IUPUI/IUMC
Wishard Hospital
Decommissioning Final Status Report

NRC License Number 13-02752-03

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Prepared:	Mike Culp	Project Manager	Date:	12-27-13
Technical Review:	Patrick McDermott	Certified Health Physicist	Date:	1-7-14
Approved:	Dave Culp	Radiological Engineer	Date:	1-7-14

Prepared by:
Chase Environmental Group, Inc.
109 Flint Road
Oak Ridge, TN 37830
865-481-8801

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ACRONYMS

ALARA	As Low As Reasonably Achievable
CFR	Code of Federal Regulations
DCGL	Derived Concentration Guideline Level
$DCGL_{EMC}$	Derived Concentration Guideline Level – Elevated Measurement Comparison
$DCGL_W$	Derived Concentration Guideline Level – Wilcoxon Rank Sum
DWP	Decommissioning Work Plan
DQO	Data Quality Objective
DSV	Default Screening Value
EOP	East Outpatient Building
FSS	Final Status Survey
FSSR	Final Status Survey Report
HHC	Health and Hospital Corporation of Marion County
HSA	Historical Site Assessment
IUPUI/IUMC	Indiana University at Indianapolis/Indiana University Medical Center
LBGR	Lower Bound of the Gray Region
LSC	Liquid Scintillation Counter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NORM	Naturally Occurring Radioactive Materials
NRC	U.S. Nuclear Regulatory Commission
NIST	National Institute of Standards and Technology
PGM	Pancake Geiger-Mueller
QA	Quality Assurance
TEDE	Total Effective Dose Equivalent
WOP	West Outpatient Building

1.0 EXECUTIVE SUMMARY

Indiana University at Indianapolis/Indiana University Medical Center (IUPUI/IUMC) has decided to permanently cease licensed activities under US Nuclear Regulatory Commission (NRC) Broad Scope radioactive materials license number 13-02752-03 at Wishard Hospital. Wishard Hospital, located at 1001 W. 10th St. Indianapolis, IN 46202, consists of 15 buildings over 25 acres of property. IUPUI/IUMC plans to raze or repurpose the buildings. Based upon records maintained by the IUPUI/IUMC Radiation Safety Office, radioactive materials were used or stored in the Myers Building, the West Outpatient Building and the East Outpatient Building. See Appendix A for a site map. IUPUI/IUMC plans to release these buildings for unrestricted use.

Facilities include research laboratories, offices, and other support areas. Radioactive materials used at the facilities consisted of a variety of beta and gamma emitting radionuclides for medical research and imaging. Primarily these included C-14, H-3, I-125, P-32, and S-35, with much lesser quantities of other tracers and imaging nuclides. Based on an analysis of the default screening values (DSVs), quantities used, physical forms, half-lives, and receipt and distribution records, only C-14, Ca-45, Cl-36, Co-57, Fe-55, H-3, and Na-22 are of concern for decommissioning.

Over the years, IUPUI/IUMC has conducted closeout surveys of rooms where radioactive materials were used at the conclusion of licensed activities. IUPUI/IUMC retained Chase Environmental Group (Chase) to perform independent third party verification of closeout procedures using current decommissioning protocols. Decommissioning was conducted under the provisions of Chase Commonwealth of Kentucky radioactive materials license number 201-605-90, utilizing a reciprocal agreement with the NRC, and in accordance with a Decommissioning Work Plan (DWP). The DWP was developed using the guidance provided in NUREG 1757, "Consolidated NMSS Decommissioning Guidance"; and NUREG 1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM). Final status surveys (FSS) were designed to implement the protocols and guidance provided in MARSSIM to demonstrate compliance with the DSVs specified in NUREG 1757, Volume 1, Appendix B. These methods ensured technically defensible data were generated to aid in determining whether or not the facilities meet the release criteria for unrestricted use specified in 10 CFR 20 Subpart E.

