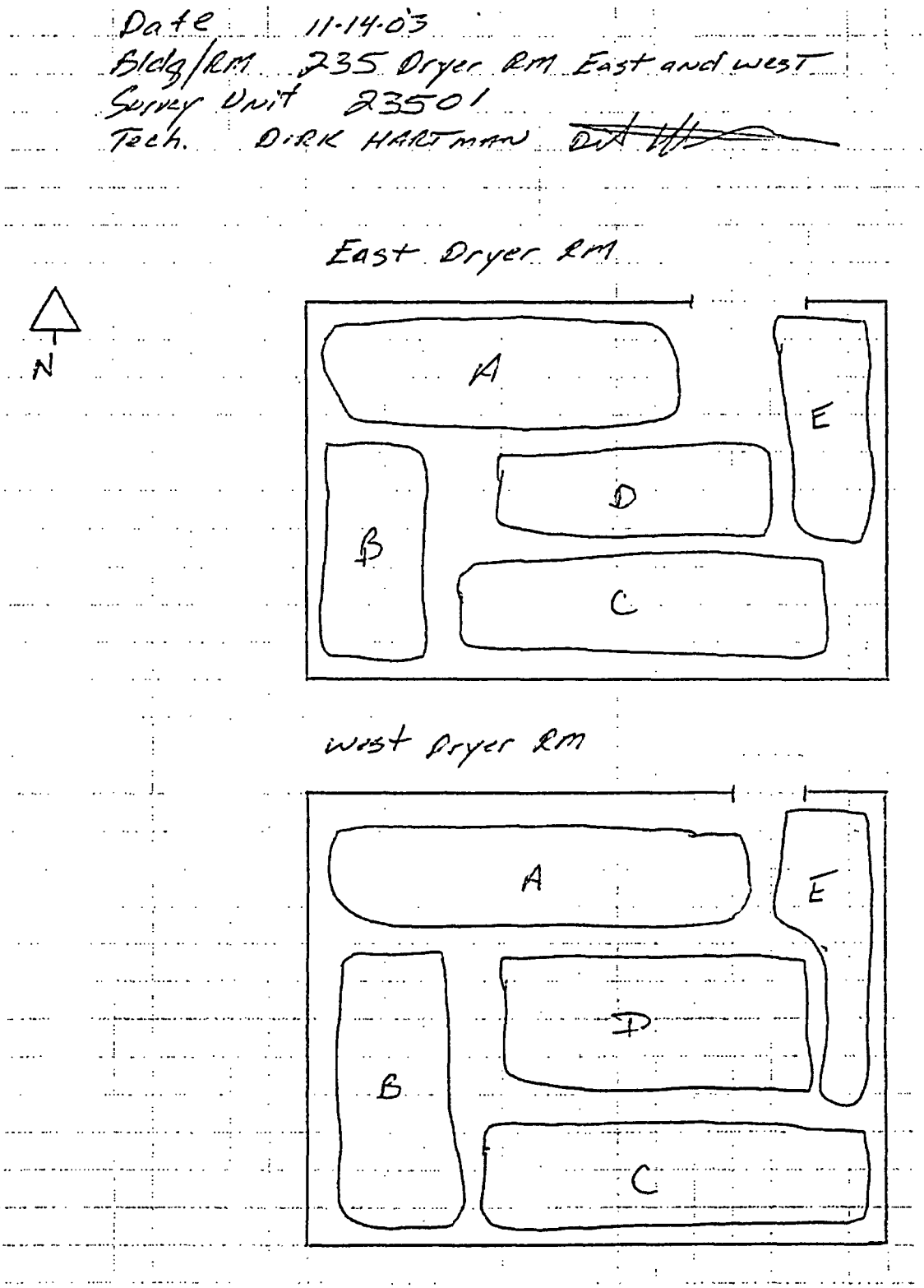
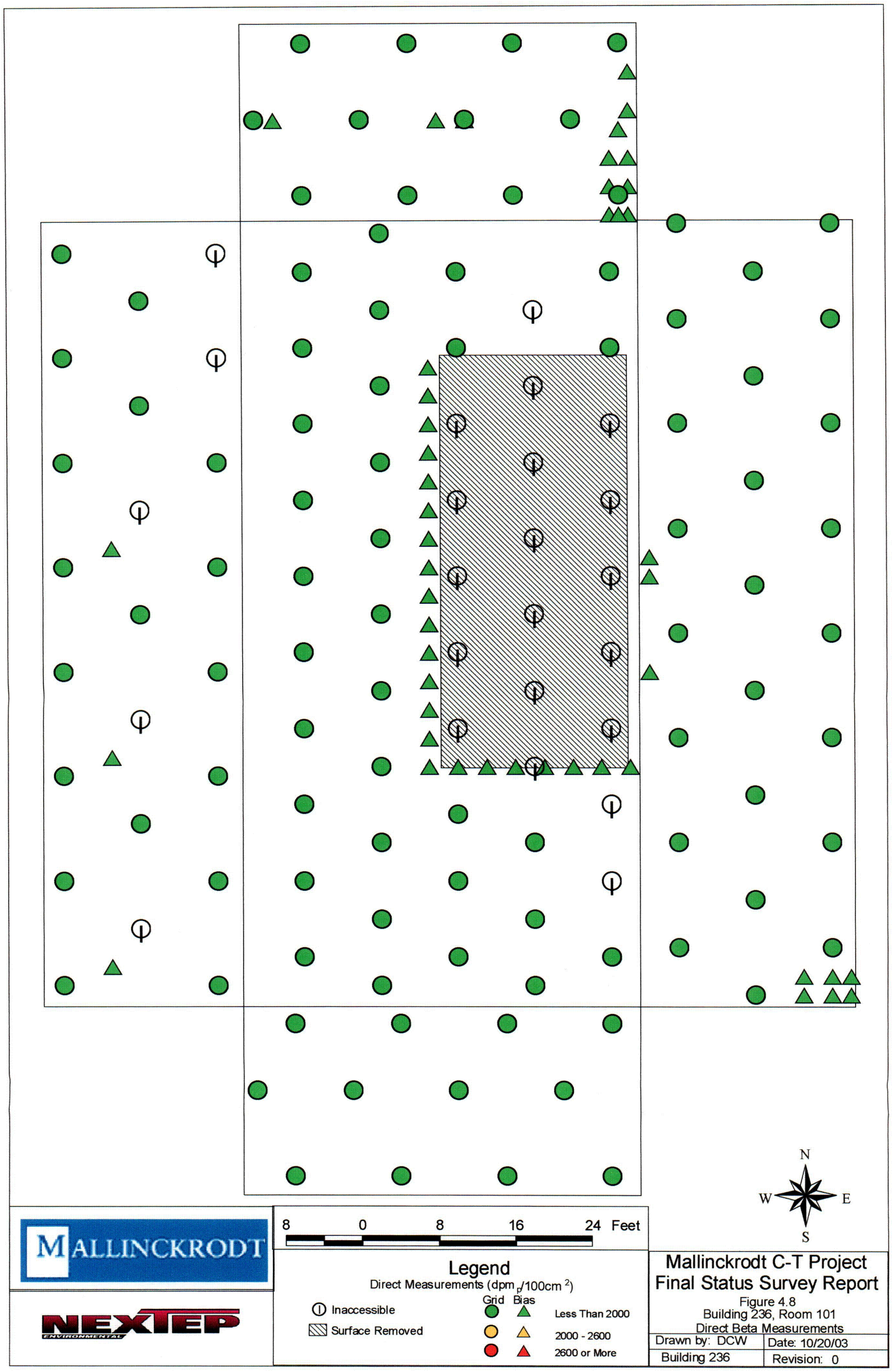


Figure 4.7
Building 235, Room 101
Dryer Room Scans


8 0 8 16 24 Feet
Legend
Direct Measurements (dpm p/100cm 2)
Grid Bias
Inaccessible
Surface Removed
Less Than 2000
2000 - 2600
2600 or More
N
W
E
S
MALLINCKRODT
NEXTEP
ENVIRONMENTAL
Mallinckrodt C-T Project
Final Status Survey Report
Figure 4.8
Building 236, Room 101
Direct Beta Measurements
Drawn by: DCW
Date: 10/20/03
Building 236
Revision: 0

