WALTER REED ARMY MEDICAL CENTER BUILDING T-2 RADIOLOGICAL DECOMISSIONING FINAL STATUS SURVEY

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EXECUTIVE SUMMARY
WALTER REED ARMY MEDICAL CENTER (WRAMC)
FINAL STATUS SURVEY FOR
RADIOLOGICAL DECOMMISSIONING OF BUILDING T-2

PURPOSE. To perform a Final Status Survey (FSS) on portions of the WRAMC Building T-2 to determine if it may be released for unrestricted use in accordance with U.S. Nuclear Regulatory Commission (NRC) regulations.

CONCLUSIONS.

A. A FSS of nine Class 2 survey units was performed in former laboratories in Building T-2. The survey was designed and implemented in accordance with the MARSSIM manual (NRC NUREG 1575, August 2000).

B. All survey unit measurements were observed to be below the calculated $DCGL_W$ values.

C. The results of this FSS show that the current condition of Building T-2 satisfactorily meets the NRC release criteria for unrestricted use.

ACRONYMS AND ABBREVIATIONS

$DCGL_W$	Derived Concentration Guideline Level, Average
$DCGL_{EMC}$	Derived Concentration Guideline Level, Elevated Measurement Comparison
FSS	Final Status Survey
HTDR	Hard to detect radionuclide
HPO	Health Physics Office
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NIST	National Institute of Standards and Technology
ROC	Radionuclide of Concern
SU	Survey unit
WRAIR	Walter Reed Army Institute of Research
WRAMC	Walter Reed Army Medical Center

REFERENCES

ISO, 1998 ISO-7503-1. International Standards Organization, *Evaluation of Surface Contamination – Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters*, ISO ISO-7503-1, 1988.

NRC, 1998 NUREG-1505. U.S. Nuclear Regulatory Commission, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*, Interim Draft Report for Comment and Use, NUREG-1505 Rev.1 , 1998.

NRC, 1999 NUREG-5512. U.S. Nuclear Regulatory Commission, *Residual Radioactive Contamination from Decommissioning Parameter Analysis*, Draft Report for Comment, NUREG/CR-5512, Vol. 3, 1999.

NRC, 2000 NUREG-1575. U.S. Nuclear Regulatory Commission, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, NUREG-1575 Rev. 1, August 2000.

NRC, 2003 NUREG-1757. U.S. Nuclear Regulatory Commission, *Consolidated NMSS Decommissioning Guidance*, NUREG-1757, Vol. 1-3, September 2003.

PNNL, 2002 Visual Sample Plan Software, Version 2.2. Battelle Memorial Institute. 2002

INTRODUCTION

Building T-2 houses former laboratories used for biomedical research and clinical investigation activities at Walter Reed Army Medical Center (WRAMC). Building T-2 is slated for demolition pending completion of FSS activities and release for unrestricted use. Following demolition, the site Building T-2 currently occupies is expected to be filled with a multi-level parking garage. This report documents the results and protocol of the completed Final Status Survey (FSS) performed for Building T-2.

This FSS is designed to be compliant with the guidance found in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, NRC, 2000). The MARSSIM provides standardized and consistent approaches for planning, conducting, evaluating and documenting radiological surveys, with a specific focus on FSS activities carried out to demonstrate compliance with license termination regulations.

SCOPE OF FSS AND SUMMARY OF PROTOCOL

This FSS is comprised of nine (9) survey units (SU), classified as MARSSIM Class 2, based on information found during performance of the Building T-2 Historical Site Assessment (HSA) dated 7 May 2004.

This FSS will be used to demonstrate that the residual radionuclide concentrations following remediation comply with concentration and exposure-based criteria. The objective of FSS activities is to obtain data of sufficient quality and quantity to support an evaluation of the criteria for Building T-2. The scope of the surveys performed included:

- Interior beta scan surveys;
- Fixed-point (static) measurements at designated locations;
- Judgment static measurements for tritium (H-3) with a windowless gas proportional detector;
- Smear surveys for removable contamination at the same locations as the fixed-point measurements; and
- NaI gamma scoping surveys in each SU.

Detailed descriptions of FSS design and execution protocol governing this effort may be found in Appendix C.

All instruments used during this investigation were monitored daily using sources traceable to the National Institute of Standards and Technology (NIST) and control charts. Control charts for each instrument and calibration certificates for the instruments and radioactive sources used during the project can be found in Appendix D.

SUMMARY OF RESULTS

Fixed-Point Measurements at Systematic Locations

One-minute counts were taken with a Ludlum 43-68 gas-flow proportional detector at each SU systematic location and logged on applicable FSS data sheets. There were a minimum of 20 fixed-point measurements performed in each SU. Each SU also had (5) 1-minute ambient background measurements collected in the center of the room.

There were no measurements that exceeded the weighted $DCGL_W$ for any SU. The results of all fixed-point measurements are provided in column 7 of the FSS Summary Data Sheets in Appendix A.

Fixed-Point Measurements at Biased Locations

Biased locations were added to the systematic sampling grid if an Action Level was exceeded during the scan survey or at the discretion of the scanning operator if he deemed further investigation would be prudent. Biased fixed-point locations are noted at the bottom portion the results listed in column 7 of the FSS Data Summary Tables, provided as Appendix A. Biased locations are also notated on the FSS SU Maps provided in Appendix B.

No biased location counts were observed to be greater than the SU-specific weighted $DCGL_W$.

Supplemental Fixed-Point Measurements for H-3

In addition to the systematic static measurements described above, judgment sampling for the presence of H-3 was also attempted using a windowless proportional detector. One-minute background and sample counts were collected in a sampling of Building T-2 SUs to supplement systematic measurements and removable swipe data in order to better report the potential presence of H-3 in these survey units. A summary of locations and results of each of these measurements is provided in Appendix A. Location markers are also provided on the FSS SU maps provided in Appendix B.

It should be noted that the stated "H-3 Residual Activity" is conservatively assumed to be entirely due to H-3. In actual fact, a portion (or even all) of the gross residual count rate may be attributable to the ROCs. However, for the sake of evaluating potential H-3 contamination, this assumption was deemed appropriate.

Floor Scan Surveys

Scan surveys of floor surfaces were performed with a Ludlum Model 239-1F floor monitor in all SUs in accordance with protocol and coverage requirements prescribed in Appendix C. Locations of spots marked for follow-up static counts and swipes are noted on FSS SU maps in Appendix B.

All scan survey results were less than instrument action levels.

Wall and Work Surface Scan Surveys

Wall and work surface surveys were performed using a Ludlum 43-68 gas-flow proportional detector at the coverage criteria stated in the protocol. 100% of work surfaces (e.g. countertops, sinks, hoods) and 25% of lower wall surfaces (< 2 meters, m) were scanned in each SU.

No measurements in excess of instrument action limits were observed during these surveys.

Gamma Scoping Surveys

Gamma scans with a 3-inch by 3-inch (3×3) sodium-iodide (NaI) detector were performed in all SUs to supplement the prescribed beta static and removable swipe measurements. The scans were performed on all floor and work surfaces with a focus on detecting spots of contamination in excess of ambient background.

No measurements in excess of instrument action limits were observed during these surveys.

Measurements for Removable Contamination

Swipes wetted with water were collected at each of the systematic and biased SU locations where fixed-point measurements were taken. The swipes were wetted to enhance collection of H-3 contamination. All swipes were prepared and counted in a Packard Tri-Carb TR2500 liquid scintillation analyzer for beta contamination. Gross alpha and beta contamination levels are reported by applying efficiencies to known calibration standards traceable to the NIST.

Smear results are reported in columns 10 and 11 of the FSS Summary Data Sheets in Appendix A. The results are reported for H-3 and C-14 in units of dpm ± 2-sigma (σ) per 100 cm^2. If the net swipe result was less than 1 dpm, the measurement was flagged as "NR" or "Not Reported." All swipe results for H-3 and C-14 were less than 9.7 and 4.2 dpm per 100 cm^2, respectively.

In addition to the swipes collected at systematic and biased locations prescribed in the survey protocol, swipes were also collected from piping of all sinks located in impacted laboratories. Swipes were taken either from within the drain trap or within the drain piping that runs between the sink and trap, depending on accessibility. These swipes were collected to investigate the potential for residual contamination from nuclides that were disposed down lab sinks in the past. A summary of these swipe results are shown in Table 1.

Table 1. Summary of Sink and Trap Smear Results

Nuclide	LSC Background (dpm/vial)	Energy Window (keV)	
H-3	13.61	0-18.6	
C-14	6.38	0-156	
Survey Unit	**Sample Location**	**H-3 Smear Net Result (dpm/smear)**	**C-14 Smear Net Result (dpm/smear)**
159	Sink #1	NR	NR
	Sink #2	3.9±1.1	NR
	Sink #3	NR	NR
	Sink #4	NR	2.8±0.7
	Sink #5	5.6±1.7	NR
225	Sink #1	NR	NR
227	Sink #1	NR	NR
	Sink #2	NR	2.5±0.7
236	Sink #1	4.5±1.4	NR
	Sink #2	NR	7.1±1.8
237	Sink #1	NR	4.3±1.0
	Sink #2	3.0±0.9	NR
	Sink #3	NR	NR
238	Sink #1	NR	2.7±0.8
241	Sink #1	NR	4.3±1.1

Notes

1. Each smear was taken within the drain trap or drain piping of each sink
2. Sink locations are noted on map of each survey unit.
3. Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

The results of the sink trap swipes indicate no removable residual H-3 or C-14 contamination present.

DISCUSSION OF RESULTS

The results of all fixed-point and removable measurements are all below the weighted $DCGL_W$ for each SU. Therefore, evaluation of the data via the Sign Test was not required to ensure that Building T-2 is suitable for release for unrestricted use. Nevertheless, Sign Test evaluations following the guidance provided in the MARSSIM are recorded for all SUs in the FSS Summary Data Sheets in Appendix A.

The results of this FSS show that the current condition of Building T-2 satisfactorily meets NRC release criteria for unrestricted use.

CONCLUSIONS

A. A FSS of nine Class 2 survey units was performed in former laboratories in Building T-2. The survey was designed and implemented in accordance with the MARSSIM manual (NRC NUREG 1575, August 2000).

B. All survey unit measurements were observed to be below the calculated $DCGL_W$ values.

C. The results of this FSS show that the current condition of Building T-2 satisfactorily meets the NRC release criteria for unrestricted use.

APPENDIX A

Building T-2 FSS SU Data Sheets from May 2004 (Rooms 15, 159, 225, 227, 236, 237, 238, 240 and 241) and Fixed Point Windowless Counter data for SUs with H-3 History

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	11-May-04
Survey Unit/Room #:	15
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	1.01E+03
Ambient Background (cpm):	195.2

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	7.00%	126	7.93E+02

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	173	7.2	8.16E+01	1	S	9.7±5.8	NR
2	W	WB	165.8	158	-7.8	-8.84E+01	1	S	NR	NR
3	W	WB	165.8	190	24.2	2.74E+02	1	S	2.0±0.6	NR
4	F	VT	224.6	199	-25.6	-2.90E+02	1	S	NR	NR
5	F	C	195.2	255	59.8	6.78E+02	1	S	NR	NR
6	W	WB	165.8	159	-6.8	-7.71E+01	1	S	NR	NR
7	W	WB	165.8	144	-21.8	-2.47E+02	1	S	1.1±0.4	NR
8	W	WB	165.8	137	-28.8	-3.27E+02	1	S	NR	NR
9	F	VT	224.6	192	-32.6	-3.70E+02	1	S	3.6±1.1	NR
10	F	VT	224.6	201	-23.6	-2.68E+02	1	S	NR	NR
11	W	WB	165.8	178	12.2	1.38E+02	1	S	NR	NR
12	W	WB	165.8	122	-43.8	-4.97E+02	1	S	NR	NR
13	F	VT	224.6	323	98.4	1.12E+03	-1	S	NR	NR
14	F	VT	224.6	202	-22.6	-2.56E+02	1	S	NR	NR
15	W	WB	165.8	153	-12.8	-1.45E+02	1	S	NR	NR
16	W	WB	165.8	157	-8.8	-9.98E+01	1	S	2.9±0.9	NR
17	W	C	195.2	134	-61.2	-6.94E+02	1	S	NR	NR
18	W	C	195.2	132	-63.2	-7.17E+02	1	S	4.8±1.4	NR
19	W	C	195.2	132	-63.2	-7.17E+02	1	S	NR	NR
20	W	C	195.2	168	-27.2	-3.08E+02	1	S	NR	NR
21	FD	M/VT	224.6	227	2.4	2.72E+01	N/A	B	NR	NR
22	FD	M	185.4	181	-4.4	-4.99E+01	N/A	B	NR	NR
23	FD	M	185.4	190	4.6	5.22E+01	N/A	B	NR	NR
24	F	VT	224.6	229	4.4	4.99E+01	N/A	B	NR	NR
25	F	VT	224.6	283	58.4	6.62E+02	N/A	B	NR	NR