IUPUI/IUMC established conservative ALARA goals for building structural surfaces and systems based on the release criteria specified in NUREG 1556, Volume 7, Table Q.2, "Acceptable Surface Contamination Levels for Equipment." Specifically, the following surface contamination limits were used:

- 5,000 dpm/100 cm^2 total surface contamination
- 500 dpm/100 cm^2 removable surface contamination

On-site activities were performed from December 16, 2013 to December 20, 2013. No residual radioactivity was detected during characterization and final status surveys.

This report presents sufficient data to confirm IUPUI/IUMC's determination that the facility is suitable for unrestricted release in accordance with NRC requirements. Final status surveys demonstrate that building structural surfaces and systems included in the scope of this report are below release criteria and are suitable for unrestricted release. All final status surface contamination measurements were a small fraction of the DSVs. Based on the Building Occupancy Scenario of NRC DandD dose modeling software Version 2.1, **the Total Effective Dose Equivalent (TEDE) to an average member of the critical group is 0.91 mrem/year (<4% of the release criterion of 25 mrem/yr). This result is very conservative as we use** the results of the survey unit with the highest average activity and the DSV of the most limiting nuclide.

2.0 SITE DESCRIPTIONS AND HISTORY

2.1 Historical Site Assessment

IUPUI/IUMC performed a Historical Site Assessment (HSA) to determine nuclides used and locations of usage. Wishard Hospital, established in 1855, consists of 15 buildings over 25 acres of property. Facilities included in the scope of this report consist of portions of three contiguous buildings including the main portion of Wishard Hospital (Myers Building), the West Outpatient Building (WOP), and one room in the East Outpatient Building (EOP). Radioactive materials were used on the basement, 6th, and 7th floors of the Myers Building; on the 3rd, 4th, and 5th floors of the WOP Building; room S301 in the EOP Building; and nuclear medicine areas located on the Myers Building basement, first, and third floors. Impacted areas consist of laboratories, offices, and other support areas. Impacted areas are constructed with concrete block or sheetrock walls; metal or plastic casework, fume hoods and sinks; composite or laminate benchtops; and vinyl flooring in lab areas.

Many areas have been renovated since being closed out. The entire 6th floor of the Myers building underwent complete renovation from laboratory space to patient rooms and support areas. The renovation involved removal and disposal of all fixtures and exposed surfaces, including ventilation and drain systems. IUPUI/IUMC plans to continue usage of radioactive materials on the 7th floor of the Myers Building. Decommissioning surveys of the Myers Building 7th floor are expected to occur in the Spring of 2014.

Impacted areas are serviced by three impacted systems – fume hood ventilation exhaust, vacuum, and drain systems. Building drains are discharged directly to the sewer system without treatment or retention. Ventilation exhaust is provided primarily via fume hoods to maintain laboratory areas at a negative pressure relative to hallway and office areas. A central vacuum system in the WOP services a portion of the impacted laboratories.

Impacted building floor plans are provided in Appendix B.

2.2 Ownership

The facilities are currently owned by the Health and Hospital Corporation of Marion County (HHC) and are included as part of the IUPUI/IUMC license facilities. In 2009, IUPUI/IUMC and HHC entered into a land-swap contract as part of a public referendum to construct an entirely new medical complex on the northwest side of the IUPUI campus. The land-swap includes Wishard Hospital, therefore IUPUI/IUMC is assuming ownership of the Wishard Hospital buildings and land.

2.3 Potential Contaminants

The table below lists the nuclides used in dispersible form at Wishard Hospital. This list was compiled through review of radionuclide receipt and distribution records.

Table 2-1: Radionuclides Used in Dispersible Form

Nuclide	Half-life (years)	Predominant Emissions
C-14	5.7E+03	Weak Beta
Ca-45	4.5E-01	Beta
Ce-141	8.9E-02	Beta/Gamma
Cl-36	3.0E+05	Beta
Co-57	7.4E-01	Gamma
Cr-51	7.6E-02	Gamma
Fe-55	2.7E+00	Weak Gamma
Fe-59	1.2E-01	Beta/Gamma
H-3	1.2E+01	Weak Beta
I-125	1.6E-01	Weak Gamma
I-131	2.2E-02	Beta/Gamma
In-111	7.8E-03	Gamma
Na-22	2.6E+00	Positron/Gamma
P-32	3.9E-02	Beta
P-33	7.0E-02	Beta
Rb-86	5.1E-02	Beta/Gamma
S-35	2.4E-01	Beta
Sr-85	1.8E-01	Gamma
Tc-99m	6.8E-04	Gamma

2.4 License Information

IUPUI/IUMC is currently operating under NRC broad scope materials License Number 13-02752-03.