C03

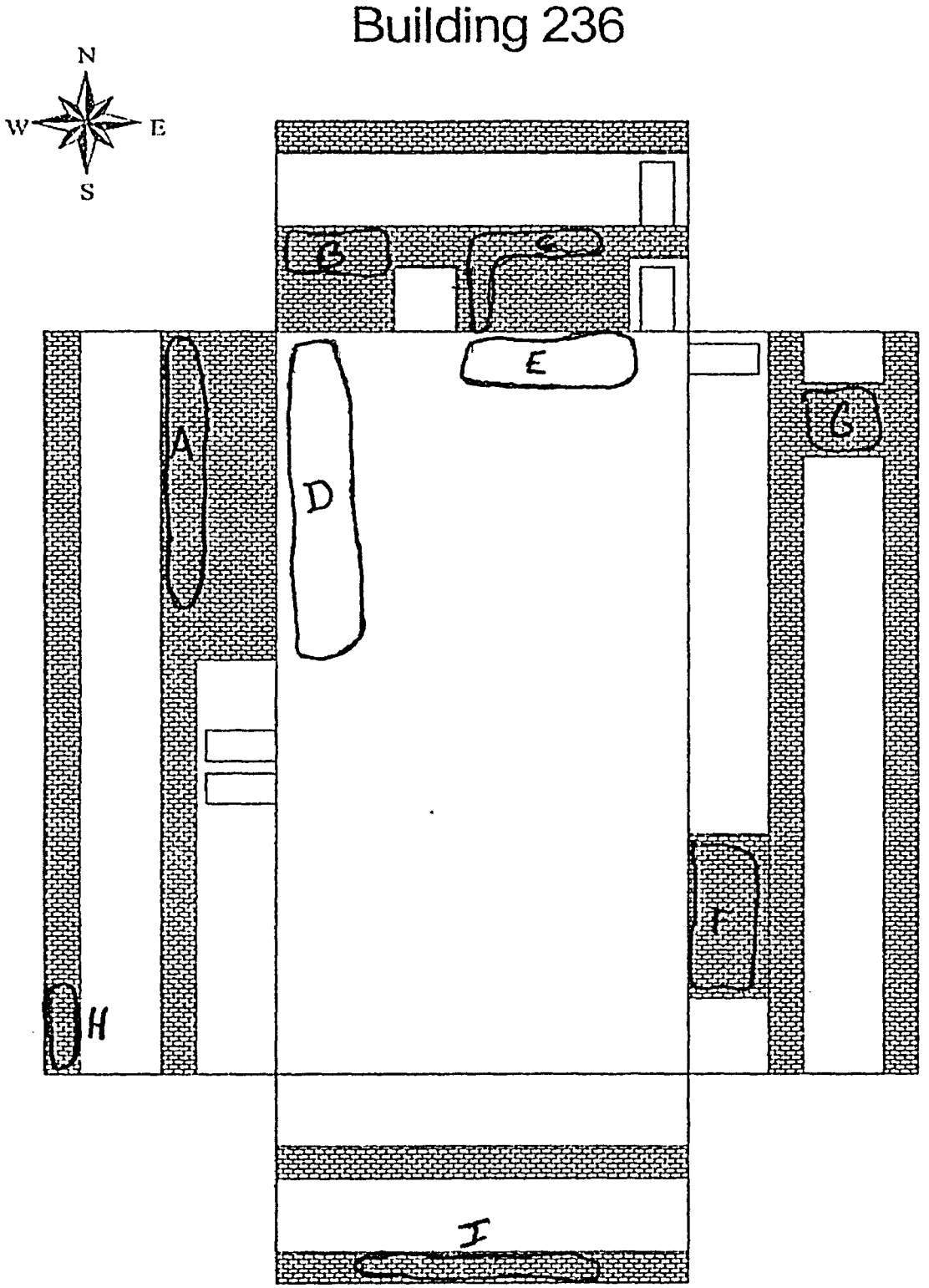


Figure 4.9
Building 235 Scans

APPENDIX 3

Instrument Calibration Sheets for SU-23501, 23502, and 23601

Type	S/N	Cal Date
Beta	131415/188704	6/17/03
	163666/B426W	1/16/03
	131410/188707	4/16/03
	117362/B860N	1/18/96 3/5/96 10/20/99
	126509/B861N	9/18/00
	127220/B426W	10/6/99
Swipe	179577	2/26/03

Ludlum
43-89
~~AG-3-T~~

CALIBRATION DATA SHEET

43-89
~~AG-3-T~~ SN: 188704 Property of: MALT

Readout Inst.: 2241-2 SN: 131415 Cal.Exp.Date: 6-12-04

~~Alpha~~ Beta Source: ~~TA~~ RHS Sr-90 SN: 2158/96 Activity: 16700 DPM

Date of Cal.: 10-24-00

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	N/A	~~1050~~ 850	1598
650		~~1100~~ 875	2165
700		~~1150~~ 900	2631
750		~~1200~~ 925	3251
800	1552	~~1250~~ 950	3698
850	2771	~~1300~~ 975	4235
900	3737	1350	—
950	4542	1400	—
1000	5755		

High Voltage set at: ~~900~~ RHS 925 volts

Background Check

High Voltage	CPM
Op. Voltage ~~-50~~ -25	131
Op. Voltage	169
Op. Voltage ~~+50~~ +25	239

Efficiency:
5 Minute Gross Counts:

Pos "A": Pos "B":
Average (A + B)/2: Gross CPM:
Background: CPM: Net CPM:

1 min Ct. 3213
1 min Bkg 183
3030 / 16700 cpm

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 18.1\ \%$$

18.1 %

Date of Calibration: 6-17-03 Expiration Date: 12-17-03

Calibrated by: Randall N. Sells (Print Name) Randall N. Sells (Signature)

Reviewed by: Dan Quigley Date: 6/18/03

EA4.10
Rev: 2
Date: 25 Feb 99

Page 4 of 4

L2241-2/L43-89
S/N: 131415/188704
6/17/03

CALN100A

Thermo NUtech

For Mallinckrodt Chemical, Inc

NATIONAL NUCLEAR ABP-100
MATERIAL SPECIFIC CALIBRATION DATA SHEET

43-89

~~ABP-100~~ SN: 188704 HIGH VOLTAGE: 925 V PROPERTY OF: MALT

READOUT INST: 2241-2 SN: 131415 CAL EXPIRE DATE: 12-12-03

ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 18.1 % CAL DATE: 6-17-03

	BACKGROUND		BR	SOURCE		SR		SA	Efficiency
SURFACE MATERIAL	OPEN Cts/2 min	SHIELD Cts/2 min	NET CPM	OPEN Cts/1 min	SHIELD Cts/1 min	NET CPM	Source #	Source Activity	SA/Eff
Concrete	396	308	88	5005	181	4824	6-A	259cc	18.6
↓	↓	↓	↓	4945	179	4766	↓	↓	18.1
				4951	210	4741			18.0
				5113	184	4929			18.7
259 x 100 = 25900								Average =	18.4
								Std Dev =	0.4
Wood	0	0	0	4007	226	3781	M-2	174cc	[illegible]
↓	0	0	0	3876	216	3660	↓	↓	[illegible]
	0	0	0	3971	211	3760			[illegible]
	0	0	0	3887	240	3647			21.0
174 x 100 = 17400								Average =	21.3
								Std Dev =	0.4
Masonite	0	0	0	3964	249	3715	M-2	174cc	21.4
↓	0	0	0	3809	191	3698	↓	↓	21.3
	0	0	0	3853	234	3619			20.8
	0	0	0	3946	198	3748			21.5
								Average =	[illegible]
								Std Dev =	[illegible]
Aluminum	0	0	0	4362	224	4138	M-2	174cc	23.8
↓	0	0	0	4397	211	4186	↓	↓	24.1
	0	0	0	4358	257	4101			23.6
	0	0	0	4390	230	4160			23.9
								Average =	23.9
								Std Dev =	[illegible]