Mean	**-1.41E+02**	
Median	**-2.52E+02**	
Range	**1.83E+03**	
Std Dev (1 σ)	**4.49E+02**	
Sum of Positive Signs		**19**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES:

NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor FD = Floor Drain W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	11-May-04
Survey Unit/Room #:	159
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	5.15E+06
Ambient Background (cpm):	227.4

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	4.55%	126	1.57E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	155	-10.8	-1.88E+02	1	S	9.6±2.9	NR
2	W	WB	165.8	177	11.2	1.95E+02	1	S	5.7±1.7	NR
3	W	WB	165.8	140	-25.8	-4.50E+02	1	S	NR	NR
4	F	VT	224.6	215	-9.6	-1.67E+02	1	S	NR	NR
5	F	VT	224.6	220	-4.6	-8.02E+01	1	S	NR	NR
6	W	M	185.4	143	-42.4	-7.40E+02	1	S	8.9±2.7	NR
7	F	VT	224.6	215	-9.6	-1.67E+02	1	S	NR	NR
8	F	VT	224.6	209	-15.6	-2.72E+02	1	S	NR	NR
9	F	VT	224.6	212	-12.6	-2.20E+02	1	S	7.3±2.2	NR
10	W	WB	165.8	158	-7.8	-1.36E+02	1	S	4.9±1.5	NR
11	F	VT	224.6	236	11.4	1.99E+02	1	S	NR	NR
12	F	VT	224.6	244	19.4	3.38E+02	1	S	NR	NR
13	W	WB	165.8	144	-21.8	-3.80E+02	1	S	NR	NR
14	F	VT	224.6	228	3.4	5.93E+01	1	S	NR	NR
15	CT	SST	373.6	194	-179.6	-3.13E+03	1	S	NR	NR
16	F	VT	224.6	220	-4.6	-8.02E+01	1	S	NR	NR
17	F	VT	224.6	230	5.4	9.42E+01	1	S	NR	NR
18	W	WB	165.8	181	15.2	2.65E+02	1	S	5.0±1.5	NR
19	W	WB	165.8	151	-14.8	-2.58E+02	1	S	3.6±1.2	NR
20	W	M	185.4	140	-45.4	-7.92E+02	1	S	NR	NR

Mean	**-2.96E+02**	
Median	**-1.67E+02**	
Range	**3.47E+03**	
Std Dev (1 σ)	**7.32E+02**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	13-May-04
Survey Unit/Room #:	225
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	7.61E+06
Ambient Background (cpm):	248.2

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	3.01%	126	2.37E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	241	75.2	1.98E+03	1	S	NR	NR
2	W	WB	165.8	178	12.2	3.22E+02	1	S	NR	NR
3	W	WB	165.8	194	28.2	7.44E+02	1	S	NR	NR
4	W	WB	165.8	195	29.2	7.70E+02	1	S	NR	NR
5	CT	SST	373.6	389	15.4	4.06E+02	1	S	NR	2.0±0.7
6	CT	SST	373.6	437	63.4	1.67E+03	1	S	NR	NR
7	F	VT	224.6	245	20.4	5.38E+02	1	S	NR	NR
8	W	WB	165.8	151	-14.8	-3.90E+02	1	S	NR	NR
9	W	WB	165.8	177	11.2	2.95E+02	1	S	NR	NR
10	F	VT	224.6	249	24.4	6.43E+02	1	S	NR	1.2±0.4
11	F	VT	224.6	237	12.4	3.27E+02	1	S	NR	NR
12	F	VT	224.6	225	0.4	1.05E+01	1	S	NR	NR
13	W	WB	165.8	162	-3.8	-1.00E+02	1	S	NR	NR
14	W	WB	165.8	201	35.2	9.28E+02	1	S	NR	NR
15	CT	SST	373.6	421	47.4	1.25E+03	1	S	NR	1.3±0.4
16	CT	SST	373.6	431	57.4	1.51E+03	1	S	NR	NR
17	F	VT	224.6	228	3.4	8.96E+01	1	S	NR	NR
18	W	WB	165.8	156	-9.8	-2.58E+02	1	S	NR	1.1±0.3
19	W	WB	165.8	184	18.2	4.80E+02	1	S	NR	NR
20	W	WB	165.8	178	12.2	3.22E+02	1	S	NR	NR

Mean	**5.77E+02**	
Median	**4.43E+02**	
Range	**2.37E+03**	
Std Dev (1 σ)	**6.35E+02**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	14-May-04
Survey Unit/Room #:	227
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	2.05E+07
Ambient Background (cpm):	210.2

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	0.98%	126	7.28E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	M	185.4	203	17.6	1.43E+03	1	S	NR	NR
2	W	M	185.4	193	7.6	6.15E+02	1	S	NR	NR
3	W	M	185.4	204	18.6	1.51E+03	1	S	NR	NR
4	W	M	185.4	183	-2.4	-1.94E+02	1	S	NR	NR
5	S	SST	373.6	211	-162.6	-1.32E+04	1	S	NR	NR
6	CT	SST	373.6	242	-131.6	-1.07E+04	1	S	NR	NR
7	CT	SST	373.6	248	-125.6	-1.02E+04	1	S	NR	NR
8	W	WB	165.8	174	8.2	6.64E+02	1	S	NR	NR
9	W	WB	165.8	198	32.2	2.61E+03	1	S	NR	NR
10	F	VT	224.6	206	-18.6	-1.51E+03	1	S	2.4±0.8	NR
11	F	VT	224.6	211	-13.6	-1.10E+03	1	S	NR	NR
12	F	VT	224.6	234	9.4	7.61E+02	1	S	NR	NR
13	CT	SST	373.6	222	-151.6	-1.23E+04	1	S	NR	NR
14	F	VT	224.6	205	-19.6	-1.59E+03	1	S	NR	NR
15	F	VT	224.6	216	-8.6	-6.96E+02	1	S	NR	1.3±0.3
16	F	VT	224.6	225	0.4	3.24E+01	1	S	NR	NR
17	W	WB	165.8	155	-10.8	-8.75E+02	1	S	NR	NR
18	W	WB	165.8	136	-29.8	-2.41E+03	1	S	NR	NR
19	W	WB	165.8	152	-13.8	-1.12E+03	1	S	NR	NR
20	W	WB	165.8	181	15.2	1.23E+03	1	S	NR	NR
21	CT	SST	373.6	395	21.4	1.73E+03	N/A	B	NR	NR
22	CT	SST	373.6	424	50.4	4.08E+03	N/A	B	NR	NR
23	CT	SST	373.6	450	76.4	6.19E+03	N/A	B	NR	NR
24	S	SST	373.6	975	601.4	4.87E+04	N/A	B	6.7±2.2	3.0±0.9

Mean	**-2.35E+03**	
Median	**-7.86E+02**	
Range	**6.19E+04**	
Std Dev (1 σ)	**4.92E+03**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	13-May-04
Survey Unit/Room #:	236
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	4.61E+06
Ambient Background (cpm):	210.6

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	5.11%	126	1.40E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	181	15.2	2.36E+02	1	S	NR	NR
2	W	WB	165.8	168	2.2	3.42E+01	1	S	NR	NR
3	CT	SST	373.6	217	-156.6	-2.43E+03	1	S	NR	NR
4	F	VT	224.6	233	8.4	1.30E+02	1	S	NR	NR
5	CT	SST	373.6	201	-172.6	-2.68E+03	1	S	NR	NR
6	W	WB	165.8	159	-6.8	-1.06E+02	1	S	NR	NR
7	W	WB	165.8	158	-7.8	-1.21E+02	1	S	NR	NR
8	F	VT	224.6	216	-8.6	-1.34E+02	1	S	NR	NR
9	F	VT	224.6	224	-0.6	-9.32E+00	1	S	NR	2.2±0.4
10	W	WB	165.8	155	-10.8	-1.68E+02	1	S	NR	NR
11	W	WB	165.8	159	-6.8	-1.06E+02	1	S	NR	NR
12	CT	L	192.2	223	30.8	4.78E+02	1	S	NR	2.4±0.5
13	F	VT	224.6	226	1.4	2.17E+01	1	S	NR	NR
14	CT	L	192.2	203	10.8	1.68E+02	1	S	NR	NR
15	W	WB	165.8	149	-16.8	-2.61E+02	1	S	NR	NR
16	CT	L	192.2	223	30.8	4.78E+02	1	S	NR	NR
17	F	VT	224.6	212	-12.6	-1.96E+02	1	S	NR	4.2±1.1
18	W	WB	165.8	171	5.2	8.08E+01	1	S	NR	NR
19	W	WB	165.8	174	8.2	1.27E+02	1	S	NR	NR
20	W	WB	165.8	163	-2.8	-4.35E+01	1	S	NR	NR
21	S	SS	200.0	204	4	6.21E+01	N/A	B	NR	NR
22	S	SS	200.0	220	20	3.11E+02	N/A	B	NR	NR

Mean	**-2.25E+02**	
Median	**-2.64E+01**	
Range	**3.16E+03**	
Std Dev (1 σ)	**8.23E+02**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES:

NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	11-May-04
Survey Unit/Room #:	237
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	5.00E+06
Ambient Background (cpm):	225

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	4.69%	126	1.18E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	152	-13.8	-2.34E+02	1	S	NR	NR
2	W	WB	165.8	156	-9.8	-1.66E+02	1	S	NR	NR
3	W	WB	165.8	167	1.2	2.03E+01	1	S	NR	NR
4	W	WB	165.8	169	3.2	5.42E+01	1	S	NR	NR
5	F	VT	224.6	264	39.4	6.67E+02	1	S	NR	NR
6	F	VT	224.6	224	-0.6	-1.02E+01	1	S	NR	NR
7	F	VT	224.6	250	25.4	4.30E+02	1	S	NR	NR
8	W	WB	165.8	171	5.2	8.80E+01	1	S	NR	NR
9	F	VT	224.6	211	-13.6	-2.30E+02	1	S	NR	NR
10	F	VT	224.6	205	-19.6	-3.32E+02	1	S	NR	NR
11	F	VT	224.6	238	13.4	2.27E+02	1	S	NR	NR
12	W	WB	165.8	162	-3.8	-6.43E+01	1	S	NR	NR
13	W	WB	165.8	164	-1.8	-3.05E+01	1	S	NR	NR
14	F	VT	224.6	251	26.4	4.47E+02	1	S	NR	NR
15	F	VT	224.6	214	-10.6	-1.79E+02	1	S	NR	NR
16	F	VT	224.6	181	-43.6	-7.38E+02	1	S	NR	1.2±0.3
17	W	WB	165.8	144	-21.8	-3.69E+02	1	S	NR	NR
18	F	VT	224.6	193	-31.6	-5.35E+02	1	S	NR	NR
19	W	WB	165.8	157	-8.8	-1.49E+02	1	S	NR	1.2±0.3
20	W	M	185.4	150	-35.4	-5.99E+02	1	B	NR	1.0±0.2

Mean	**-8.51E+01**	
Median	**-1.07E+02**	
Range	**1.40E+03**	
Std Dev (1 σ)	**3.54E+02**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	13-May-04
Survey Unit/Room #:	238
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	5.00E+06
Ambient Background (cpm):	227.2

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	4.69%	126	1.18E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	192	26.2	4.43E+02	1	S	3.7±1.1	3.4±0.8
2	W	WB	165.8	183	17.2	2.91E+02	1	S	1.4±0.4	2.5±0.6
3	W	WB	165.8	151	-14.8	-2.50E+02	1	S	2.8±0.8	NR
4	F	VT	224.6	224	-0.6	-1.02E+01	1	S	6.7±2.0	NR
5	F	VT	224.6	203	-21.6	-3.66E+02	1	S	NR	3.3±0.8
6	F	VT	224.6	213	-11.6	-1.96E+02	1	S	3.5±1.1	4.9±1.2
7	W	WB	165.8	156	-9.8	-1.66E+02	1	S	1.5±0.4	1.9±0.5
8	F	VT	224.6	217	-7.6	-1.29E+02	1	S	NR	4.7±1.2
9	F	VT	224.6	222	-2.6	-4.40E+01	1	S	1.6±0.5	NR
10	W	WB	165.8	136	-29.8	-5.04E+02	1	S	NR	3.0±0.7
11	W	WB	165.8	161	-4.8	-8.12E+01	1	S	4.3±1.3	2.5±0.6
12	F	VT	224.6	183	-41.6	-7.04E+02	1	S	8.7±2.6	NR
13	F	VT	224.6	213	-11.6	-1.96E+02	1	S	6.4±1.9	NR
14	W	WB	165.8	148	-17.8	-3.01E+02	1	S	NR	NR
15	W	WB	165.8	151	-14.8	-2.50E+02	1	S	NR	NR
16	F	VT	224.6	193	-31.6	-5.35E+02	1	S	NR	3.0±0.8
17	CT	L	192.2	201	8.8	1.49E+02	1	S	NR	1.6±0.4
18	W	WB	165.8	131	-34.8	-5.89E+02	1	S	NR	2.4±0.6
19	W	WB	165.8	169	3.2	5.42E+01	1	S	2.1±0.6	NR
20	W	WB	165.8	184	18.2	3.08E+02	1	S	6.6±2.0	2.5±0.6