2.5 Operational and Closeout Radiological Surveys

During the HSA, the radiological status of impacted facilities was determined by reviewing historical survey records and interviewing Radiation Safety personnel. Routine surveys were performed by authorized users during the period of usage. These surveys focused on specific areas of usage within each room as well as surrounding areas to ensure that residual contamination did not exist above their local action level for removable surface contamination (200 cpm/100 cm^2). Additionally, when areas no longer needed to use radioactive materials, closeout surveys were performed consisting of wipe surveys for removable radioactivity and for more recent surveys, direct scan surveys of surfaces with a pancake Geiger-Mueller (PGM) detector. Any identified areas of elevated activity were decontaminated and re-surveyed until the operational limits of background for PGM surveys and background for removable radioactivity measurements were met.

2.6 Previous Decommissioning Activities

There have been no previous decommissioning activities at the facility. However, rooms where radioactive materials were used or stored received closeout surveys per IUPUI/IUMC procedures.

3.0 CURRENT/FUTURE USE

The buildings are being prepared for decommissioning. After decommissioning, the buildings will likely be demolished.

4.0 FACILITY RELEASE CRITERIA

The unrestricted use radiological release criteria of NRC 10CFR20 Subpart E was used for decommissioning this facility. Specifically, impacted areas of the facility were surveyed in accordance with the guidance contained in MARSSIM to demonstrate compliance with the criteria of 10CFR20.1402, “Radiological Criteria for Unrestricted Use.” The criteria are that residual radioactivity results in a TEDE to an average member of the critical group that does not exceed 25 mrem per year, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

5.0 NUCLIDES OF CONCERN

All short-lived nuclides ($t_{1/2}$ < 120 days) and nuclides where more than ten half-lives have elapsed since the last usage were eliminated from consideration as nuclides of concern. After eliminating these nuclides, seven nuclides are considered for decommissioning as presented in the table below.

Table 5-1: Nuclides of Concern for Decommissioning

Nuclide	Half-life (years)	Predominant Emissions
C-14	5.7E+03	Weak Beta
Ca-45	4.5E-01	Beta
Cl-36	3.0E+05	Beta
Co-57	7.4E-01	Gamma
Fe-55	2.7E+00	Weak Gamma
H-3	1.2E+01	Weak Beta
Na-22	2.6E+00	Positron/Gamma

6.0 DERIVED CONCENTRATION GUIDELINE LEVELS

The NRC has published DSVs in NUREG 1757 for commonly used radionuclides. DandD v.2.1 software was used to determine DSVs for isotopes not listed in NUREG 1757. Surface contamination limits were derived using the building occupancy scenario together with default parameter values. Screening values were selected such that the 0.9 quantile of projected doses was less than or equal to 25 mrem/year (i.e., when probabilistic dose assessment calculations were performed, there was a 90% probability the calculated dose would be less than 25 mrem/year). For each nuclide of concern, an initial concentration of 1 dpm/100 cm^2 was input into the software to develop a scaling factor in mrem/year per dpm/100 cm^2. Copies of the dose model output reports are presented in Appendix C. Screening values for the nuclides of concern are provided in the table below.