DATE OF CALIBRATION: 6-17-03 EXPIRATION DATE: 12-17-03

CALIBRATED BY: Randall H. Sells (Print Name) Randall H. Sells (Signature)

REVIEWED BY: Alan Ziegler DATE: 6/18/03

@ Contact Geometry

L2241-2/L43-89
S/N: 131415/188704
6/17/03

CT-RP-66
Chi Squared Test

Instrument Model #	2241	Date:	06/24/2003
Instrument Serial#	131415	Source Nuclide:	SrY90
Probe Model #	43-89	Source Serial #	2178-96
Probe Serial #	188704	Source dpm (4π):	56039
Window Setting:		Efficiency (cpm/dpm):	0.19
Threshold Setting:		Background cpm:	135.2
High Voltage:	925	BKGD N-1	4
		BKGD Count Time (min):	1

Count # (n)	Gross Counts Observed	Expected	Background Counts
1	10358	10449	121
2	10405	10449	130
3	10502	10449	122
4	10336	10449	148
5	10281	10449	155
6	10196	10449	
7	10620	10449	
8	10466	10449	
9	10454	10449	
10	10328	10449	
11	10525	10449	
12	10403	10449	
13	10382	10449	
14	10418	10449	
15	10471	10449	
16	10669	10449	
17	10552	10449	
18	10690	10449	
19	10392	10449	
20	10525	10449	

sample mean (xbar) =	10449	Multiplier to convert	
sample variance (s^2) =	15903	to dpm:	5.4
background variance (b^2) =	239.7		
sample sigma (s) =	127		
(95% Confidence) 2.752 s =	350		
(99% Confidence) 3.615 s =	459		
		MDA(cpm) =	57
df = n-1 =	19	MDA(dpm) =	306
chitest = p(x<χ^2) =	6.727E-02		
chisquare (χ^2) =	28.919		
Acceptable χ^2 min =	8.907		
Acceptable χ^2 max =	32.852		
χ^2 test passes (yes/no)?	YES		
99% Conf. Interval Test min =	9854		
95% Conf. Interval Test min =	9984		
Daily Source Check Mean Net Counts	10313		
95% Conf. Interval Test max =	10663		
99% Conf. Interval Test max =	10773		

Test performed by: Steve Struck

Checked by: Date:

L2241-2/L43-89
S/N: 131415/188704
6/17/03

Thermo NUtech
A ThermoRetec Company
601 Scarboro Road
Oak Ridge, TN 37830

LUDLUM 2221
CALIBRATION DATA SHEET

ThermoRetec
Smart Solutions. Positive Outcomes.

(423) 481-0683 Phone
(423) 481-0121 Fax
www.thermpretec.com

Ludlum2221S/N: 163666 Property Of:

Battery Check OK @ 5.6 Pts
Replace @ 6.4

High Voltage Check

HV Meter: Fluke 29 S/N: 65410232 Cal Exp. Date 1-30-03

Meter Reading	Pre Cal	Post Cal	Tolerance
600 Volts	660	605	10 %
1000 Volts	1100	1005	10 %
1400 Volts	1540	1410	10 %

Input Sensitivity:

(Threshold @ 10 mv) Pre Cal: 35 mV , Post Cal: 35 mV
MP-2 S/N: 684 Calibration Exp. Date: 1-29-03

Rate/ Meter	MP-2	2221	Display Digital	Display Analog	Tol
400 CPM	x1		400	400	10%
4K CPM	x10		3998	4000	10%
40K CPM	x100		39999	40000	10%
400K CPM	x1000		400080	400000	10%
Scaler: 100K CPM	0.5 sec		50010	100000	10%
100K CPM	1.0 min		100020		10%
100K CPM	2.0 min		200039		10%
100K CPM	5.0 min		500097		10%

Log 400 400 4K 4K 40K 40K 400k 400k

Functional Check:

Ext Count ✓ Reset ✓ Speaker ✓ Headphones ✓ Light ✓

Date Of Calibration: 1-16-03 Expiration Date: 1-16-03

Calibrated By: Randall H. Sells (Print) (Signature)

Reviewed By: [signature] Date: 1/30/03

L2221/AB-100
S/N: 163666/B426W
1/16/03

CALN100A

Thermo NUtech

For Mallinckrodt Chemical, Inc

NATIONAL NUCLEAR ABP-100
MATERIAL SPECIFIC CALIBRATION DATA SHEET

RHS

ABP-100 SN: B426W HIGH VOLTAGE: 875 V PROPERTY OF: TYCO E.S.

READOUT INST: Lud 2221 SN: 163666a CAL EXPIRE DATE: 7-16-03

ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 42.0 % CAL DATE: 1-22-03

	BACKGROUND		BR	SOURCE		SR		SA	Efficiency
SURFACE MATERIAL	OPEN Cts/2 min	SHIELD Cts/2 min	NET CPM	OPEN Cts/1 min	SHIELD Cts/1 min	NET CPM	Source #	Source Activity	SR-89 Sr
Concrete	561	416	73	6857	292	6625	6-A	33250	19.9
				6853	246	6607			19.9
				6846	242	6604			19.9
				6784	236	6548			19.7
								Average =	19.9
								Std Dev =	0.1
Wood	0	0	0	5222	238	4984	M-2	22250	22.4
	0	0	0	5281	240	5041			22.7
	0	0	0	5181	224	4957			22.3
	0	0	0	5296	252	5064			22.8
								Average =	22.5
								Std Dev =	0.2
Masonite	0	0	0	5296	232	5064	M-2	22250	22.8
	0	0	0	5302	234	5068			22.9
	0	0	0	5311	248	5063			22.8
	0	0	0	5366	236	5130			23.1
								Average =	22.9
								Std Dev =	0.1
Aluminum	0	0	0	6037	223	5814	M-2	22250	26.1
	0	0	0	5706	256	5470			24.6
	0	0	0	6013	248	5765			25.9
	0	0	0	5892	227	5665			25.5
								Average =	25.5
								Std Dev =	0.7

178 dpm X 125 = 22250

DATE OF CALIBRATION: 1-24-03 EXPIRATION DATE: 7-24-03

CALIBRATED BY: Randall H. Sells (Print Name) (Signature)

REVIEWED BY: DATE: 1/30/03

L2221/AB-100
S/N: 163666/B426W
1/16/03

CT-RP-66
Chi Squared Test

Instrument Model #	2221	Date:	02/04/2003
Instrument Serial#	163666	Source Nuclide:	SrY90
Probe Model #	AB 100	Source Serial #	2178-96
Probe Serial #	B426W	Source dpm (4π):	56489
Window Setting:	3720	Efficiency (cpm/dpm):	0.28
Threshold Setting:	352	Background cpm:	183.4
High Voltage:	875	BKGD N-1	4
		BKGD Count Time (min):	1

Count # (n)	Gross Counts Observed	Expected	Background Counts
1	15360	15546	185
2	15361	15546	193
3	15477	15546	179
4	15562	15546	179
5	15520	15546	181
6	15587	15546	
7	15478	15546	
8	15392	15546	
9	15639	15546	
10	15609	15546	
11	15401	15546	
12	15433	15546	
13	15601	15546	
14	15743	15546	
15	15608	15546	
16	15828	15546	
17	15577	15546	
18	15518	15546	
19	15510	15546	
20	15599	15546	

sample mean (xbar) =	15546	Multiplier to convert to dpm:	3.6
sample variance (s^2) =	15181		
background variance (b^2) =	34.8		
sample sigma (s) =	123		
(95% Confidence) 2.752 s =	339		
(99% Confidence) 3.615 s =	446		
		MDA (cpm) =	66
df = n-1 =	19	MDA (dpm) =	240
chitest = p(x<χ^2) =	4.858E-01		
ch'square (χ^2) =	18.654		
Acceptable χ^2 min =	8.907		
Acceptable χ^2 max =	32.852		
χ^2 test passes (yes/no)?	YES		
99% Conf. Interval Test min =	14917		
95% Conf. Interval Test min =	15023		
Daily Source Check Mean Net Counts	15363		
95% Conf. Interval Test max =	15702		
99% Conf. Interval Test max =	15809		