Mean	**-1.54E+02**	
Median	**-1.81E+02**	
Range	**1.15E+03**	
Std Dev (1 σ)	**3.07E+02**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	13-May-04
Survey Unit/Room #:	240
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	2.05E+07
Ambient Background (cpm):	219

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	0.98%	126	5.65E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	167	1.2	9.72E+01	1	S	4.9±1.5	NR
2	W	WB	165.8	178	12.2	9.88E+02	1	S	NR	2.0±0.3
3	W	WB	165.8	188	22.2	1.80E+03	1	S	NR	2.6±0.7
4	W	WB	165.8	164	-1.8	-1.46E+02	1	S	NR	3.8±1.0
5	W	WB	165.8	167	1.2	9.72E+01	1	S	NR	2.3±0.5
6	W	WB	165.8	168	2.2	1.78E+02	1	S	2.4±0.7	3.9±1.0
7	F	VT	224.6	223	-1.6	-1.30E+02	1	S	8.3±2.5	NR
8	F	VT	224.6	231	6.4	5.18E+02	1	S	NR	NR
9	F	VT	224.6	200	-24.6	-1.99E+03	1	S	NR	NR
10	W	WB	165.8	174	8.2	6.64E+02	1	S	NR	NR
11	W	WB	165.8	149	-16.8	-1.36E+03	1	S	NR	3.0±0.8
12	W	WB	165.8	145	-20.8	-1.68E+03	1	S	NR	NR
13	W	WB	165.8	162	-3.8	-3.08E+02	1	S	8.2±2.5	3.4±0.9
14	F	VT	224.6	225	0.4	3.24E+01	1	S	2.2±0.7	NR
15	F	VT	224.6	224	-0.6	-4.86E+01	1	S	2.7±0.7	NR
16	CT	L	192.2	208	15.8	1.28E+03	1	S	3.0±0.9	NR
17	CT	L	192.2	202	9.8	7.94E+02	1	S	NR	2.8±0.7
18	W	WB	165.8	180	14.2	1.15E+03	1	S	NR	2.2±0.3
19	W	WB	165.8	173	7.2	5.83E+02	1	S	4.0±1.0	NR
20	D	W	159.6	133	-26.6	-2.15E+03	1	S	NR	2.3±0.3

Mean	**1.78E+01**	
Median	**9.72E+01**	
Range	**3.95E+03**	
Std Dev (1 σ)	**1.08E+03**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

Survey Unit Final Status Survey Summary Data Sheet
WRAMC Building T2 Decommissioning

May 2004

Survey Date:	13-May-04
Survey Unit/Room #:	241
FSS Floor Classification:	2
SU DCGLw (dpm/100cm2):	2.05E+07
Ambient Background (cpm):	214

Survey Instruments	Survey Type	Ratemeter S/N	Probe S/N	Window Density Thickness (mg/cm2)	Total Efficiency[1]	Probe Active Area (cm2)	Planning MDC (dpm/100cm^2)
Ludlum 2350/43-68	Static Counts	120619	RN011354	0.4	0.98%	126	5.65E+03

1	2	3	4	5	6	7	8	9	10	11
Sample ID	Sample Location[2]	Surface Material[3]	Material Specific Background[4] (cpm)	Static Count Result (cpm)	Net Static Count Rate (cpm)	Residual Surface Activity (dpm/100cm2)	MARSSIM Sign Test Parameter	Sample Type[5]	H-3 Smear Net Result[6] (dpm/100cm2)	C-14 Smear Net Result[6] (dpm/100cm2)
1	W	WB	165.8	190	24.2	1.96E+03	1	S	5.5±1.7	NR
2	W	WB	165.8	172	6.2	5.02E+02	1	S	2.1±0.6	NR
3	W	WB	165.8	178	12.2	9.88E+02	1	S	NR	NR
4	W	WB	165.8	153	-12.8	-1.04E+03	1	S	NR	NR
5	F	VT	224.6	235	10.4	8.42E+02	1	S	2.3±0.6	NR
6	F	VT	224.6	222	-2.6	-2.11E+02	1	S	NR	NR
7	F	VT	224.6	224	-0.6	-4.86E+01	1	S	6.4±1.9	NR
8	W	WB	165.8	141	-24.8	-2.01E+03	1	S	NR	NR
9	W	WB	165.8	171	5.2	4.21E+02	1	S	NR	NR
10	F	VT	224.6	195	-29.6	-2.40E+03	1	S	NR	NR
11	F	VT	224.6	207	-17.6	-1.43E+03	1	S	NR	NR
12	F	VT	224.6	196	-28.6	-2.32E+03	1	S	NR	NR
13	W	WB	165.8	159	-6.8	-5.51E+02	1	S	NR	NR
14	W	WB	165.8	153	-12.8	-1.04E+03	1	S	NR	NR
15	W	WB	165.8	145	-20.8	-1.68E+03	1	S	6.8±2.0	NR
16	W	WB	165.8	157	-8.8	-7.13E+02	1	S	NR	NR
17	W	WB	165.8	171	5.2	4.21E+02	1	S	NR	NR
18	W	WB	165.8	155	-10.8	-8.75E+02	1	S	NR	NR
19	W	WB	165.8	168	2.2	1.78E+02	1	S	NR	NR
20	W	WB	165.8	161	-4.8	-3.89E+02	1	S	NR	NR

Mean	**-4.69E+02**	
Median	**-4.70E+02**	
Range	**4.36E+03**	
Std Dev (1 σ)	**1.16E+03**	
Sum of Positive Signs		**20**
Sign Test Critical Value (n=20)		**14**
Sign Test Evaluation		**PASS**

NOTES: NR = Not Reported

1 Total Efficiency = Instrument static 2-pi efficiency * ISO-7503 Surface Efficiency * Weighted Room Nuclide Ratio as per Building T-2 HSA.

2 F = floor W = lower wall (< 2m) S = sink CT = countertop H = fume hood

3 Surface Materials: WB=Wallboarb VT = Vinyl Tile C = Concrete M = Metal W = Wood L = Laminate Countertop
SST = Synthetic Stone Countertop SS = Stainless Steel

4 If the ambient background measurements in the room were significantly lower than the material-specific values measured elsewhere in Building 40, than the ambient values were used to obtain net residual activity in the SU.

5 Sample Type: S=Systematic B=Biased. Biased locations chosen based on results of scanning survey and are not included in Sign test calculations.

6 Smear results reported as Result ± 2σ if net value positive. NR if net result was negative.

APPENDIX B

Building T-2 FSS SU Maps
(Rooms 15, 159, 225, 227, 236, 237, 238, 240 and 241)