Table 6-1: Default Screening Values for Nuclides of Concern

Nuclide	Half-life (years)	Predominant Emissions	DandD Result (mrem/yr per dpm/100 cm^2)	Default Screening Value[1] (dpm/100 cm^2)
C-14	5.7E+03	Weak Beta	6.80E-06	3.7E+06
Ca-45	4.5E-01	Beta	8.92E-06	2.8E+06
Cl-36	3.0E+05	Beta	5.03E-05	5.0E+05
Co-57	7.4E-01	Gamma	1.18E-04	2.1E+05
Fe-55	2.7E+00	Weak Gamma	5.57E-06	4.5E+06
H-3	1.2E+01	Weak Beta	2.02E-07	1.2E+08
Na-22	2.6E+00	Positron/Gamma	2.62E-03	9.5E+03

The DSV's are the basis for developing the derived concentration guideline levels (DCGL's). The DCGL is the radionuclide specific surface activity concentration that could result in a dose equal to the release criterion. $DCGL_W$ is the concentration limit if the residual activity is essentially evenly distributed over a large area. For this project, $DCGL_W$ is equal to the DSV. In the case of non-uniform contamination, MARSSIM allows for

[1] The default screening value is calculated by dividing the release criterion of 25 mrem/yr by the DandD result in mrem/yr per dpm/100 cm^2.

evaluation of higher levels of permissible activity over small areas using the $DCGL_{EMC}$. Due to the radiological cleanliness of the facility and IUPUI/IUMC's conservative ALARA goal, $DCGL_{EMC}$ is not used. Additionally, due to the conservative ALARA goal, application of the unity rule for multiple radionuclides is not required to demonstrate compliance with the release criteria. An important assumption of the dose model is that removable contamination is <10% of total contamination. Historical survey results as well as characterization, final status and quality assurance (QA) survey results confirm that removable contamination levels are very low and meet this assumption. H-3 cannot be accurately detected directly by field instrumentation due to its low energy. Therefore, H-3 contamination was evaluated by removable contamination measurements only.

For conservatism, the limiting DSV of 9,500 dpm/100 cm^2 (Na-22) was used as a gross beta DCGL and to calculate doses from residual radioactivity. A removable surface activity DCGL of 950 dpm/100 cm^2 was established to ensure a removable fraction of 10% was verified, consistent with the assumptions of the dose model.

Pure Gamma Emitting Nuclides

Co-57 and Fe-55 are primarily gamma-emitting nuclides that were used in dispersible forms. These isotopes decay by electron capture and produce x-rays that can be detected on proportional gas flow detectors with sufficient sensitivity to ensure that these nuclides are maintained at a small fraction of their DSVs utilizing the gross beta DCGL.

Summary of Project Surface Contamination Limits

Compliance with the DSVs is demonstrated by applying gross beta surface contamination limits as presented in the table below.

Table 6-2: Summary of Project Beta Surface Contamination Limits

Total Contamination (dpm/100 cm^2)	Removable Contamination (dpm/100 cm^2)
9,500	950

7.0 ALARA GOALS (INVESTIGATION LEVELS)

IUPUI/IUMC established conservative ALARA goals based on the release criteria for equipment and materials specified in NUREG 1556, Volume 7, Table Q.2, "Acceptable Surface Contamination Levels for Equipment."[2] Specifically, the following surface contamination limits were used:

- 5,000 dpm/100 cm^2 total surface contamination
- 500 dpm/100 cm^2 removable surface contamination[3]

[2] A removable surface contamination limit of 500 dpm/100 cm^2 is used to be consistent with the removable fraction used in the dose model.

[3] Because the LSC was set up to present data in cpm, a conservative investigation level of 200 cpm/100 cm^2 for each LSC channel was used to ensure compliance with the 500 dpm/100 cm^2 removable surface contamination investigation level.

Because of the conservatism of the ALARA goals, these criteria were applied to gross beta measurements and the unity rule was not applied. The number of measurements required by MARSSIM to demonstrate compliance with the release criteria was calculated using the $DCGL_W$ and not the ALARA goal.

8.0 ALARA ANALYSIS

Due to the extremely low doses associated with residual radioactivity at the facility, a quantitative ALARA analysis was not required. Default screening values were used to establish DCGLs. Furthermore, IUPUI/IUMC routinely maintained all laboratory areas of the facility at levels < 200 dpm/100 cm^2 removable activity.