Test performed by: Steve Struck 2/4/03

Checked by: Date: 2-4-03

L2221/AB-100
S/N: 163666/B426W
1/16/03

Lud
43-89
~~AO-3-7~~
CALIBRATION DATA SHEET

4389 ~~AO-3-7~~ SN: 188707 Property of: MALT

Readout Inst.: Lud 2241-2 SN: 131410 Cal.Exp.Date: 10-16-03

Beta ~~Alpha~~ Source: Sr-Y-90 SN: 2158/96 Activity: 17100 DPM

Date of Cal.: 10-24-00

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	—	~~1050~~ 750	2657
650	—	~~1100~~ 760	2899
700	1320	~~1150~~ 770	3161
750	2640	~~1200~~ 780	3519
800	4040	1250	N/A
850	N/A	1300	
900		1350	
950		1400	
1000			

High Voltage set at: 770 volts

Background Check

High Voltage	CPM
Op. Voltage ~~-50~~ -10	107
Op. Voltage	111
Op. Voltage ~~+50~~ +10	134

*47mm Source @ Contact Geometry Center of Probe

Efficiency:
5 Minute Gross Counts:

Pos "A": ——— Pos "B": ———
Average (A + B)/2: ——— Gross CPM: ———
Background: CPM: ——— Net CPM: ———

1min Ct 3146
1min BKG 127
3019 / 17100 dpm
17.7%

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = \text{—— } \%$$

Date of Calibration: 4-16-03 Expiration Date: 10-16-03

Calibrated by: Randall H. Sells (Print Name) [signature] (Signature)

Reviewed by: [signature] Date: 4/22/03

CA4.10
Rev: 2
Date: 25 Feb 99

L2241-2/L43-89
S/N: 131410/188707
4/16/03

CALN100A

Thermo NUtech

For Mallinckrodt Chemical, Inc

NATIONAL NUCLEAR ABP-100
MATERIAL SPECIFIC CALIBRATION DATA SHEET

Lud 43-89

~~ABP-100~~ SN: 180707 HIGH VOLTAGE: 770 V PROPERTY OF: MALT

READOUT INST: Lud 2241-2 SN: 131410 CAL EXPIRE DATE: 10-16-03

ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 17.7 % CAL DATE: 4-16-03

	BACKGROUND		BR	SOURCE		SR		SA	Efficiency
SURFACE MATERIAL	OPEN Cts/2 min	SHIELD Cts/2 min	NET CPM	OPEN Cts/1 min	SHIELD Cts/1 min	NET CPM	Source #	Source Activity	SR-SA/ SA
Concrete	264	230	17	4753	277	4476	6-A	25900	
				4877	301	4576			17.7
				4811	297	4514			17.4
				4705	315	4390			16.9
259 x 100 = 25900								Average =	17.3
								Std Dev =	0.3
Wood	0	0	0	3725	256	3469	M-2	17400	19.9
	0	0	0	3606	243	3363			19.3
	0	0	0	3581	223	3358			19.3
	0	0	0	3544	245	3309			19.0
174 x 100 = 17400						3299		Average =	19.4
								Std Dev =	0.4
Masonite	0	0	0	3646	318	3328	M-2	17400	19.1
	0	0	0	3713	324	3389			19.5
	0	0	0	3735	319	3416			19.6
	0	0	0	3600	327	3273			18.8
								Average =	19.3
								Std Dev =	0.4
Aluminum	0	0	0	4203	193	4010	M-2	17400	23.0
	0	0	0	4185	207	3978			22.9
	0	0	0	4119	183	3936			22.6
	0	0	0	4023	195	3828			22.0
								Average =	22.7
								Std Dev =	0.5

DATE OF CALIBRATION: 4-17-03 EXPIRATION DATE: 10-17-03

CALIBRATED BY: Randall H. Sells (Print Name) Randall H. Sells (Signature)

REVIEWED BY: Ken Fraley DATE: 4/22/03

L2241-2/L43-89
S/N: 131410/188707
4/16/03

CT-RP-66
Chi Squared Test

Instrument Model #	2241	Date:	04/28/2003
Instrument Serial#	131410	Source Nuclide:	SrY90
Probe Model #	43-89	Source Serial #	2178-98
Probe Serial #	188707	Source dpm (4π):	56268
Window Setting:		Efficiency (cpm/dpm):	0.14
Threshold Setting:	35 mV	Background cpm:	79.8
High Voltage:	770	BKGD N-1	4
		BKGD Count Time (min):	1

Count # (n)	Gross Counts Observed	Expected	Background Counts
1	7885	7848	82
2	7914	7848	80
3	7726	7848	80
4	8036	7848	82
5	7901	7848	75
6	7851	7848	
7	7923	7848	
8	7889	7848	
9	7693	7848	
10	7890	7848	
11	7874	7848	
12	7831	7848	
13	7929	7848	
14	7861	7848	
15	7700	7848	
16	7852	7848	
17	7828	7848	
18	7881	7848	
19	7724	7848	
20	7805	7848	

sample mean (xbar) =	7848	Multiplier to convert to dpm:	7.2
sample variance (s^2) =	7273		
background variance (b^2) =	8.2		
sample sigma (s) =	85	FSS Normalization	
(95% Confidence) 2.752 s =	235	S_i =	0.287
(99% Confidence) 3.615 s =	308		
		MDA(cpm) =	45
df = n-1 =	19	MDA(dpm) =	320
chitest = p(x<χ^2) =	5.487E-01		
chisquare (χ^2) =	17.609		
Acceptable χ^2 min =	8.907		
Acceptable χ^2 max =	32.852		
χ^2 test passes (yes/no)?	YES		
99% Conf. Interval Test min =	7459		
95% Conf. Interval Test min =	7533		
Daily Source Check Mean Net Counts	7768		
95% Conf. Interval Test max =	8003		
99% Conf. Interval Test max =	8076		

Test performed by: Steve Struck 4-28-03

Checked by: Jim C. Woolford Date: 4-28-03

L2241-2/L43-89
S/N: 131410/188707
4/16/03

Site: _____
Job #: _____

AB-100
~~AC-3-7~~
CALIBRATION DATA SHEET

AB-100
~~AC-3-7~~ SN: B860N Property of: ENC

Readout Inst.: Ludlum 2221 SN: 117362 Cal. Exp. Date: 7-8-96

SrY-90
~~Alpha~~ Source: 1239/92 SN: 1239/92 Activity: 20300 DPM

Date of Cal.: 10-1-95

PLATEAU: * CALIB @ 35 mv

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	_____	1050	_____
650	_____	1100	_____
700	_____	1150	_____
750	_____	1200	_____
800	4460	1250	_____
850	6636	1300	_____
875	7338		
900	7759	1350	_____
925	8008		
950	8115	1400	_____
975	8286		
1000	8656		

Background Check:

High Voltage	CPM
Op. Voltage -50	284
Op. Voltage	440
Op. Voltage +50	574

High Voltage set at: 950 volts

Efficiency:

A: Front Cntr Pos.
B: Rear Cntr Pos.
Cntr "C"

5 Minute Gross Counts:

Pos "A": 38683 40964 Pos "B": 40956

(A+B+C)/3 Average ~~(A + B)/2~~: 40181 Gross CPM: 8036.2

Background: 1982 CPM: 396.4 Net CPM: 7639.8

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 37.6\ \%$$

Date of Calibration: 1-18-96 Expiration Date: 7-18-96

Calibrated by: SARA SMITH (Print Name) Sara Smith (Signature)