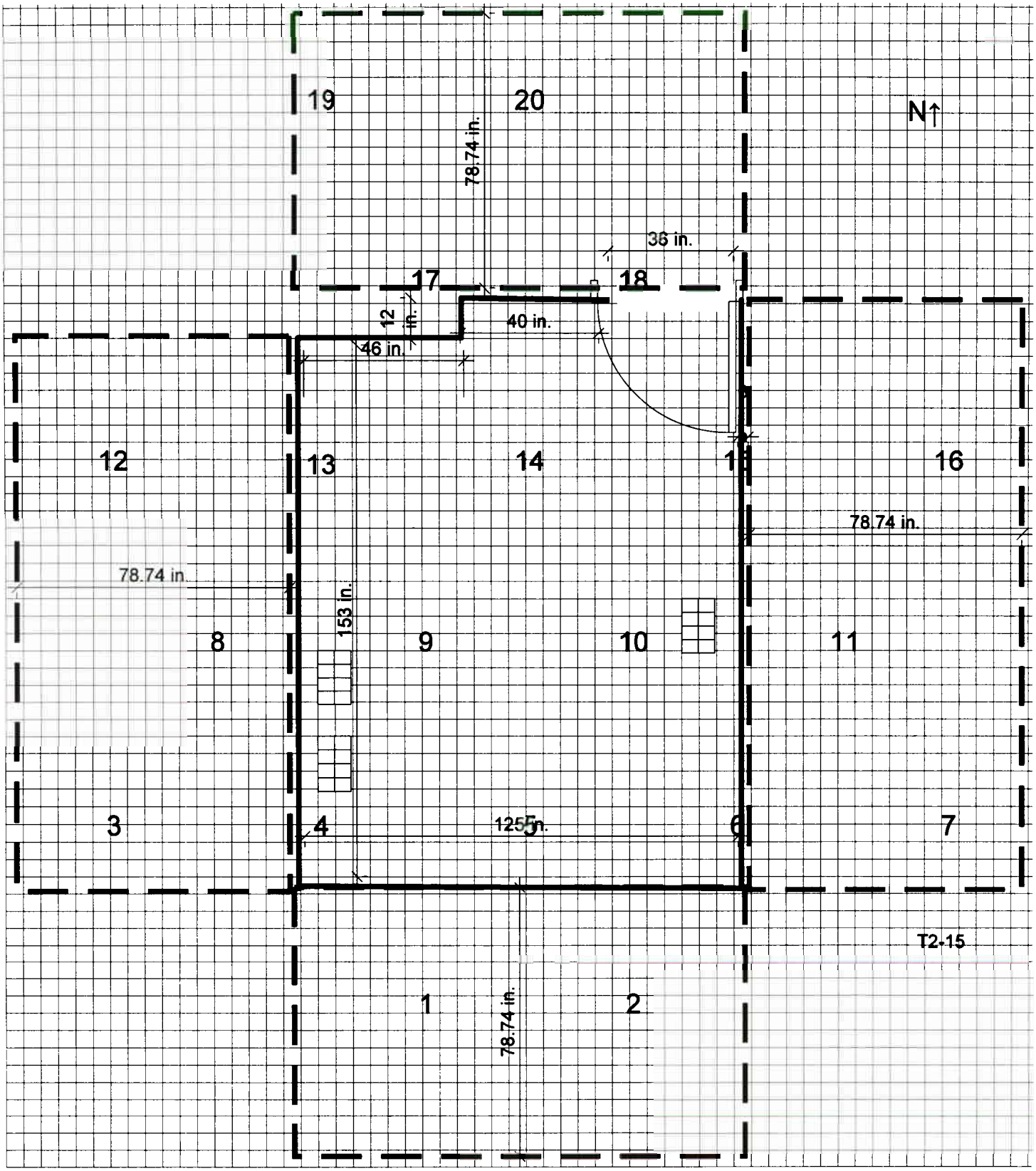
Building T-2 FSS Map Legend

I. Marker Descriptions

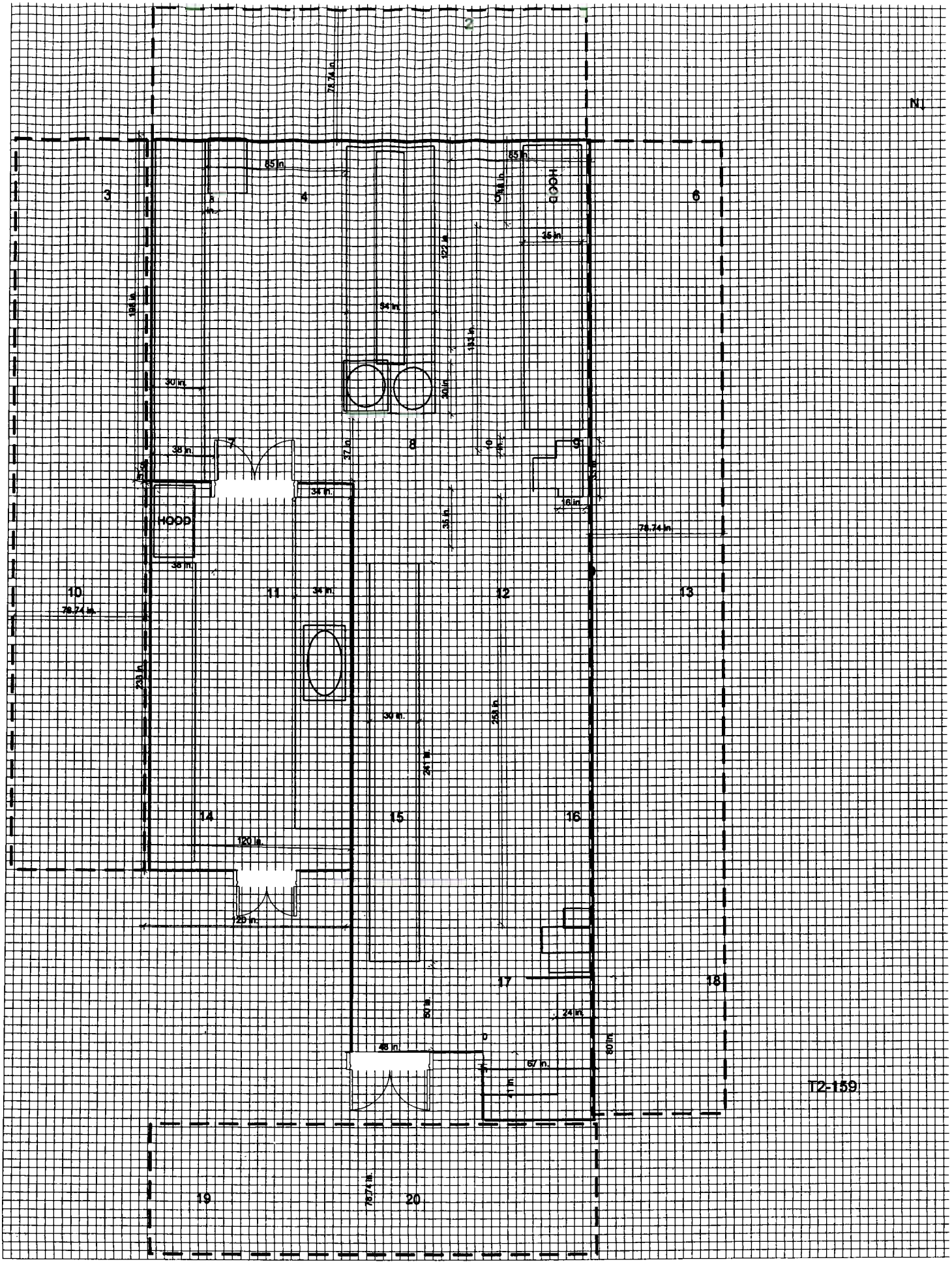
5, 18	Systematic Survey Location (1 or 2 digit identifiers)
■	Biased Fixed-Point Location
(H1)	Biased H-3 Fixed-Point Measurement with Windowless Proportional Counter
⟶	Arrow Noting Transfer of Systematic Location Due to Obstruction. The origination of the arrow represents where the sample was placed during survey design.
– – –	Wall Boundary

II. General Labeling Notes

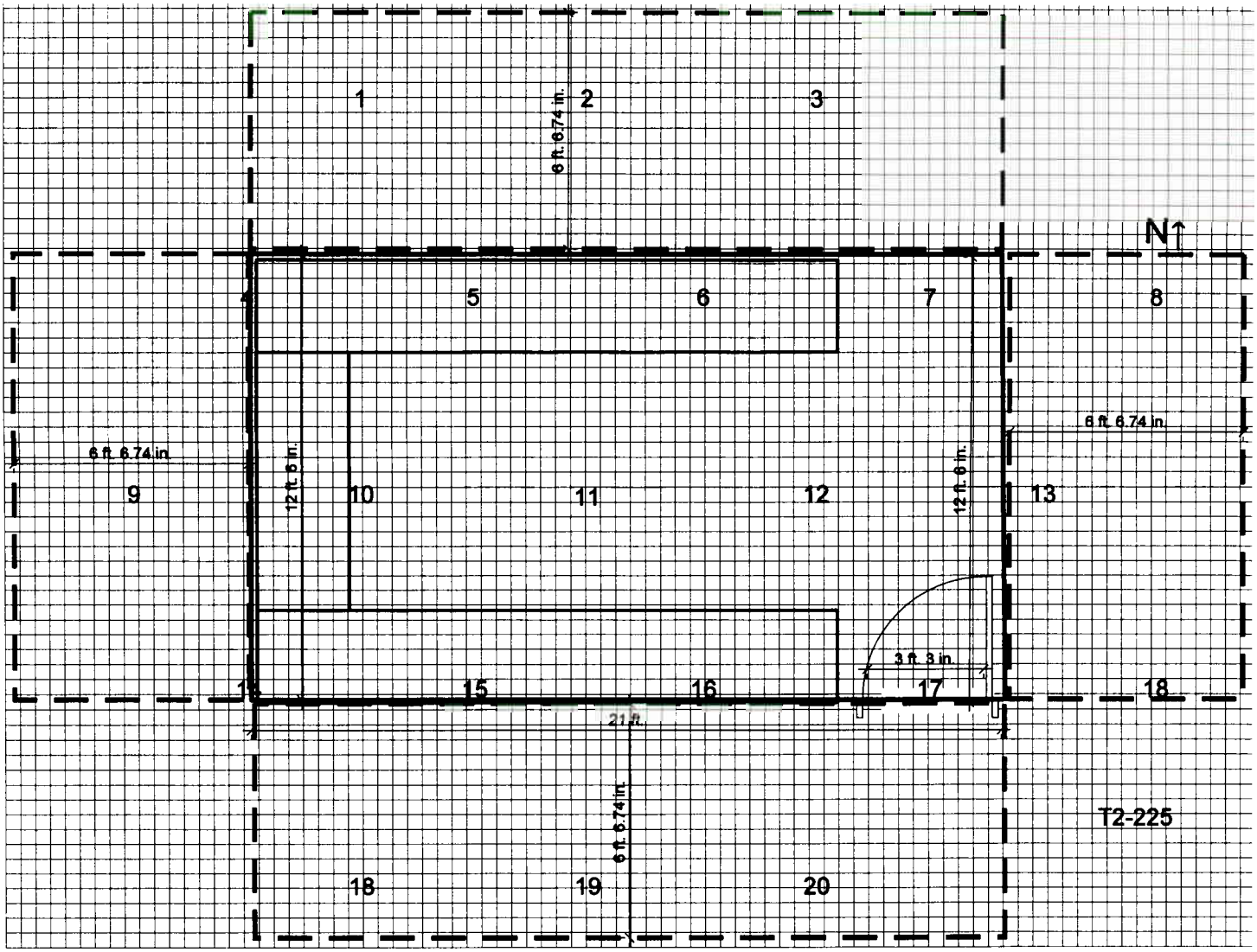
1. The overlaid grid has an approximate scale of 1 Square = 5 Inches.
2. The floor of the room is shown within the solid lines. The walls of each SU are depicted within the dashed lines, as if they were "unfolded" with an approximate height of 2 meters.
3. The systematic sample locations located within the dashed rectangular areas are actually located on the walls.