NUREG 1757, Volume 2, Appendix N states in part: "For ALARA during decommissioning, all licensees should use typical good-practice efforts such as floor and wall washing, removal of readily removable radioactivity in buildings or in soil areas, and other good housekeeping practices. In addition, licensees should provide a description in the Final Status Survey Report (FSSR) of how these practices were employed to achieve the final activity levels. In light of the conservatism in the building surface and surface soil generic screening levels developed by NRC, NRC staff presumes, absent information to the contrary, that licensees who remediate building surfaces or soil to the generic screening levels do not need to provide analyses to demonstrate that these screening levels are ALARA. In addition, if residual radioactivity cannot be detected, it may be assumed that it has been reduced to levels that are ALARA. Therefore, the licensee may not need to conduct an explicit analysis to meet the ALARA requirement."

9.0 PROJECT MANAGEMENT AND ORGANIZATION

Chase implemented their Commonwealth of Kentucky radioactive materials license at the site. IUPUI/IUMC oversaw decommissioning activities and maintained responsibility for building maintenance, fire, and security functions. Chase and IUPUI/IUMC coordinated activities such that neither party violated the license of the other party.

10.0 TRAINING

IUPUI/IUMC provided Chase personnel with site specific Contractor Site Orientation Training. Chase provided training for decommissioning-specific programs, plans and procedures.

11.0 RADIATION SAFETY AND HEALTH PROGRAM

Radiological work was performed according to the Chase radioactive materials license Radiation Safety Program.

12.0 ENVIRONMENTAL MONITORING PROGRAM

Due to the limited scope of the project, a project-specific environmental monitoring program was not required.

13.0 RADIOACTIVE WASTE MANAGEMENT

No radioactive waste was generated.

14.0 QUALITY ASSURANCE PROGRAM

The project was conducted under the Chase Corporate Quality Assurance Program. Additional project-specific QA requirements were included in the DWP to meet the guidelines of MARSSIM Section 9.

15.0 SURVEY INSTRUMENTATION

15.1 Instrument Calibration

Laboratory and portable field instruments were calibrated within the previous year with National Institute of Standards and Technology (NIST) traceable sources to radiation emission types and energies to provide detection capabilities similar to the nuclides of concern. Portable instrument calibration records are included as Appendix D. Liquid scintillation counter records are maintained by IUPUI/IUMC.

15.2 Functional Checks

Functional checks were performed at least daily when in use. The background, source check, and field measurement count times for radiation detection instrumentation were specified by procedure to ensure measurements were statistically valid. Background readings were taken as part of the daily instrument check and compared with the acceptance range for instrument and site conditions.

15.3 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and measurement of total and removable contamination were chosen to provide a minimum detectable concentration (MDC) that met the data quality objectives (DQOs). MARSSIM equations relative to building surfaces have been modified to convert to units of dpm/100 cm^2. Count times and scanning rates are determined using the following equations:

15.3.1 Static Counting

Static counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is an expansion of NUREG 1507, “Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions”, Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

Where:

MDC_{static} = minimum detectable concentration (dpm/100 cm^2)
B_r = background count rate (counts per minute)
t_b = background count time (minutes)
t_s = sample count time (minutes)
E_{tot} = total detector efficiency for radionuclide emission of interest (cpm/dpm)
A = detector probe area (cm^2)

A typical static MDC calculation for the Ludlum Model 43-37 gas flow proportional detector is shown below:

$$MDC_{STATIC} = \frac{3 + 3.29\sqrt{(1500)(.1)\left(1 + \frac{0.1}{0.1}\right)}}{(0.1)(0.2)\frac{582}{100}} = 515\,\text{dpm/100cm}^2$$

15.3.2 Ratemeter Scanning

Scanning Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is a combination of MARSSIM equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p} \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

Where:

MDC_{scan} = minimum detectable concentration (dpm/100 cm^2)
d' = desired performance variable (1.38)
b_i = background counts during the residence interval (counts)
i = residence interval (seconds)
p = surveyor efficiency (0.5)
E_{tot} = total detector efficiency for radionuclide emission of interest (cpm/dpm)
A = detector probe area (cm^2)