Reviewed by: Randall A. Dudek Date: 1-23-96

EA4.10
Rev: 1
Date: 25 Jan 88

EA4.10-66

L2221/AB-100
S/N: 117362/B860N
1/18/96

Site: _____
Job #: _____

AB-100

~~AC-7-7~~
CALIBRATION DATA SHEET

AB-100
~~AC-7-7~~ SN: B860N Property of: EAC

Readout Inst.: 2221 SN: 117362 Cal. Exp. Date: 7-8-96

~~Alpha~~ Beta Source: Sr-90 SN: 1239/92 Activity: 20300 DPM

Date of Cal.: 10-25-95

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	0	1050	8796
650	2	1100	15162
700	106	1150	N/A
750	699	1200	
800	2042	1250	
850	4403	1300	
900	6287	1350	
950	7569	1400	
1000	7950		

Background Check

High Voltage	CPM
Op. Voltage -50	
Op. Voltage	
Op. Voltage +50	

High Voltage set at: 950 volts

Efficiency:

5 Minute Gross Counts:

Pos "A": 3717 Pos "B": N/A
Average (A + B)/2: N/A Gross CPM: 7434.2
Background: CPM: 247.8 (1239) Net CPM: 7186.4

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 35.4\ \%$$

Date of Calibration: 3-5-96 Expiration Date: 9-5-96

Calibrated by: Randall H. Sells (Print Name) Randall H. Sells (Signature)

Reviewed by: _____ Date: _____

EA4.10
Rev: 1
Date: 25 Jan 88

EA4.10-65

L2221/AB-100
S/N: 117362/B860N
3/5/96

Thermo NUtech
A ThermoRetec Company
601 Scarboro Road
Oak Ridge, TN 37830

ThermoRetec
Smart Solutions. Positive Outcomes.

(423) 481-0683 Phone
(423) 481-0121 Fax
www.thermoretec.com

Bicron
AB-100
~~AG-37~~

CALIBRATION DATA SHEET

AB-100
~~AG-37~~ SN: B860N Property of: TR

Readout Inst.: 2221 SN: 117362 Cal.Exp.Date: 7/21/2000

Beta
~~Alpha~~ Source: Sr-90 SN: 123892 Activity: ~~15400~~ 15200 DPM 15200 dpm
RHS

Date of Cal.: 4/20/99

* @35mV
@Contact Geometry

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	—	1050	6942
650	—	1100	9136
700	—	1150	—
750	—	~~1200~~ 925	5077
800	1062	~~1250~~ 950	5652
850	2726	~~1300~~ 975	6046
900	4438	~~1350~~ 1000	6324
950	5594	~~1400~~ 1025	6493
1000	6470		

High Voltage set at: 1000 volts

Background Check	
High Voltage	CPM
Op. Voltage ~~-50~~ -35	245
Op. Voltage	261
Op. Voltage ~~+50~~ +25	261

1050 - 6913

Efficiency:
5 Minute Gross Counts:

Pos "A": 30485 Pos "B": 31943
Average (A + B)/2: 31214 Gross CPM: 6242.8
Background: CPM: 257.2 Net CPM: 5985.6
1286

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 39.4\ \%$$

Date of Calibration: 10/20/99 Expiration Date: 10/20/2000

Calibrated by: Randall H. Sells (Print Name) Randall H Sells (Signature)

Reviewed by: Allan Yeadon Date: 10/20/99

EA4.10
Rev: 2
Date: 25 Feb 99

L2221/AB-100
S/N: 117362/B860N
10/20/99

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Bicron
ABP-100
~~AC 3-7~~

CALIBRATION DATA SHEET

ABP-100
~~AC 3-7 SN:~~ B861N Property of: TN

Readout Inst.: 2221 SN: 126509 Cal.Exp.Date: 5/18/2000

Beta
~~Alpha~~ Source: Sr-Y-90 SN: 1238/92 Activity: 15400 DPM

Date of Cal.: 4/12/99 @ 35mV (350)

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	—	1050	10501
650	—	1100	—
700	397	~~1150~~ 900	6188
750	1495	~~1200~~ 925	6665
800	3255	~~1250~~ 950	6704
850	5045	~~1300~~ 975	7212
900	6218	~~1350~~ 1000	7739
950	6980	1400	—
1000	7758		

Background Check

High Voltage	CPM
Op. Voltage -50	301
Op. Voltage	397
Op. Voltage +50	463

High Voltage set at: 950 volts

Efficiency:
5 Minute Gross Counts:

Pos "A": 34052 Pos "B": 33102 RHS
Average (A + B)/2: 33577 Gross CPM: 6715.4 Net CPM 6319
Background: CPM: 1982 Net CPM: 396.4 -396.4 Bkg

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 41.0\ \%$$

Date of Calibration: 9/18/99 Expiration Date: 9/18/2000

Calibrated by: Randall H. Sells (Print Name) (Signature)

Reviewed by: Alan Quigley Date: 9/19/99

EA4.10
Rev: 2
Date: 25 Feb 99

L2221/ABP-100
S/N: 126509/B861N
9/18/99

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Oak Ridge, TN 37830

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Bicron
AB-100
~~AC 3-7~~

CALIBRATION DATA SHEET

AB-100
~~AC 3-7~~ SN: B426W Property of: TR

Readout Inst.: 2221 SN: 127220 Cal.Exp.Date: 5/18/2000

Beta
~~Alpha~~ Source: Sr-Y-90 SN: 1238/92 Activity: 15400 DPM

Date of Cal.: 4/12/99 * @ 35 mV @ Contact

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	3.	1050	9957
650	104	1100	
700	686	~~1150~~	
750	2236	~~1200~~ 875	6376
800	4290	~~1250~~ 900	6806
850	5996	~~1300~~ 925	6706
900	6665	~~1350~~ 950	7095
950	7058	~~1400~~ 975	7397
1000	7695		

High Voltage set at: 925 volts

Background Check

High Voltage	CPM
Op. Voltage -50	264.
Op. Voltage	253
Op. Voltage +50	296

Efficiency:
5 Minute Gross Counts:

Pos "A": 32914 Pos "B": 34104
Average (A + B)/2: 33509 Gross CPM: 6701.8
Background: CPM: 268.6 Net CPM: 6433.2
1343

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 41.8\ \%$$

Date of Calibration: 10/6/99 Expiration Date: 10/6/2000

Calibrated by: Randall H. Sells (Print Name) (Signature)

Reviewed by: [signature] Date: 10/8/99

EA4.10
Rev: 2
Date: 25 Feb 99

L2221/B426W
S/N: 127220/B426W
10/6/99

JUL-16-2003 16:52 314 654 1251 MALLINCKRODT #2114 P.006

Ludlum Measurements, Inc. — Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER TYCO / MALLINCKRODT ORDER NO. 292439 / 270031

Mfg. Ludlum Measurements, Inc. Model 3030 Serial No. 179577

Cal. Date 25-Feb-03 Cal Due Date 26-Aug-03 Cal. Interval 6 Months

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 20 % Alt 701.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Window Operation

☑ Audio ck.

Alpha Sensitivity 120 mV Beta Sensitivity 4 mV Beta Window 50 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

Instrument Volt Set 725 V High Voltage set with detector connected.