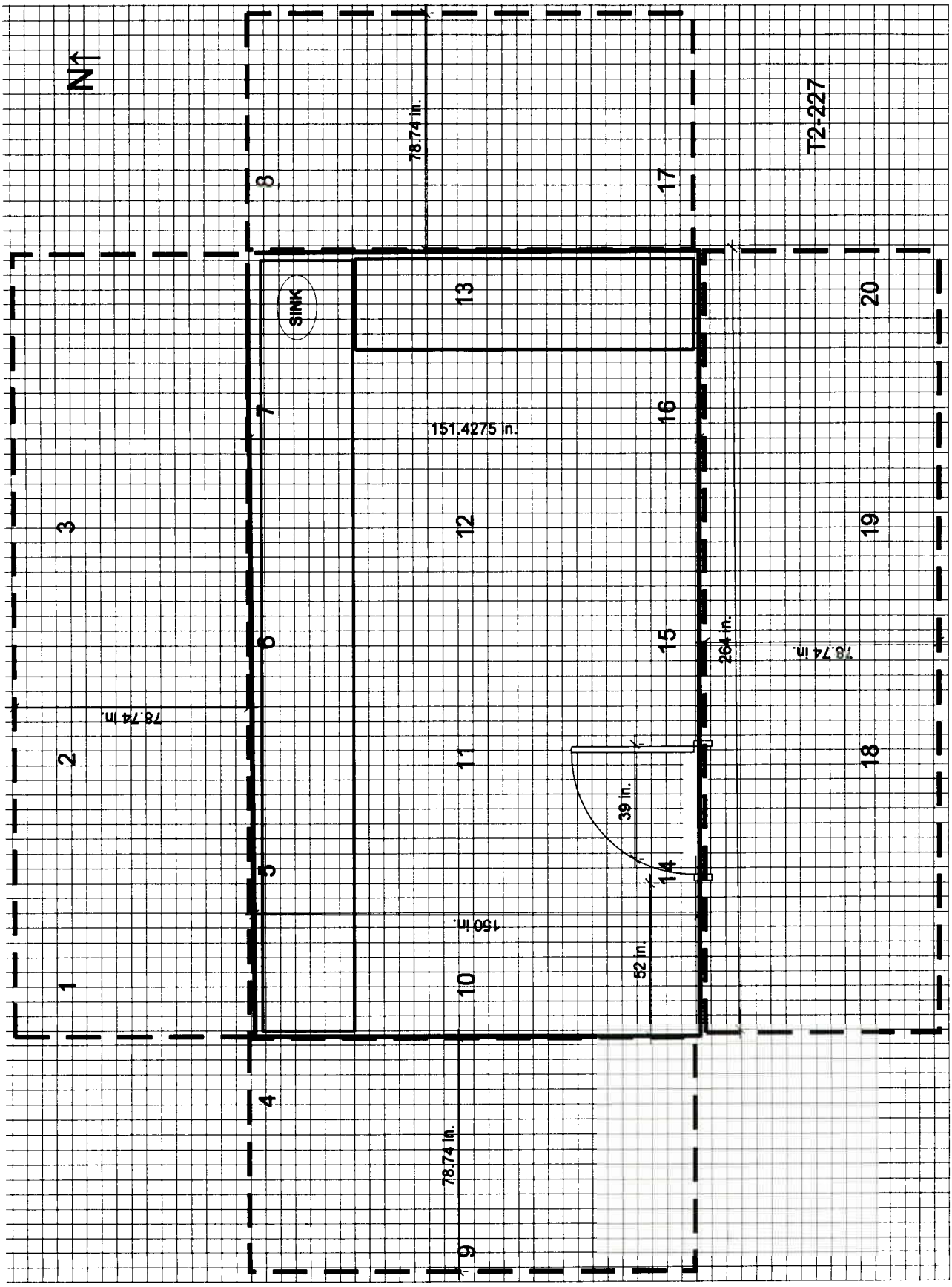
ROOM 15
WRAMC BLDG T-2



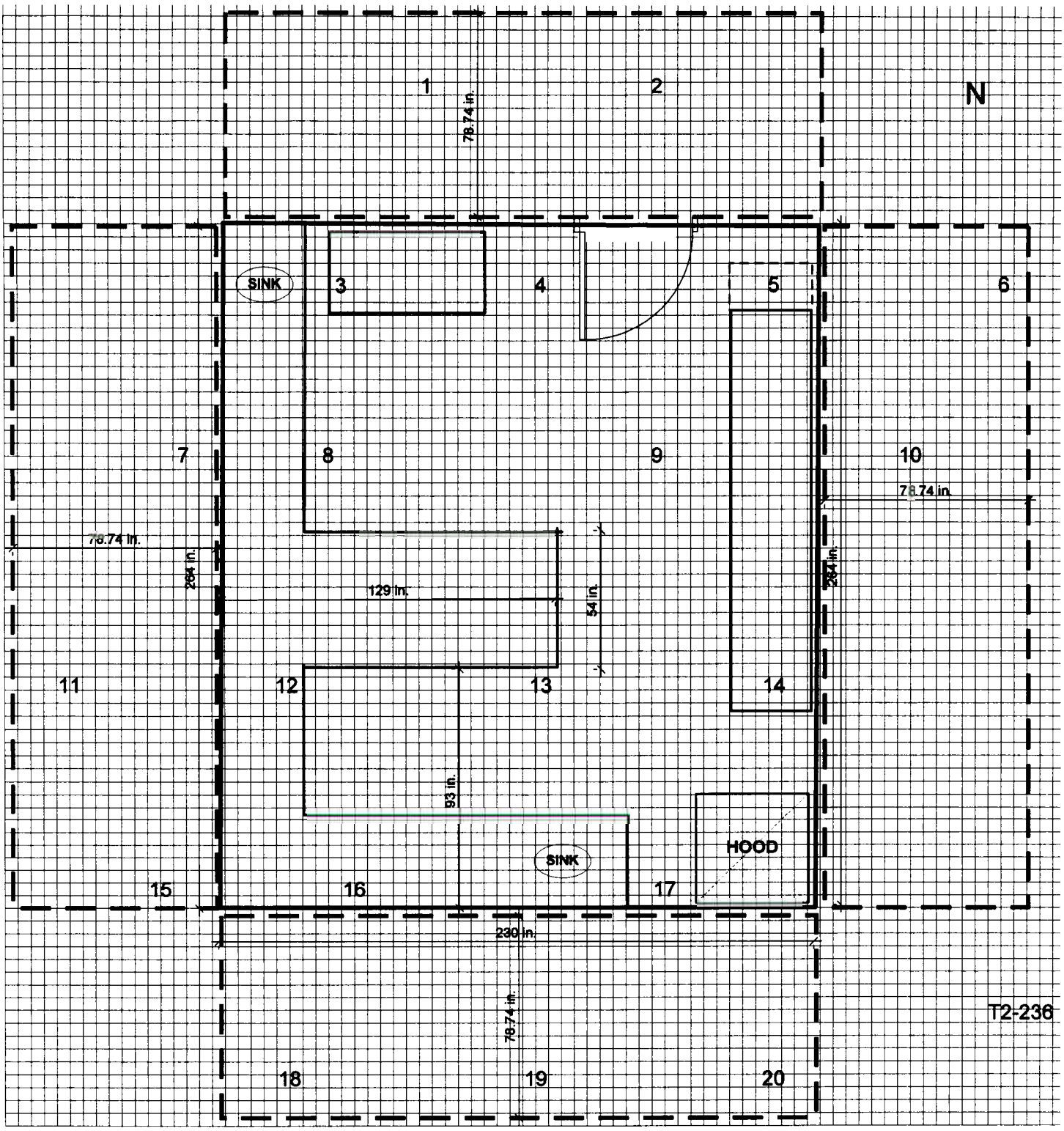
ROOM 159
WRAMC BLDG T-2



Room 225
WRAMC BLDG T-2

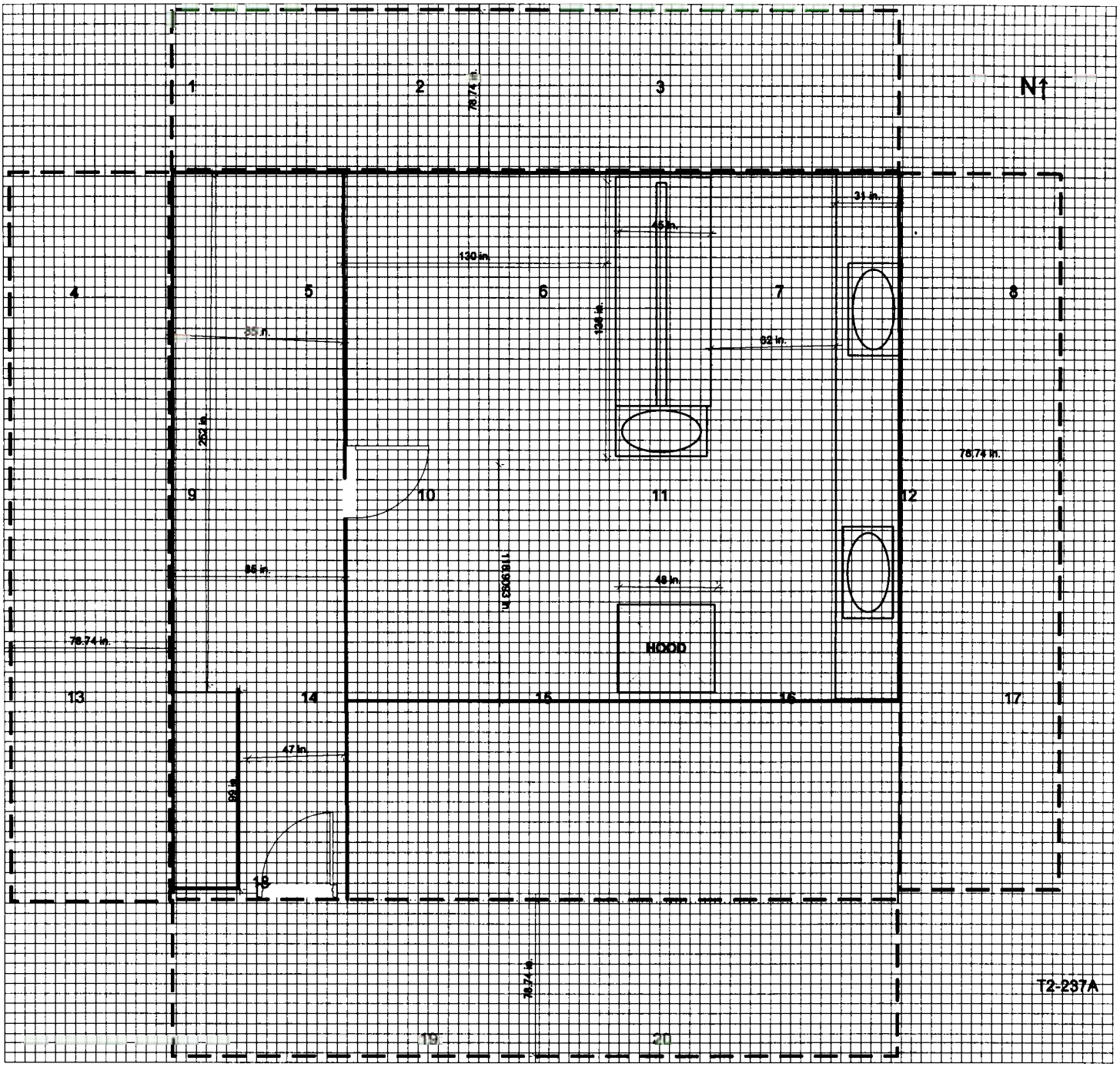


Room 227
WRAMC BLDG T-2



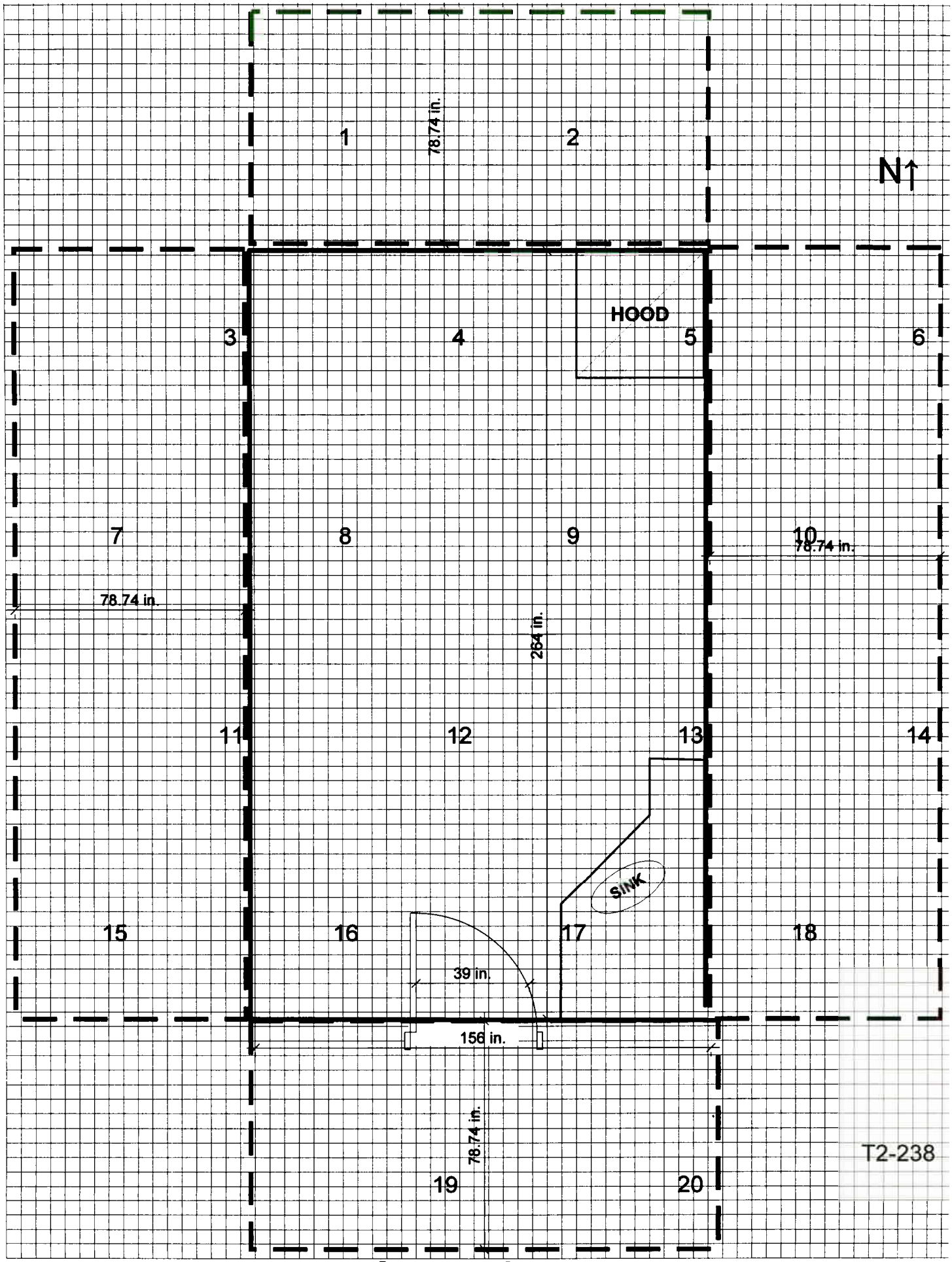
ROOM 236

WRAMC BLDG T-2

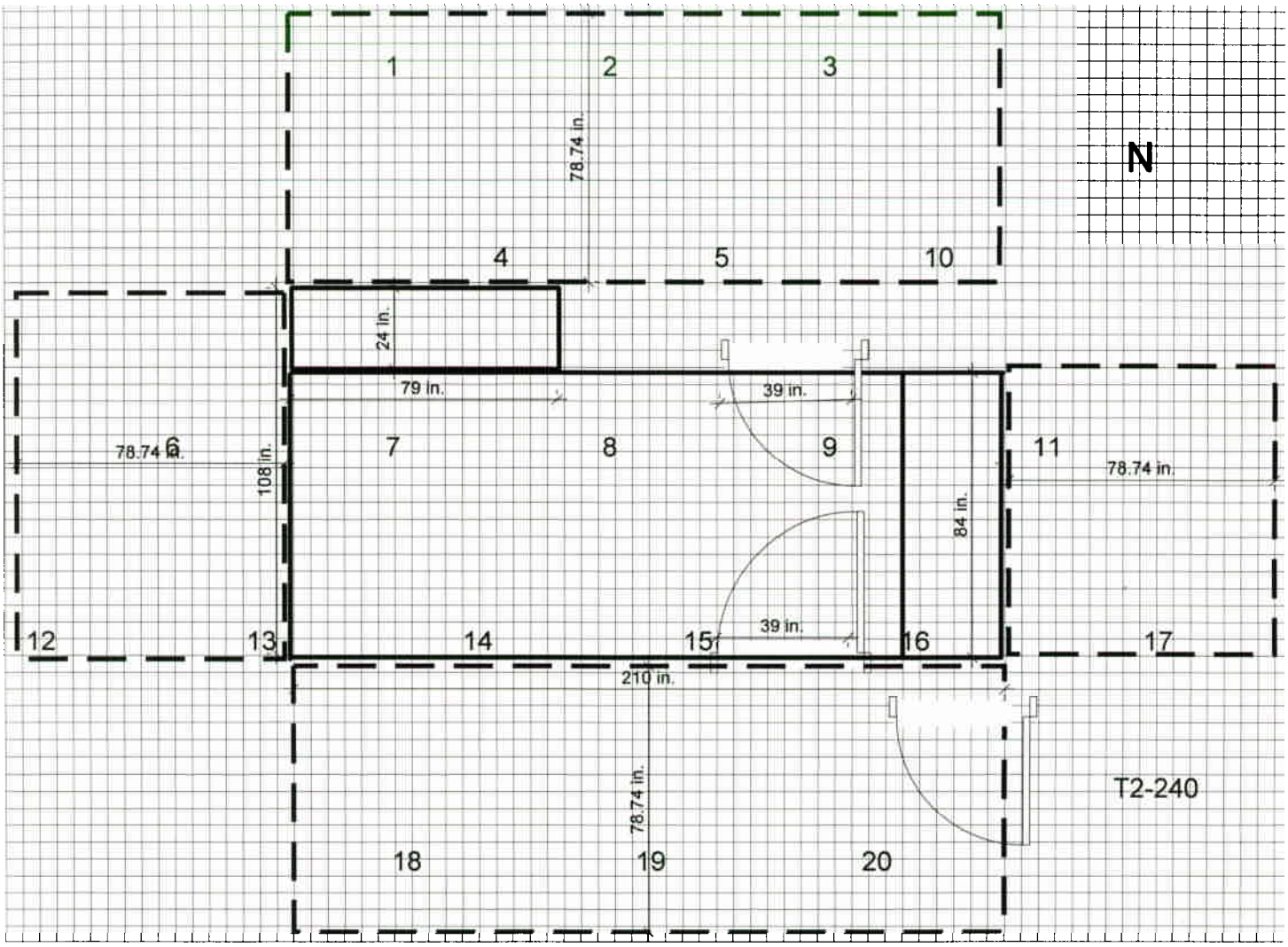


Room 237

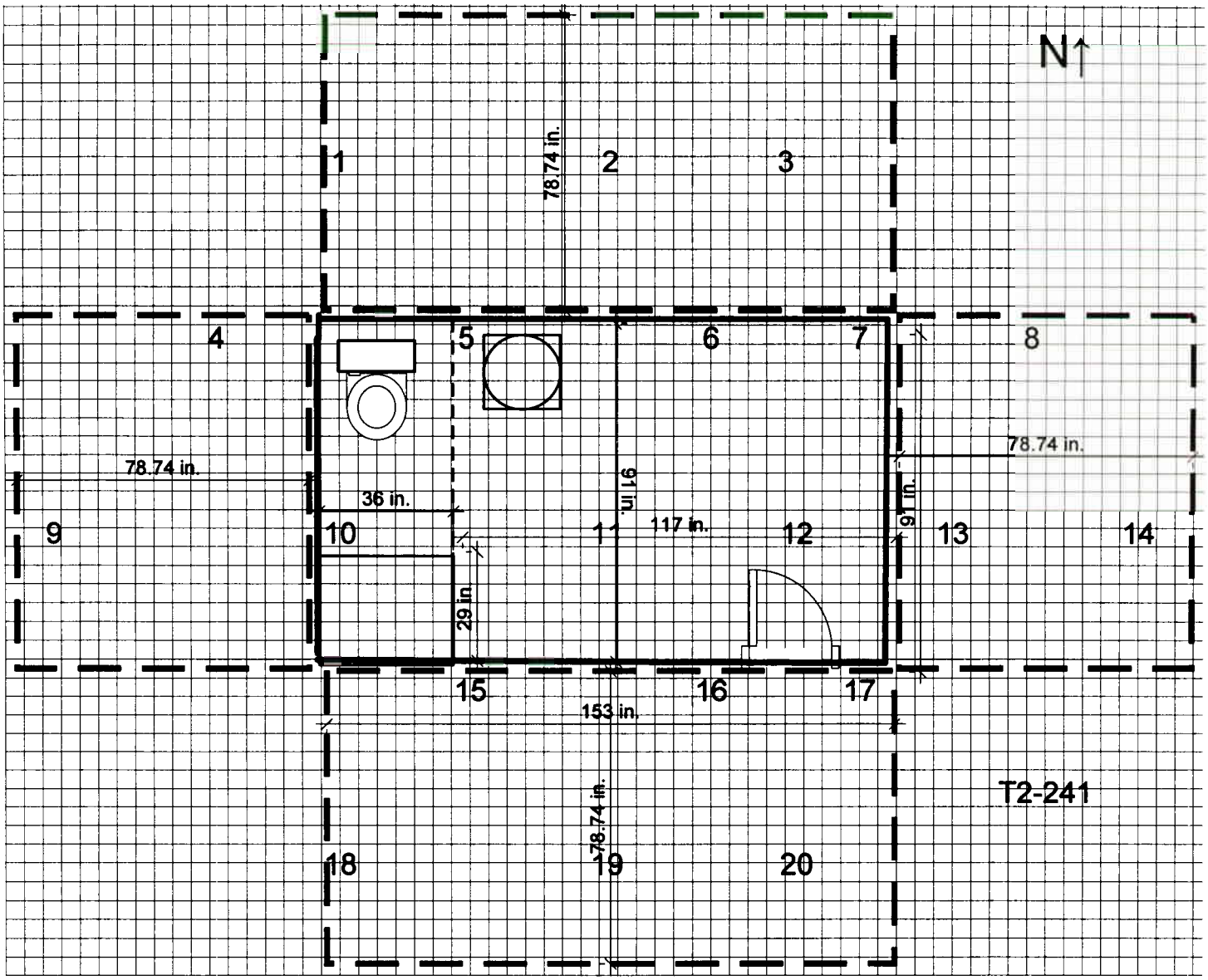
WRAMC BLDG T-2



ROOM 238
WRAMC BLDG T-2



Room 240
WRAMC BLDG T-2



Room 241

WRAMC BLDG 241

APPENDIX C

Building T-2 FSS Design and Protocol

INTRODUCTION

A major component of a survey design is the efficient use of sampling at distinct locations combined with scanning to accurately determine the final status of a SU. The statistical procedures described in this section are used to establish the number of samples taken at distinct locations needed to determine if the median concentration in the SU exceeds the regulatory limit, with a specified degree of precision. Thus, these statistical procedures are essential in the planning and design of the FSS and the analysis and interpretation of the resulting data.

The survey and sampling approach described below encompass both sampling at discrete points and scanning of building surfaces. In this manner, both the average concentration and elevated areas of residual radioactive material exceeding the cleanup criteria are addressed.
The following sections describe the MARSSIM process.

RADIONUCLIDES OF CONCERN

The radionuclides of concern (ROC) for the Building T-2 FSS are shown in Table C- 1.

Table C- 1. Radionuclides of Concern for Building T-2 FSS

ROC	Name	Principal Emissions	Screening DCGL (dpm/100 cm^2)[1]
H-3	Tritium	β^-_{max} (0.0186 MeV)	1.14E+08
C-14	Carbon-14	β^-_{max} (0.156 MeV)	3.4E+06
Ra-226[2]	Radium-226	β^+ (0.545 MeV) γ (1.275 MeV) γ (0.511 MeV)[3]	1.01E+03

Notes: 1. Screening DCGLs taken from NUREG-5512
2. Ra-226 is a ROC for Room 15 Only. As-Built drawings for Building T-2 indicated Room 15 as a 'Radium Storage Area.' No radioactive material authorizations or protocols found.

IDENTIFICATION OF SURVEY UNITS, CLASSIFICATION, AND DCGLS

As discussed in MARSSIM, site areas being final status surveyed should be classified according to their potential for residual radioactivity. The classification process is discussed in detail in MARSSIM Sections 2.2, 4.4, 5.5.2, and 5.5.3.

Nine rooms were identified as having the potential for residual contamination as a result of use or storage of radioactive materials. Although none had documented spills, the HPO decided to conservatively classify all 9 as MARSSIM Class 2 for the sake of this FSS. However, due to the history of radioactive material use in Building T-2 and no indication of contamination in review of historical documents, the upper wall and ceiling areas of each SU were considered Non-Impacted and as such were not investigated during this FSS.

Weighted room-specific DCGLs were formulated based on the findings of the Building T-2 HSA. A weighted DCGL was calculated using a surrogate approach to account for hard-to-detect radionuclides (HTDR), such as H-3, which cannot be directly measured in the field. The surrogate formula from the MARSSIM (NRC, 2000) is provided below:

$$DCGL_W = \frac{1}{\frac{Y_{H-3}}{DCGL_{H-3}} + \frac{Y_{C-14}}{DCGL_{C-14}} + \frac{Y_{other}}{DCGL_{other}}}$$

where: $DCGL_W$ = Weighted $DCGL_W$ for SU
Y_i = Abundance of each ROC in SU based on HSA findings
$DCGL_i$ = Screening DCGL for each ROC from NUREG-5512

A summary table of the Building T-2 SUs and calculated DCGLs is provided in Table C- 2.

Table C- 2. Building T-2 FSS SUs

Survey Unit (room)	SU Classification	Nuclide	Nuclide Fraction	Weighted $DCGL_w$ ($dpm/100cm^2$)	Notes
15	2	Ra-226	100.0%	**1.01E+03**	Notated as 'Radium Storage Room' on T2 as-built drawings. No records or surveys available to confirm.
159	2	H-3	35.0%		Short-lived nuclides decayed away.
		C-14	65.0%		
		Other	0.0%	**5.15E+06**	
225	2	H-3	57%		Short-lived nuclides decayed away.
		C-14	43%		
		Other	0%	**7.61E+06**	
227	2	H-3	86.0%		Short-lived nuclides decayed away.
		C-14	14.0%		
		Other	0.0%	**2.05E+07**	
236	2	H-3	27%		Short-lived nuclides decayed away.
		C-14	73%		
		Other	0%	**4.61E+06**	
237	2	H-3	33%		Short-lived nuclides decayed away.
		C-14	67%		
		Other	0%	**5.00E+06**	
238	2	H-3	33%		Short-lived nuclides decayed away.