A typical MDC_{SCAN} calculation for the Ludlum 43-37 gas flow proportional detector is shown below:

$$\mathrm{i} = 13.3\,\mathrm{cm} \cdot \frac{\mathrm{inch}}{2.54\,\mathrm{cm}} \cdot \frac{\mathrm{sec}}{20\,\mathrm{inch}} \cdot = 0.262\,\mathrm{sec}$$

$$\mathrm{b_i} = 0.262\,\mathrm{sec} \cdot \frac{1500\,\mathrm{counts}}{\mathrm{minute}} \cdot \frac{\mathrm{minute}}{60\,\mathrm{sec}} = 6.55\,\mathrm{counts}$$

$$MDC_{SCAN} = \frac{1.38\sqrt{6.55}\left(\frac{60}{0.262}\right)}{\left(\sqrt{0.5}\right)(0.2)\left(\frac{582}{100}\right)} = 983\,\mathrm{dpm/100cm^2}$$

15.3.3 Smear Counting

Smear counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{smear} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E}$$

Where:

MDC_{smear} = minimum detectable concentration level (dpm/smear)
B_r = background count rate (counts per minute)
t_b = background count time (minutes)
t_s = sample count time (minutes)
E = instrument efficiency for radionuclide emission of interest (cpm/dpm)

Typical MDC calculations for H-3 and C-14 are shown below.

$$^{3}\mathrm{H\ MDC_{SMEAR}} = \frac{3 + 3.29\sqrt{(25)(1)\left(1 + \frac{1}{1}\right)}}{(1)(0.60)} = 44\,\mathrm{dpm}$$

$$^{14}\mathrm{C\ MDC_{SMEAR}} = \frac{3 + 3.29\sqrt{(15)(1)\left(1 + \frac{1}{1}\right)}}{(1)(0.80)} = 26\ \mathrm{dpm}$$

$$\text{OPEN MDC}_{\text{SMEAR}} = \frac{3 + 3.29\sqrt{(50)(1)\left(1 + \frac{1}{1}\right)}}{(1)(0.95)} = 38 \text{ dpm}$$

15.4 Uncertainty

The uncertainty for each static measurement is calculated using equation 6-15 from MARSSIM:

$$\sigma = 1.96\sqrt{\frac{C_{s+b}}{T_{s+b}{}^2} + \frac{C_b}{T_b{}^2}}$$

where:

σ	=	uncertainty
1.96	=	multiplier to achieve a 95% confidence level
C_{s+b}	=	gross sample counts
T_{s+b}	=	sample count time (min.)
C_b	=	gross background counts
T_b	=	background count time (min.)

Uncertainties presented with total surface activity results are additionally corrected for detection efficiency and probe area for presentation in the same units as total surface activity results.

15.5 Instrumentation Specifications

The instrumentation used for facility decommissioning surveys is summarized in the following tables.

Table 15-1: Instrumentation Specifications

Detector Model	Detector Type	Detector Area	Meter Model	Window Thickness	Typical Efficiency
Ludlum 43-68	Gas Flow Proportional	126 cm^2	Ludlum 2241-3	0.8 mg/cm^2	20 % (Tc-99)
Ludlum 43-37 Floor Monitor	Gas Flow Proportional	582 cm^2	Ludlum 2241-3	0.8 mg/cm^2	20 % (Tc-99)
Packard TriCarb (or Equivalent)	Liquid Scintillation	N/A	N/A	N/A	60% (H-3) 80% (C-14) 95% (open)

Table 15-2: Typical Instrument Operating Parameters and Sensitivities

Measurement Type	Detector Model	Max. Scan Rate[4]	Count Time	Background (cpm)	MDC (dpm/100 cm^2)
Surface Scans	Ludlum 43-68	10 in./sec.	N/A	500	2,279 (Tc-99)
Surface Scans	Ludlum 43-37	20 in./sec.	N/A	1,500	983 (Tc-99)
Total Surface Activity	Ludlum 43-68	N/A	6 sec.	500	1,425 (Tc-99)
Total Surface Activity	Ludlum 43-37	N/A	6 sec.	1,500	515 (Tc-99)
Removable Activity	Packard TriCarb	N/A	60 sec.	25 (H-3) 15 (C-14) 50 (open)	44 (H-3) 26 (C-14) 38 (open)