☑ HV Readout (2 points) Ref./Inst. 495 / 500 V Ref./Inst. 1480 / 1500 V

(EEPROM Settings)

(PC) Count Time: 1.0

QC mode turned OFF. Alpha Alarm: 999999 cpm

Firmware version: 39013N12 Beta Alarm: 999999 cpm

Overload set at 1/4 turn past OFF. Alpha/Beta Alarm: 999999 cpm

Battery voltage measured at 13.27 Vdc. Calibration Due Date: 08/26/2003

C14 Efficiency = 11 %(4 pi) Net LOC (Loss of Count) time = 30 minutes (default)

Alpha Channel Digital Readout

REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400K cpm	399414	399414
40K cpm	39944	39944
4K cpm	3995	3995
400 cpm	400	400
40 cpm	40	40

Beta/Gamma Channel Digital Readout

REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400K cpm	399439	399439
40K cpm	39945	39945
4K cpm	3995	3995
400 cpm	400	400
40 cpm	40	40

*Uncertainty within ± 10% C.F. within ± 20% (0) indicates 0.1 minute count

COMMENTS:
Eff. for S-Alpha Src Volt, 4450cpm, read 2878 in one minute = 64% 2π
Eff. for Tc-99 Src 2145-00, 3070 cpm, read 1444 in one minute = 50% 2π

Reference Instruments and/or Sources:

☑ Alpha S/N Pu-239 3744 ☑ Beta S/N Tc-99 Ni-FY ☐ Other

☑ m 500 S/N 134709 ☐ Oscilloscope S/N ☐ Multimeter S/N

Calibrated By: [signature] Date 26 Feb 03

Reviewed By: [signature] Date 4 Mar 03

AC Inst. Only ☑ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

L3030
S/N: 179577
2/26/03

Ludlum Measurements, Inc.

Model 3030 Plateau Data

2/25/03
1:38:50 PM

Header 1: John Q Public
Header 2: Serial#179577
Header 3: Site:Building 1
Header 4: Room 7 EastWall
Header 5: More Comments?
Header 6: More Comments?

Calibration Due Date: 2/26/04

Model 3030 Date: 2/26/03
Model 3030 Time: 11:42:00 AM

User PC Time: 1.0

Alpha Isotope: Pu-239
Alpha Source Size (dpm): 365000
Alpha Source Size (µCi): 0.164414414

Beta Isotope: Tc-99
Beta Source Size (dpm): 22600
Beta Source Size (µCi): 0.01018018

Starting High Voltage: 675
Starting High Voltage: 800
High Voltage Increment: 25

Plateau Count Mode: SCALER
Source Count Time (min): 0001.0
Background Count Time (min): 1.0

HV	ALPHA Source (Beta)	ALPHA Background	ALPHA Eff	ALPHA CrossTalk	BETA Source (Alpha)	BETA Background	BETA Eff	BETA Crosstalk
675	137685 (3889)	0	37.7%	2.8%	6010 (1)	36	26.4%	0.0%
700	137877 (3657)	0	37.8%	2.6%	6966 (1)	45	30.6%	0.0%
725	138583 (2500)	2	38.0%	1.8%	7969 (1)	49	35.0%	0.0%
750	137851 (1483)	0	37.8%	1.0%	8551 (3)	50	37.6%	0.0%
775	137047 (1071)	1	37.5%	0.7%	9470 (1)	70	41.6%	0.0%
8	137105 (783)	1	37.6%	0.4%	10082 (2)	203	43.7%	0.0%

L3030
S/N: 179577
2/26/03

Ludlum Measurements, Inc.

Model 3030 MDA Calculation Data

2/26/03
1:42:00 PM

Alpha Background(cpm): 2.0
Beta Background(cpm): 49.0

Alpha Efficiency %: 38.0
Beta Efficiency %: 35.0

Confidence Level: 95%

Count Time	Alpha MDA(dpm)	Beta MDA(dpm)
0.1	111.9	295.7
0.5	35.5	129.5
1.0	24.4	100.8
2.0	18.6	84.5
5.0	14.8	73.6
10.0	13.6	69.8
50.0	12.5	66.5
60 (1.0)	24.4	100.8

L3030
S/N: 179577
2/26/03

APPENDIX 4
Threshold Comparison Test Reports (TCTR)

MALLINCKRODT C-T
DECOMMISSIONING PROJECT
Threshold Comparison Test Report - Buildings

Run Date: Wednesday, December 10, 2003

Survey Unit Number: 23501 Class: 2 Data Points: Beta Grid Type: R Spacing: 27.9 ft.

SURVEY UNIT TABLE

Bldg	Rm	Surface	Fixed Equipment	Surface Area Included (sq. ft)	Remarks
B235	101	FNSEW	Q1Q3	13758	West room of building 235
B235	102	FNSEW	Q1	8780	East room of building 235
			Total Area	22538	

INITIALIZATION DATA

Measurement Types Selected: RG, BI, CH

Date Range: All

Thresholds:

EMC: 13,000 DCGLw: 2,600

SURVEY UNIT TEST STATUS

Test Performed	Status			$dpm_\beta/100\ cm^2$
Min/Max	Pass	Maximum Survey Value	B	582.0
Background	Fail	Minimum Background	M	1.0
DCGLw	Pass	Difference		581.0
DCGLavg	Pass	Average Activity	128.5	
EMC	Pass	Average Below DCGL	128.5	
Wilcoxon Rank Sum Test	N/A	Average Background	77.9	
Sign Test for Paired Data	Pass			

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

THE FOLLOWING DATA POINTS FAILED THE EMC TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE DCGLw TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE BACKGROUND TEST:

Survey Unit # 23501 Building: B235

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm²)	Remarks	Exc	Res.
101	E	18.0	16.7	CB	RG	1	6213	477.4		C	
101	E	72.0	16.7	CB	RG	1	6223	235.1		C	
101	E	45.0	16.7	CB	RG	1	6218	209.8		C	
101	F	68.3	63.3	C	RG	1	6212	322.1		C	
101	N	41.3	9.0	B	RG	1	6207	437.6		C	
101	N	14.3	9.0	B	RG	1	6206	368.9		C	
101	N	68.3	9.0	B	RG	1	6208	365.3		C	
101	Q3	3.0	0.0	C	BI	1	7731	468.9	Expansion Joint	C	
101	Q3	1.0	0.0	C	BI	1	7729	354.3	Expansion Joint	C	
101	Q3	4.0	0.0	C	BI	1	7732	325.7	Expansion Joint	C	
101	Q3	2.0	0.0	C	BI	1	7730	268.4	Expansion Joint	C	
101	W	63.3	12.7	B	RG	1	6209	582.2		C	
101	W	36.3	12.7	B	RG	1	6214	397.8		C	
102	F	5.4	36.0	C	RG	1	6234	308.0		C	
102	F	5.4	9.0	C	RG	1	6238	189.3		C	
102	F	32.4	63.0	C	RG	1	6231	178.0		C	
102	F	5.4	63.0	C	RG	1	6230	118.7		C	
102	F	32.4	9.0	C	RG	1	6239	93.2		C	
102	S	7.2	18.0	C	RG	1	6242	78.7		C	

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -Buildings

THE FOLLOWING DATA POINTS PASSED BACKGROUND, DCGLw, AND EMC SCREENING TESTS:

Survey Unit # 23501 Building: .B235

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm²)	Remarks	Exc	Res.
101	F	41.3	36.3	C	RG	1	6216	65.0			
101	F	41.3	63.3	C	RG	1	6211	19.8			
101	F	68.3	36.3	C	RG	1	6217	2.8			
101	F	14.3	9.3	C	RG	1	6220	-8.5			
101	F	41.3	9.3	C	RG	1	6221	-33.9			
101	F	68.3	9.3	C	RG	1	6222	-45.2			
101	Q1	3.0	0.0	M	BI	1	6245	14.7	Rm 101		
101	Q1	4.0	0.0	M	BI	1	6246	4.6	Rm 101		
101	Q1	1.0	0.0	M	BI	1	6243	3.9	Rm 101		
101	Q1	2.0	0.0	M	BI	1	6244	2.3	Rm 101		
101	Q3	4.0	0.0	C	BI	1	7351	50.1	Expan. Joint		
101	Q3	1.0	0.0	C	BI	1	7348	42.9	Expan. Joint		
101	Q3	2.0	0.0	C	BI	1	7349	3.6	Expan. Joint		
101	Q3	3.0	0.0	C	BI	1	7350	-21.5	Expan. Joint		
101	Q3	5.0	0.0	C	BI	1	7733	-125.3	Expansion Joint		
101	S	64.3	17.8	C	RG	1	6224	48.0			
101	S	10.3	17.8	C	RG	1	6226	33.9			
101	S	37.3	17.8	C	RG	1	6225	28.3			
101	W	9.3	12.7	B	RG	1	6219	65.1			
102	E	72.3	19.8	B	RG	1	6240	183.5			
102	F	32.4	36.0	C	RG	1	6235	11.3			
102	N	32.4	8.7	B	RG	1	6228	182.2			
102	N	5.4	8.7	M	RG	1	6227	13.2			
102	Q1	2.0	0.0	M	BI	1	6249	19.3	Rm 102		
102	Q1	5.0	0.0	M	BI	1	6252	3.9	Rm 102		
102	Q1	1.0	0.0	M	BI	1	6248	-2.3	Rm 102		
102	Q1	6.0	0.0	M	BI	1	6253	-3.1	Rm 102		
102	Q1	3.0	0.0	M	BI	1	6250	-7.7	Rm 102		
102	Q1	4.0	0.0	M	BI	1	6251	-9.3	Rm 102		
102	S	34.2	18.0	C	RG	1	6241	-3.0			
102	W	9.0	21.6	CB	RG	1	6237	129.2			
102	W	63.0	21.6	CB	RG	1	6229	122.7			
102	W	36.0	21.6	CB	RG	1	6233	113.7			