		C-14	67%		
		Other	0%	**5.00E+06**	
240	2	H-3	86.0%		Short-lived nuclides decayed away.
		C-14	14.0%		
		Other	0.0%	**2.05E+07**	
241	2	H-3	86.0%		Short-lived nuclides decayed away.
		C-14	14.0%		
		Other	0.0%	**2.05E+07**	

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on the Sign Test. The Sign Test was chosen since the proportion of the DCGLs to the expected residual contamination is large enough to be considered insignificant despite the fact that both H-3 and C-14 are present in natural background (NRC, 2000). A secondary benefit of using the Sign Test is that a background reference area is no longer necessary to complete the evaluation.

The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected. The formulas used to calculate the number of samples are:

$$n = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4\left(SignP - 0.5\right)^2}.$$

and,

$$SignP = \Phi\left[\frac{\Delta}{\left(s^2_{sample} + \frac{s^2_{analytical}}{r}\right)^{1/2}}\right].$$

where:

$\Phi(z)$	is the cumulative standard normal distribution function,
n	is the number of samples,
s	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region, i.e., $DCGL_W$-LBGR
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. The calculations were performed using the Visual Sample Plan (VSP) software, ver. 2.2 (PNNL, 2002). VSP incorporates the MARSSIM statistical calculations into a visual user interface for easy SU design and sample placement. The values of these inputs that result in the calculated number of sampling locations are shown in Table C- 3. A summary of the dimensions of all reclassified SUs is also provided in Table C- 4.

Table C- 3. Summary of MARSSIM Design Parameters SUs

MARSSIM Design Parameter	Value
DCGL[1]	1
LBGR[1]	0.3
Δ (DCGL-LBGR)	0.7
Sigma	0.424
Type I Error Percentage (α)	2.5%
Type II Error Percentage (β)	5%
$Z_{1-\alpha}$	1.96
$Z_{1-\beta}$	1.645
MARSSIM Overage	20%
Minimum Number of SU Samples	20

[1] A sum of ratios (SOR) or 'unity rule' technique (MARSSIM Section 4.3.3) was used for determining the number of samples since multiple ROCs were used in Building T-2.

Systematic Measurement Spacing

Systematic measurement locations were laid out in each SU using a systematic triangular grid as outlined in MARSSIM Section 5.5.2.5. The grid spacing was calculated using the following equation:

$$L = \sqrt{\frac{A}{0.866n}}$$

where:

L = SU Grid Spacing
A = Area of Survey Unit
n = Number of Measurements in Survey Unit

Table C- 4. SU Information and Dimensions

Survey Unit Number	Class	Area[1] (ft^2)	Calculated Number of Samples	Triangular Grid Spacing (ft)
15	2	437	20	5.0
159	2	2023	24	9.8
225	2	698	21	6.3
227	2	724	24	6.5
236	2	957	23	7.4
237	2	1867	23	9.7
238	2	741	20	6.5
240	2	502	21	5.4
241	2	361	20	4.6

Notes: 1. The area of SU includes the lower wall areas to 2 meters.

The VSP software automatically calculated the triangular grid spacing and superimposed a triangular grid array over the footprint of each SU. The actual number of samples placed within each SU was variable depending upon its size and shape.

The coordinates of the sample locations were plotted on scaled diagrams of each SU shown in Appendix B for survey technicians to mark in the field. If the stated location was unavailable for survey due to an obstruction, it was moved to the closest relative position. Location movements of this kind are shown on the SU Maps with arrows depicting location movement.

Elevated Measurement Comparison (EMC)

There is no need for calculation of a $DCGL_{EMC}$ for these surveys since any areas found to exceed the $DCGL_W$ will be remediated and resurveyed until a satisfactory condition exists.

SURVEY INSTRUMENTATION AND TECHNIQUES

The purpose of this section is to describe direct radiation measurement, sample collection and analysis techniques that will be implemented during Building T-2 FSS. Physical and performance characteristics of each detector probe are provided in Table C- 5.

Weighted efficiencies were calculated for the 43-68 and 239-1F probes based on the abundance of HTDRs in each SU. In short, the beta efficiencies measured for C-14 were adjusted for the fraction of the nuclide mix that could not be detected using that probe. These calculations are shown in Table C- 7. These weighted efficiencies were used in FSS SU Data Sheets provided in Appendix A.