15.6 Efficiency Determination

ISO 7503-1 methods were used for the limiting nuclide (Na-22) to determine field concentrations for final status data and calculation of resultant doses from residual radioactivity. MARSSIM protocols for building structures use ISO-7503-1 methodology that takes into account the texture of the surface and the 2π detector efficiency. Under MARSSIM, the default surface efficiency for beta emitters with maximum energies greater than 400 keV is conservatively set at 0.5.

15.7 Datalogging

Structural surface scans and static measurements were performed using datalogging instrumentation. While scanning, in addition to the surveyor listening to the audible output, integrated counts were recorded. Logged data were downloaded and processed using data management software to perform data analyses and reporting. Reporting includes graphical (4-plot) presentation of scan data as well as summary statistics functions. The 4-Plot is described in the NIST e-Handbook of Statistical Methods (http://www.itl.nist.gov/div898/handbook/index.htm).

A 4-plot consists of the following:

- A run **sequence plot** presents logged data in chronological order, providing a time history of the survey data.
- A **lag plot** checks whether a data set or time series is random or not. Random data should not exhibit any identifiable structure in the lag plot. Non-random structure in the lag plot indicates that the underlying data are not random.
- A **histogram plot** graphically summarizes the distribution of a univariate data set, showing center (i.e., the location) of the data, spread (i.e., the scale) of the data, skewness of the data, presence of outliers, and presence of multiple modes.

[4] Maximum scan rates are calculated based on the instrument MDCs. Actual scan rates will be much slower.

- A **probability plot** is a goodness-of-fit test used to verify the distributional model. The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed. The data are plotted against a theoretical normal distribution in such a way that the points should form an approximate straight line. Departures from this straight line indicate departures from normality

16.0 DATA QUALITY OBJECTIVES (DQO)

The following is a list of the major DQOs for the survey design:

- Static measurements were taken to achieve an MDC_{static} of less than 4,750 dpm/100 cm^2.
- Scanning was conducted at a rate to achieve an MDC_{scan} of less than 4,750 dpm/100 cm^2.
- Removable contamination measurements were counted to achieve an MDC_{smear} of less than 200 dpm/100 cm^2 per channel.
- Individual measurements were made to a 95% confidence interval.
- Decision error probability rates were set at 0.05 for both α and β.
- The null hypothesis (H_0) and alternate hypothesis (H_A) are that of NUREG 1505 scenario A:
  - H_0 is that the survey unit does not meet the release criteria
  - H_A is that the survey unit meets the release criteria
- Quality assurance surveys were conducted at a rate of 5%.
- Characterization surveys were conducted under the same quality assurance criteria as final status surveys such that the data were used as final status survey data to the maximum extent possible.

17.0 AREA CLASSIFICATIONS

Based on the results of the historical site assessment and previous survey results, facility areas were classified as impacted or non-impacted.

17.1 Non-Impacted Area

Non-impacted areas were areas without residual radioactivity from licensed activities and were not surveyed during final status surveys. The following areas were classified as non-impacted:

- Structural surfaces above a two meter height
- Building elevations and wings without a history of radioactive materials usage
- Building elevations and wings with a history of usage of only short-lived nuclides
- The 6th floor of the Myers Building[5]

[5] The 6th floor of the Myers Building was completely renovated into patient care areas. The basis for non-impacted classification is that all impacted surfaces had been removed and disposed during renovation. Additionally, closeout procedures of rooms where radioactive materials were used were performed after

- Internal surfaces of positively pressurized systems (air, gas, water, etc.)
- Building exterior surfaces
- Surface and subsurface soils of outside grounds

Based on historical operations, a potential existed for residual contamination from spills or tracking on surfaces less than two meters in height. Thorough surveys of impacted area entrances/exits and ventilation exhausts were conducted during characterization to provide adequate assurance that any residual contamination was contained within impacted areas. These surveys were performed to verify the non-impacted classification of surrounding areas.