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -Buildings

Summary of Background Data and Thresholds Used in this Analysis

Measurement Type: BK ***DCGL:*** 2,600 ***EMC:*** 13,000

Matrix	*Number of Data Points*	*Average Background*	*Sigma*	*Background Threshold (Tbk)*	*DCGLw Threshold (Td)*	*EMC Threshold (Tc)*
	($dpm_\gamma/100cm^2$)	($dpm_\gamma/100cm^2$)	($dpm_\gamma/100cm^2$)	($dpm_\gamma/100cm^2$)	($dpm_\gamma/100cm^2$)	($dpm_\gamma/100cm^2$)
B	30	192.4	16.0	224.4	2,824	13,224
C	90	35.4	20.1	75.5	2,675	13,075
CB	51	96.1	21.7	139.4	2,739	13,139
M	10	24.0	15.7	55.3	2,655	13,055

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -Buildings

STATISTICAL TEST RESULTS

Run Date: 12/10/2003 4:14:57 PM

Survey Unit Number 23501 Class: 2

Selected Test: SIGN TEST FOR PAIRED DATA

Test Status Pass

Thresholds:

EMC 13,000 DCGL 2,600

DATA SUMMARY TABLE

33 Survey points processed and 4 matrices processed

S+ = 33 **Wc =** 21

******** The survey unit has passed the SIGN TEST FOR PAIRED DATA ********

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -Buildings

Run Date: Wednesday, December 10, 2003

Survey Unit Number: 23601 Class: 2 Data Points: Beta Grid Type: T Spacing: 17.6 ft.

SURVEY UNIT TABLE

Bldg	*Rm*	*Surface*	*Fixed Equipment*	*Surface Area Included (sq. ft)*	*Remarks*
B236	101	FNSEW		9025	verify wa
			Total Area	9025	

INITIALIZATION DATA

Measurement Types Selected: RG, BI, CH

Date Range: All

Thresholds:

EMC: 13,000 DCGLw: 2,600

SURVEY UNIT TEST STATUS

Test Performed	Status			$dpm_\beta/100\ cm^2$
Min/Max	Pass	Maximum Survey Value	B	1,874.0
Background	Fail	Minimum Background	M	1.0
DCGLw	Pass	Difference		1,873.0
DCGLavg	Pass	Average Activity	418.6	
EMC	Pass	Average Below DCGL	418.6	
Wilcoxon Rank Sum Test	N/A	Average Background	77.9	
Sign Test for Paired Data	Pass			

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -Buildings

THE FOLLOWING DATA POINTS FAILED THE EMC TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE DCGLw TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE BACKGROUND TEST:

Survey Unit # 23601 Building: B236

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_\beta/100cm^2$)	Remarks	Exc	Res.
101	E	27.3	19.0	B	RG	2	1672	1,873.8		C	
101	E	2.3	6.0	B	CH	2	2455	633.6		C	
101	E	5.3	19.0	B	RG	2	1670	623.3		C	
101	E	38.3	19.0	B	RG	2	1673	607.9		C	
101	E	0.0	3.0	B	CH	2	2457	606.6		C	
101	E	54.3	11.0	B	RG	2	1667	596.3		C	
101	E	16.3	3.0	B	RG	2	1655	585.3		C	
101	E	16.3	19.0	B	RG	2	1671	583.5		C	
101	E	27.3	3.0	B	RG	2	1656	580.4		C	
101	E	2.3	1.0	B	CH	2	2453	557.8		C	
101	E	60.3	19.0	B	RG	2	1675	542.3		C	
101	E	43.3	11.0	B	RG	2	1666	535.9		C	
101	E	81.3	3.0	B	RG	2	1661	528.3		C	
101	E	49.3	19.0	B	RG	2	1674	526.9		C	
101	E	0.0	11.0	B	RG	2	1662	511.5		C	
101	E	44.3	22.0	B	CH	2	2450	507.6		C	
101	E	21.3	11.0	B	RG	2	1664	496.1		C	
101	E	0.0	1.0	B	CH	2	2456	496.1		C	
101	E	46.3	22.0	B	CH	2	2451	493.5		C	
101	E	71.3	3.0	B	RG	2	1660	493.2		C	
101	E	0.0	6.0	B	CH	2	2458	475.5		C	
101	E	49.3	3.0	B	RG	2	1658	475.0		C	
101	E	38.3	3.0	B	RG	2	1657	426.5		C	
101	E	5.3	3.0	B	RG	2	1654	419.3		C	
101	E	34.3	22.0	B	CH	2	2452	419.0		C	
101	E	32.3	11.0	B	RG	2	1665	393.3		C	
101	E	10.3	11.0	B	RG	2	1663	386.8		C	
101	E	60.3	3.0	B	RG	2	1659	374.4		C	
101	E	65.3	11.0	GB	RG	2	1668	99.0		C	
101	E	76.3	11.0	GB	RG	2	1669	97.7		C	
101	E	71.3	19.0	GB	RG	2	1676	87.4		C	
101	E	81.3	19.0	GB	RG	2	1677	55.3		C	
101	F	18.0	54.0	C	RG	2	1784	1,639.6		C	
101	F	30.0	24.0	C	RG	2	1792	1,240.1		C	
101	F	18.0	24.0	C	RG	2	1774	1,188.9		C	
101	F	21.0	24.0	C	RG	2	1789	995.0		C	
101	F	18.0	33.0	C	RG	2	1777	866.6		C	
101	F	24.0	24.0	C	RG	2	1790	809.7		C	
101	F	18.0	63.0	C	RG	2	1787	691.0		C	

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm²)	Remarks	Exc	Res.
101	F	18.0	51.0	C	RG	2	1783	633.1		C	
101	F	18.0	60.0	C	RG	2	1786	621.5		C	
101	F	18.0	57.0	C	RG	2	1785	607.0		C	
101	F	5.0	28.0	C	RG	2	1623	593.5		C	
101	F	18.0	66.0	C	RG	2	1788	564.6		C	
101	F	39.0	24.0	C	RG	2	1795	524.0		C	
101	F	18.0	36.0	C	RG	2	1778	485.4		C	
101	F	27.0	24.0	C	RG	2	1791	427.5		C	
101	F	18.0	48.0	C	RG	2	1782	395.7		C	
101	F	36.0	24.0	C	RG	2	1794	370.6		C	
101	F	18.0	39.0	C	RG	2	1779	346.5		C	
101	F	18.0	45.0	C	RG	2	1781	332.0		C	
101	F	18.0	27.0	C	RG	2	1775	321.4		C	
101	F	18.0	30.0	C	RG	2	1776	305.9		C	
101	F	13.0	24.0	C	RG	2	1632	279.9		C	
101	F	18.0	42.0	C	RG	2	1780	227.8		C	
101	F	13.0	32.0	C	RG	2	1633	222.9		C	
101	F	5.0	52.0	C	RG	2	1626	220.6		C	
101	F	13.0	1.0	C	RG	2	1651	202.8		C	
101	F	13.0	16.0	C	RG	2	1631	193.0		C	
101	F	33.0	24.0	C	RG	2	1793	172.7		C	