Table C- 5. Summary of Instrumentation for Building T-2 FSS

Detector / Instrument	Detector Type	Active Area (cm^2)	Window Density Thickness (mg/cm^2)	Radiation Sensitivity & Uses
Ludlum 43-68	Gas Proportional	126	0.4	Gross alpha / beta
Ludlum 239-1F Floor Monitor	Gas Proportional	582	0.8	Gross alpha / beta
Ludlum 44-110	Windowless Gas Proportional	126	N/A	H-3, Gross alpha / beta
Ludlum 44-20	3" x 3" NaI	N/A	N/A	Gross gamma

Beta Scan Surveys

MARSSIM suggests that scan surveys for Class 1 SUs be performed to cover 100% of the accessible areas in each SU. Class 2 SU scans can be performed over a minimum of 10% of the accessible areas. The purpose of the gamma/beta scan survey is to identify areas of elevated radioactivity so that biased locations can be identified and evaluated. The scan survey protocol used in Building T-2 was conservatively assigned to ensure that residual contamination at or near the DCGL would be detected. For the purposes of this FSS design, scan surveys were performed according to the criteria shown in Table C- 6 below:

Table C- 6. Building T-2 FSS Scan Survey Criteria

Survey Units	Description	Class	Scanning Criteria
All	Floors and work surfaces (countertops, sinks, hoods, fixtures)	2	100%
	Lower walls (below 2m)	2	25%
	Upper Walls (above 2m) and Ceilings	Not Impacted	N/A

Building floor surfaces were surveyed utilizing a Ludlum Model 239-1F floor monitor system. This cart system utilizes a Model 43-37 large-area gas flow proportional detector (approximately 582 cm^2 window area) supplied with P-10 counting gas. A Ludlum Model 2224 survey meter was used as the instrument package. The detector spacing was set to approximately 1 cm from the floor surface during scans. The floors were scanned by moving the floor monitor in straight paths at a speed of 1 probe width per second with spacing that will ensure that the minimum surface area is covered as required by the SU classification.

Floor monitor action levels were set to approximate 3-times the SU ambient background. Observed count rates in excess of this action level were flagged for investigation as a biased static count location.

Wall, countertop, and sink scans were performed using Ludlum 43-68 gas-flow proportional detector with 126 cm² window area. The 43-68 probe was moved at a speed of 1 probe-width per second over the surface at a height of 1 cm. Instrument action levels were set to twice the SU material-specific background levels. Action levels served as a trigger for performing biased static counts and wet swipes.

Gamma Scan Surveys

Scans for gamma contamination were also performed within all SUs in Building T-2. A 3×3 NaI detector in gross count rate mode was used to scan floor, counter, and wall surfaces in all SUs. The intent of these surveys was to identify potential gamma contamination that beta-sensitive instrumentation cannot effectively measure. Particular attention was paid to areas and installed equipment with the highest potential for residual contamination. Examples being sinks, fume hoods, floor drains, piping, etc.

Surveys were executed by installing the detector in a jig that allowed the operator to walk upright while suspending the detector approximately 1-inch off the surface of the floor. The operator used the audio output of the ratemeter to identify areas of elevated contamination. The action level for these surveys was 3-times the ambient background measurement taken in each room prior to beginning the survey.

Fixed-Point Surface Radioactivity Measurements

Fixed-point, or static, surface radioactivity measurements were performed with the same Ludlum Model 43-68 gas proportional detectors described above. Static counts were taken at all systematic, biased, and background survey locations in each SU as shown in Appendix A. All counts were 1-minute in duration with results recorded on the FSS Summary Data Sheets.

Determination of Background

Determination of background values is of the utmost importance in building decommissioning projects. Since 'Net' residual contamination values are used to assert whether Building T-2 satisfies release criteria for unrestricted use, both as direct comparison to $DCGL_W$'s and as input into the Sign Test, application of accurate and applicable background values is crucial to proper decision-making. In this light, significant efforts were made to characterize the background levels in Building T-2. Both ambient count rates and surface emission count rates from various building materials were taken in each SU. At a minimum, five 1-minute ambient background measurements were taken in the center of the room with the proportional detectors facing upward. This data is recorded in the "Ambient Background" line on each SU FSS Data Sheet (see Appendix A). A summary of the compiled background data is shown in Table C-8. Values from the table were subtracted from each sample location before data analysis was attempted.

Table C- 7. Calculated Weighted Instrument Efficiencies for each Building T-2 SU

Room/Area	FSS Class	Nuclide	Calculated Nuclide Fraction [A]	Probe[1]	Instrument Efficiency (2-pi) [B]	Assumed Surface Efficiency[2] [C]	Nuclide Weighted Efficiency [A*B*C]	Total Weighted Efficiency
15	2	Ra-226	100.0%	43-68	0.28	0.25	7.00%	**7.00%**
159	2	H-3	35.0%	43-68	0.00	0.10	0.00%	
		C-14	65.0%	43-68	0.28	0.25	4.55%	**4.55%**
225	2	H-3	57%	43-68	0.00	0.10	0.00%	
		C-14	43%	43-68	0.28	0.25	3.01%	**3.01%**
227	2	H-3	86.0%	43-68	0.00	0.10	0.00%	
		C-14	14.0%	43-68	0.28	0.25	0.98%	**0.98%**
236	2	H-3	27%	43-68	0.00	0.10	0.00%	
		C-14	73%	43-68	0.28	0.25	5.11%	**5.11%**
237	2	H-3	33%	43-68	0.00	0.10	0.00%	
		C-14	67%	43-68	0.28	0.25	4.69%	**4.69%**
238	2	H-3	33%	43-68	0.00	0.10	0.00%	
		C-14	67%	43-68	0.28	0.25	4.69%	**4.69%**
240	2	H-3	86.0%	43-68	0.00	0.10	0.00%	
		C-14	14.0%	43-68	0.28	0.25	0.98%	**0.98%**
241	2	H-3	86.0%	43-68	0.00	0.10	0.00%	
		C-14	14.0%	43-68	0.28	0.25	0.98%	**0.98%**

NOTES:

1. The Ludlum 43-68 proportional counter was outfitted with 0.4 mg/cm2 mylar windows for maximum low-energy beta efficiency.
2. Tritium (H-3) surveys were also performed using a Ludlum 44-110 window-less proportional counter. The asserted 5% 2-pi efficiency is de-rated from the factory-measured 37.8% 2-pi efficiency quoted in most recent Ludlum calibration.
3. As per guidance in ISO-7503. The surface efficiency used for H-3 surveys with the 44-110 was chosen to be 10%.

Table C- 8. Measured Background Count Rates for Various Surfaces in Building T-2

	Material	Wall Board	Vinyl Floor Tile	Laminate Countertops	Synthetic Stone Countertops	Wood	Metal Wall Surfaces	Stainless Steel
Probe	*Reference Room*[2]	*223*	*223*	*252*	*252*	*223*	*223*	219
43-68 S/N RN 011354	*Mean*	165.8	224.6	192.2	373.6	159.6	185.4	200.0
(0.4 mg/cm2)	*Std Dev (1s)*	9.0	10.9	4.7	13.5	2.5	6.7	12.7

NOTES:

1 CPM values are mean and standard deviation of (5) 1-minute counts with 43-68 probe.

2 Chosen reference rooms are unimpacted rooms in Building T-2 with similar building materials as those surveyed.

Minimum Detectable Concentrations (MDCs)

Fixed-Point MDCs

MDCs for fixed-point measurements were calculated using the conventional formula for equal background and sample count times of 1 minute.

$$\mathrm{MDC}_{\mathrm{static}}\left(dpm/100cm^2\right) = \frac{3 + 4.65\sqrt{R_b}}{Eff * 1.26}$$

where: R_b is the background count rate in cpm
Eff is the instrument 2-pi beta efficiency.
1.26 is the active area correction factor for the 43-68 probe

MDC's were calculated for the Ludlum 43-68 proportional detectors in each SU since the instrument total efficiency varied due to the effect of HTDRs. Planning MDCs were calculated for each SU based on the highest material-specific background value in each SU. These are shown at the top of each FSS Summary Data Sheet in Appendix A. Planning static MDCs ranged from 7.93E+02 to 2.55E+04 dpm per 100 cm^2. The wide range of values was due to the fluctuating total efficiency of the 43-68, which varied inversely with the proportion of H-3 in the nuclide mix.

Scan MDCs

Planning Scan MDC's were developed in accordance with guidance in NUREG-1507 for all detectors used for scanning purposes during the Building T-2 FSS. The instrument probe combinations used for scanning included the Ludlum Model 239-1F Floor Monitor with model 43-37 gas-flow proportional detector (582 cm^2 active area) and Ludlum Model 2350 with Model 43-68 gas-flow proportional detectors (126 cm^2 active area). The MDCs were calculated using maximum background count rates observed during initial QC activities and a nominal instrument total efficiency of 1%, taking into consideration the inability to detect H-3. The calculations for the Ludlum 239-1F floor monitor and the Ludlum 43-68 probe are provided below.

Scan MDC calculations are also provided for Room 15 as a special case since Ra-226 is the only documented ROC. Therefore, the instrument efficiencies are not de-rated for the presence of HTDRs.

MAXIMUM SCAN MDC FOR LUDLUM 239-1F FLOOR

Instrument: Ludlum 2224 **S/N:** 119772
Probe: Ludlum 43-37 (0.8 mg/cm^2) **S/N:** PR123464

Index of Sensitivity from MARSSIM Table 6.5	1.38
False Positive Proportion	0.6
False Negative Proportion	0.95
Observation Interval (seconds):	1
Background Count Rate (CPM):	1100
MDCR (Net CPM):	**354.5**
Scan Sensitivity (Gross CPM):	**1454.5**

From Eqn 6-10 of MARSSIM, the Scan MDC can be estimated using:

Surveyor Efficiency:	0.5
Instrument Total Efficiency:	0.01
Surface Efficiency:	0.25
Probe Area Correction (Physical Probe Area /100 cm^2):	528
Scan MDC (dpm/100cm^2):	**3.80E+04**

MAXIMUM SCAN MDC FOR LUDLUM 43-68 PROBE

Instrument: Ludlum 2350 **S/N:** 120619
Probe: Ludlum 43-68 (0.4 mg/cm^2) **S/N:** RN011354

Index of Sensitivity from MARSSIM Table 6.5		1.38
False Positive Proportion	0.6	
False Negative Proportion	0.95	
Observation Interval (seconds):		1
Background Count Rate (CPM):		325
MDCR (Net CPM):		**192.7**
Scan Sensitivity (Gross CPM):		**517.7**

From Eqn 6-10 of MARSSIM, the Scan MDC can be estimated using:

Surveyor Efficiency:	0.5
Instrument Total Efficiency:	0.01
Surface Efficiency:	0.25
Probe Area Correction (Physical Probe Area /100 cm^2):	126

Scan MDC (dpm/100cm^2): 1.66E+05

ROOM 15 SCAN MDC FOR LUDLUM 239-1F FLOOR MONITOR (Ra-226)

Instrument: Ludlum 2224 **S/N:** 119772
Probe: Ludlum 43-37 (0.8 mg/cm^2) **S/N:** PR123464

Index of Sensitivity from MARSSIM Table 6.5		1.38
False Positive Proportion	0.6	
False Negative Proportion	0.95	
Observation Interval (seconds):		1
Background Count Rate (CPM):		1100
MDCR (Net CPM):		**354.5**
Scan Sensitivity (Gross CPM):		**1454.5**

From Eqn 6-10 of MARSSIM, the Scan MDC can be estimated using:

Surveyor Efficiency:	0.5
Instrument Total Efficiency:	0.11
Surface Efficiency:	0.25
Probe Area Correction (Physical Probe Area /100 cm^2):	528

Scan MDC (dpm/100cm^2): 3.45E+03

ROOM 15 SCAN MDC FOR LUDLUM 43-68 PROBE (Ra-226)

Instrument: Ludlum 2350 **S/N:** 120619
Probe: Ludlum 43-68 (0.4 mg/cm^2) **S/N:** RN011354

Index of Sensitivity from MARSSIM Table 6.5	1.38
False Positive Proportion	0.6
False Negative Proportion	0.95
Observation Interval (seconds):	1
Background Count Rate (CPM):	325
MDCR (Net CPM):	**192.7**
Scan Sensitivity (Gross CPM):	**517.7**

From Eqn 6-10 of MARSSIM, the Scan MDC can be estimated using:

Surveyor Efficiency:	0.5
Instrument Total Efficiency:	0.28
Surface Efficiency:	0.25
Probe Area Correction (Physical Probe Area /100 cm^2):	126
Scan MDC (dpm/100cm^2):	**5.68E+03**

Swipe Measurements for Removable Contamination

Removable contamination measurements were assessed by using water-dampened smears. These 'wet swipes' were taken at each systematic and biased fixed-point location on floor, lower wall, and work surfaces by applying moderate pressure in a "S" pattern to approximate a 100 cm^2 area.

APPENDIX D

Instrument Quality Control

INSTRUMENT CALIBRATION

All instruments used during the course of the survey were in current calibration traceable to the NIST.

QUALITY CONTROL TRACKING

Quality Control (QC) measurements were performed daily prior to any survey data being collected. A controlled area was used to perform these checks. The QC criteria for the instruments used during daily surveys were defined as follows:

Tight quality controls were administered to ensure that the data reported is of the highest quality. If any single measurement were found to be outside of 3σ (Investigation Level), the measurement was repeated. If the second count was also found to be outside of 3σ, the instrument was investigated to assess if any external biases or instrument physical damage was present.

Quantitative Instruments

Instruments used in this category were the Ludlum model 2350 data logger and the Ludlum model 2221 scaler/ratemeter. These instruments were designated as 'quantitative,' meaning that activity determinations (i.e. dpm/100cm^2) could be made using these instruments. Daily performance checks of these instruments included daily background and source checks with Carbon-14. These results were plotted on control charts and compared with ±2σ and ±3σ boundary markers.

Administration of QC for the Ludlum 2350 was handled in the following manner. Each daily background and source measurement was recorded and the resulting counts plotted on the control chart. The tolerance bands on each control chart were determined from repeated baseline measurements taken at the beginning of the survey effort. If any point was found to reside outside of 3σ, the instrument could still be used provided that the condition did not occur on two consecutive tries. Control charts for each instrument are shown in the figures that follow.

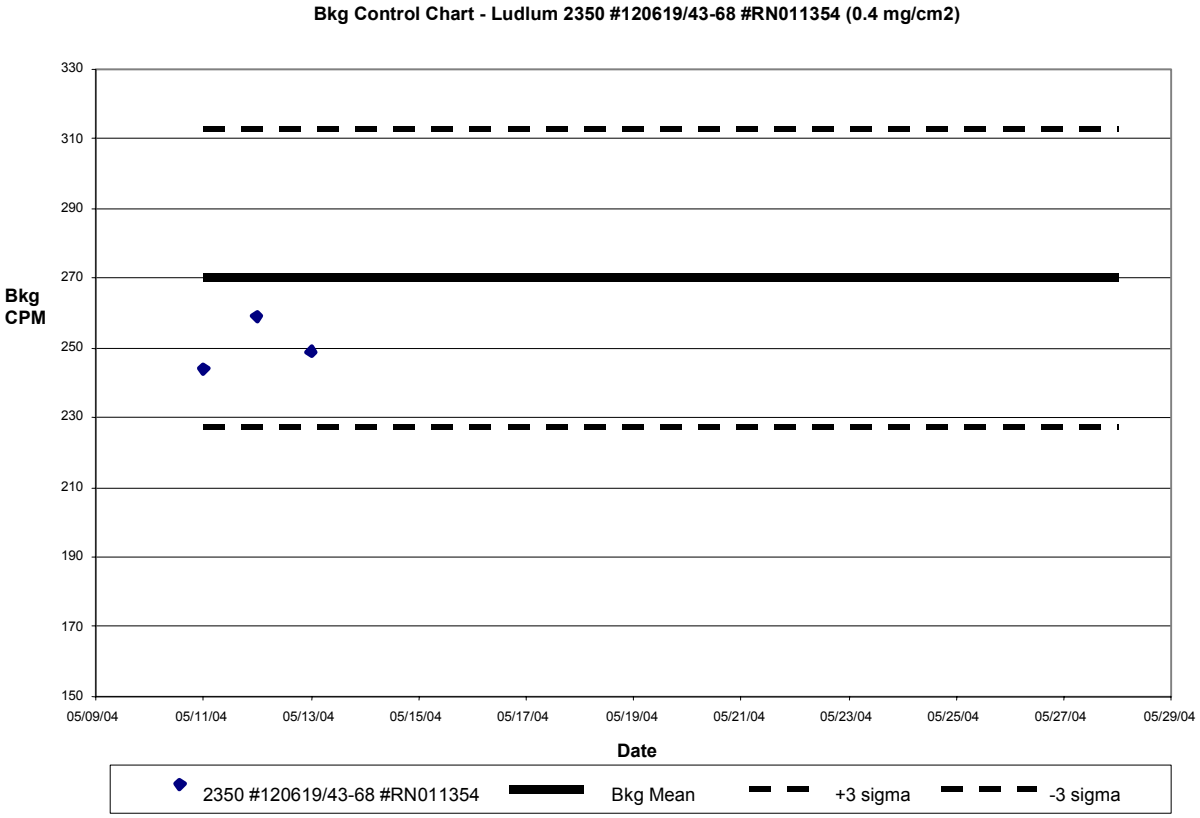


Figure E- 1. Background QC Control Chart for Ludlum 2350 SN 120619 and 43-68 SN RN011354

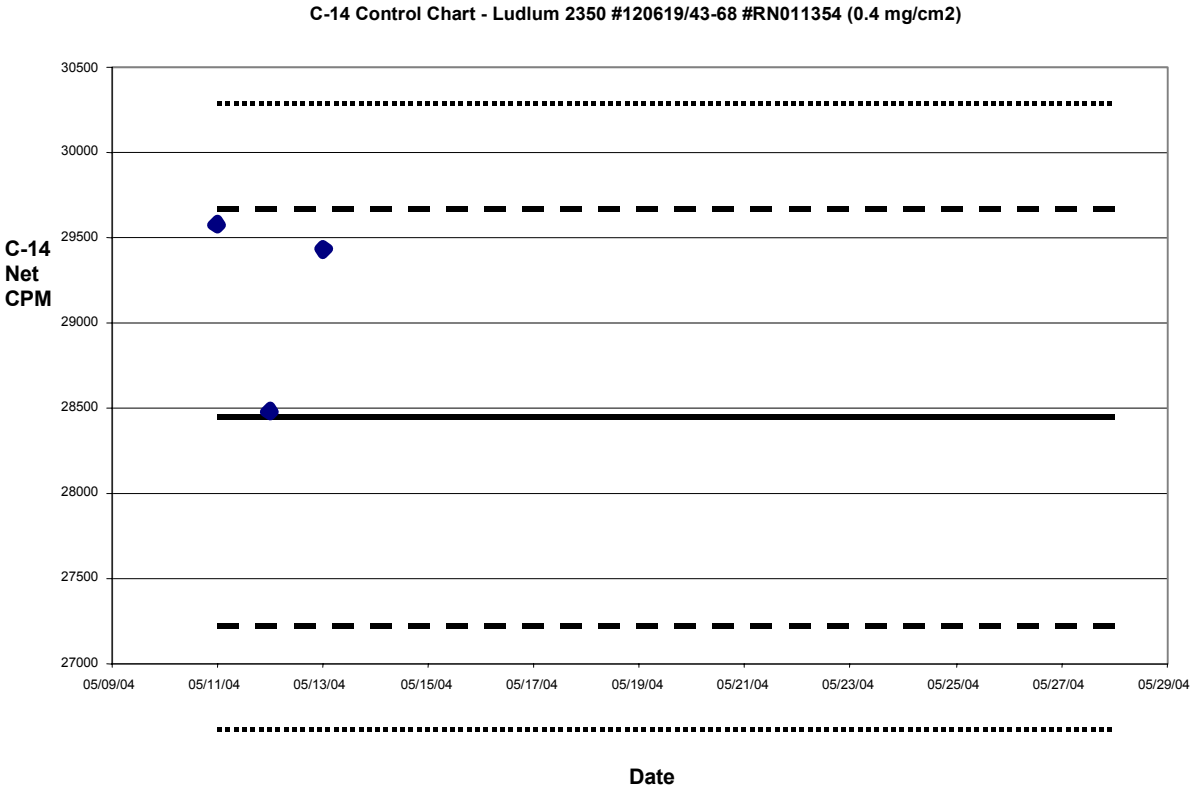


Figure E- 2. C-14 QC Control Chart for Ludlum 2350 SN 120619 and 43-68 SN RN011354

Qualitative Instruments

This category includes all hand-held survey instruments. These instruments were checked daily against a ±20% performance criteria established at the beginning of the survey. If any single measurement was found outside of ±20%, the instrument was taken out of service and investigated. The instruments in this category were those used for gamma walkover surveys, surveillance control and frisking. Instruments in this category were the Ludlum model 2221 equipped with a 44-20 NaI probe and Ludlum Model 239-1F Floor Monitor.

The QC charts for each of these instruments are provided below. As described for the quantitative instruments, the daily measurements were compared to a set of baseline data collected at the beginning of the survey.

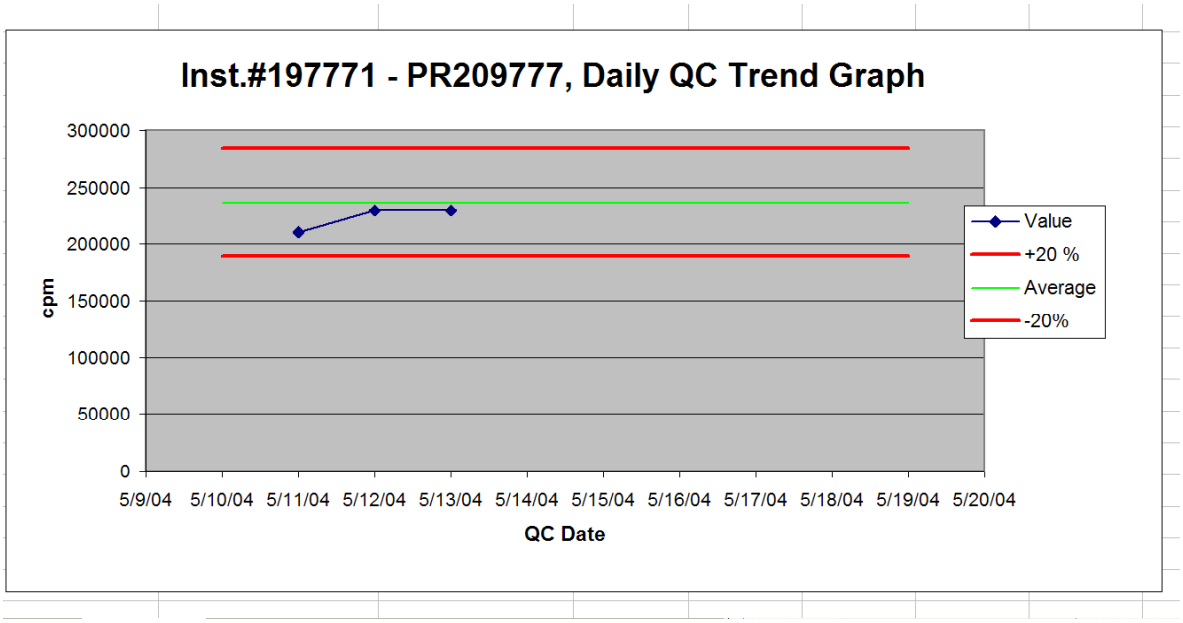


Figure E- 3. Cs-137 QC Control Chart for Ludlum 2221 SN 197771 and 44-20 NaI SN PR209777

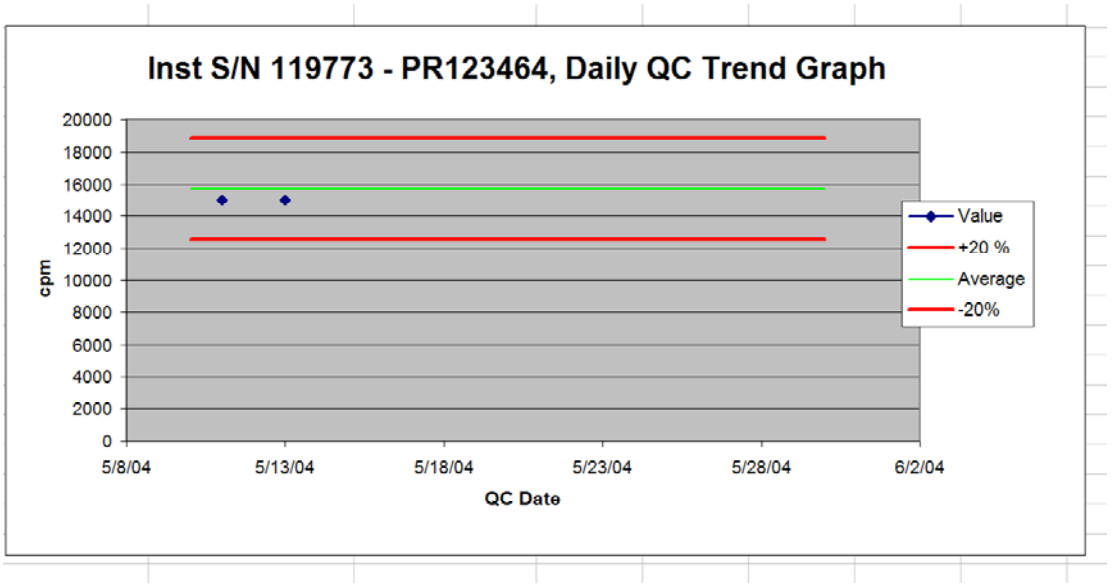


Figure E- 4. C-14 QC Control Chart for Ludlum 239-1F FM SN 119773 and 43-37 SN PR123464