THE FOLLOWING DATA POINTS PASSED BACKGROUND, DCGLw, AND EMC SCREENING TESTS:

Survey Unit # 23601 Building: B236

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm²)	Remarks	Exc	Res.
101	F	29.0	80.0	C	CH	2	1647	172.7		C	
101	F	29.0	72.0	C	CH	2	1646	167.0		C	
101	F	5.0	36.0	C	RG	2	1624	163.1		C	
101	F	13.0	64.0	C	RG	2	1637	159.2		C	
101	F	21.0	4.0	C	RG	2	1640	158.3		C	
101	F	21.0	12.0	C	RG	2	1641	148.6		C	
101	F	5.0	60.0	C	RG	2	1627	147.7		C	
101	F	5.0	76.0	C	RG	2	1629	144.8		C	
101	F	13.0	56.0	C	RG	2	1636	138.0		C	
101	F	5.0	12.0	C	RG	2	1621	134.1		C	
101	F	13.0	80.0	C	RG	2	1639	134.1		C	
101	F	37.0	76.0	C	RG	2	1650	133.5		C	
101	F	5.0	4.0	C	RG	2	1620	129.3		C	
101	F	29.0	8.0	C	RG	2	1644	128.4		C	
101	F	5.0	44.0	C	RG	2	1625	126.9		C	
101	F	13.0	72.0	C	RG	2	1638	125.5		C	
101	F	29.0	16.0	C	RG	2	1645	119.7		C	
101	F	29.0	1.0	C	RG	2	1652	113.5		C	
101	F	13.0	8.0	C	RG	2	1630	111.0		C	
101	F	5.0	20.0	C	RG	2	1622	110.0		C	
101	F	21.0	19.0	C	RG	2	1653	103.4		C	
101	F	21.0	76.0	C	RG	2	1643	82.4		C	
101	F	13.0	48.0	C	RG	2	1635	78.2		C	
101	N	2.0	11.0	B	CH	2	1726	732.6		C	
101	N	0.0	11.0	B	RG	2	1725	730.0		C	
101	N	27.0	3.0	B	RG	2	1502	714.9		C	
101	N	5.0	19.0	B	RG	2	1507	697.9		C	
101	N	21.5	11.0	B	RG	2	1505	691.4		C	
101	N	10.5	11.0	B	RG	2	1504	685.0		C	
101	N	22.0	11.0	B	CH	2	1728	659.3		C	
101	N	38.0	3.0	B	RG	2	1503	639.8		C	
101	N	5.0	3.0	B	RG	2	1500	597.4		C	
101	N	39.0	4.0	B	CH	2	2463	588.6		C	
101	N	38.0	10.0	B	CH	2	2465	587.3		C	

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm²)	Remarks	Exc	Res.
101	N	39.0	1.0	B	CH	2	2462	577.0		C	
101	N	16.0	19.0	B	RG	2	1508	561.6		C	
101	N	16.0	3.0	B	RG	2	1501	547.7		C	
101	N	32.5	11.0	B	RG	2	1506	526.9		C	
101	N	37.0	4.0	B	CH	2	2460	525.6		C	
101	N	37.0	7.0	B	CH	2	2461	505.1		C	
101	N	39.0	7.0	B	CH	2	2464	499.9		C	
101	N	37.0	1.0	B	CH	2	2459	496.1		C	
101	N	19.0	11.0	B	CH	2	1727	476.8		C	
101	N	39.0	16.0	B	CH	2	2468	472.9		C	
101	N	39.0	12.0	B	CH	2	2466	429.3		C	
101	N	38.0	19.0	B	RG	2	1510	411.3		C	
101	N	38.0	1.0	B	CH	2	2467	407.4		C	
101	N	27.0	19.0	B	RG	2	1509	393.3		C	
101	S	36.5	3.0	B	RG	2	1734	515.0		C	
101	S	41.0	10.0	B	RG	2	1738	514.1		C	
101	S	31.0	10.0	CB	RG	2	1737	460.1		C	
101	S	20.0	10.0	B	RG	2	1736	419.0		C	
101	S	25.5	3.0	B	RG	2	1733	415.6		C	
101	S	9.0	10.0	CB	RG	2	1735	388.1		C	
101	S	3.5	3.0	B	RG	2	1731	385.3		C	
101	S	3.5	19.0	GB	RG	2	1739	205.6		C	
101	S	14.5	19.0	GB	RG	2	1740	141.4		C	
101	S	36.5	19.0	GB	RG	2	1742	125.9		C	
101	S	25.5	19.0	GB	RG	2	1741	75.8		C	
101	W	72.0	19.0	B	RG	2	1486	717.1		C	
101	W	72.0	3.0	B	RG	2	1471	710.7		C	
101	W	83.0	3.0	B	RG	2	1472	710.7		C	
101	W	55.5	8.0	B	CH	2	1477	643.9		C	
101	W	77.5	8.0	B	CH	2	1479	587.3		C	
101	W	50.0	3.0	B	RG	2	1469	538.5		C	
101	W	81.3	19.0	B	RG	2	1487	512.8		C	
101	W	17.0	3.0	B	RG	2	1466	496.1		C	
101	W	61.0	19.0	B	RG	2	1485	484.5		C	
101	W	28.0	19.0	B	RG	2	1482	411.3		C	
101	W	44.5	11.0	B	RG	2	1476	399.7		C	
101	W	50.0	19.0	B	RG	2	1484	389.4		C	
101	W	61.0	3.0	B	RG	2	1470	371.4		C	
101	W	11.5	11.0	B	RG	2	1473	359.9		C	
101	W	39.0	19.0	B	RG	2	1483	356.0		C	
101	W	22.5	11.0	B	RG	2	1474	350.9		C	
101	W	6.0	3.0	B	RG	2	1465	339.3		C	
101	W	66.5	11.0	B	RG	2	1478	332.9		C	
101	W	28.0	3.0	M	RG	2	1467	177.8		C	
101	W	17.0	19.0	GB	CH	2	1481	105.4		C	
101	W	6.0	19.0	GB	CH	2	1480	102.8		C	
101	W	33.5	8.0	M	CH	2	1475	74.6		C	
101	E	2.3	3.0	B	CH	2	2454	204.3			
101	F	13.0	40.0	C	RG	2	1634	74.3			
101	F	21.0	68.0	C	RG	2	1642	72.9			
101	F	37.0	4.0	C	RG	2	1648	62.3			
101	F	37.0	68.0	C	RG	2	1649	59.6			
101	F	5.0	68.0	C	RG	2	1628	59.6			
101	S	14.5	3.0	B	RG	2	1732	223.0			
101	W	39.0	3.0	M	RG	2	1468	41.6			

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -Buildings

Summary of Background Data and Thresholds Used in this Analysis

Measurement Type: BK *DCGL:* 2,600 *EMC:* 13,000

Matrix	*Number of Data Points*	*Average Background*	*Sigma*	*Background Threshold (Tbk)*	*DCGLw Threshold (Td)*	*EMC Threshold (Tc)*
	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)
B	30	192.4	16.0	224.4	2,824	13,224
C	90	35.4	20.1	75.5	2,676	13,076
CB	51	96.1	21.7	139.4	2,739	13,139
GB	0	0.0	0.0	0.0	2,600	13,000
M	10	24.0	15.7	55.3	2,655	13,055

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report -

STATISTICAL TEST RESULTS

Run Date: 12/10/2003 4:17:30 PM

Survey Unit Number 23601 Class: 2

Selected Test: SIGN TEST FOR PAIRED DATA

Test Status Pass

Thresholds:

EMC 13,000 DCGL 2,600

DATA SUMMARY TABLE

120 Survey points processed and 5 matrices processed

S+ = 120 **Wc =** 69

******** The survey unit has passed the SIGN TEST FOR PAIRED DATA ********