17.2 Impacted Areas

Impacted areas were those areas that had potential residual radioactivity from licensed activities. Impacted areas are subdivided into Class 1, Class 2 or Class 3 areas. Class 1 areas have the greatest potential for contamination and therefore receive the highest degree of survey effort for the final status survey using a graded approach, followed by Class 2, and then by Class 3. Impacted sub-classifications are defined as follows:

17.2.1 Class 1 Area

Areas with the highest potential for contamination, and meet the following criteria: (1) impacted; (2) potential for delivering a dose above the release criterion; (3) potential for small areas of elevated activity; and (4) insufficient evidence to support classification as Class 2 or Class 3.

There are no Class 1 areas.

17.2.2 Class 2 Area

Areas that meet the following criteria: (1) impacted; (2) low potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

Areas with a history of radioactive materials usage were classified as Class 2.

17.2.3 Class 3 Area

Areas that meet the following criteria: (1) impacted; (2) little or no potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

Areas surrounding areas of usage were classified as Class 3 areas.

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usage of radioactive materials and prior to renovation, such that there is not a potential for cross-contamination of underlying structural surfaces during dismantlement. Furthermore, survey results of areas with similar operational histories that have not been renovated verify the effectiveness of closeout procedures.

17.3 Survey Units

A survey unit is a geographical area of specified size and shape for which a separate decision is made whether or not that area meets the release criteria. A survey unit is normally a portion of a building or site that is surveyed, evaluated, and released as a single unit. For the purposes of this project, areas of similar construction and composition were grouped together as survey units and tested individually against the DCGLs and the null hypothesis to show compliance with the release criteria. Survey units were homogeneous in construction, contamination potential, and contamination distribution.

The number of discrete sampling locations needed to determine if a uniform level of residual radioactivity exists within a survey unit does not depend on the survey unit size. However, the sampling density should reflect the potential for small elevated areas of residual radioactivity. Survey units were sized according to the potential for small elevated areas of residual radioactivity. Recommended maximum survey unit sizes for building structures, based on floor area, is Class 1: up to 100 m^2 , Class 2: 100 m^2 to 1000 m^2 and Class 3: no limit.

Survey Unit Numbering Protocol

Each survey unit is assigned a unique number consisting of the building number followed by a dash and a four digit identifier. The four digit identifier consists of one digit for the elevation, one digit for the classification, and two digits as a numerical identifier in the event the first 2 digits are the same for two or more survey units using the format below:

Building Number – Elevation/Classification/Numerical Identifier

The default numeric identifier is 01

Buildings:
WOP = West Outpatient Building, EOP = East Outpatient Building, and MYR = Myers Building

Elevations:
B = Basement, 3 = 3rd Floor, 4 = 4th Floor, and 5 = 5th Floor

Building systems survey units were arranged by building and system type. There are three types of systems – ventilation, vacuum, and drain. Each system survey unit encompasses all of a certain type within the building.

Systems Components:
DR – Drain
VA – Vacuum
VE – Ventilation

Examples:
WOP-5201 is West Outpatient Building, fifth floor, Class 2
EOP-3301 is East Outpatient Building, third floor, Class 3
MYR-DR01 is Myers Building drains

Survey unit classifications and designations were determined from the HSA and are listed in the tables below. Survey unit designations are presented graphically on the building floor plans presented in Appendix B.

Table 17-1: Building Structural Survey Units

Building	Elevation	Survey Unit Numbers
WOP	Third	3201, 3202, 3203, 3301
	Fourth	4201, 4202, 4301
	Fifth	5201, 5202, 5301
EOP	Third	3201, 3301
MYR	Basement	B201, B301

Table 17-2: Building Systems Survey Units

Building	Drain	Vacuum	Ventilation
WOP	DR01	VA01	VE01
EOP	DR01	NONE	NONE
MYR	DR01	VA01	VE01

18.0 CHARACTERIZATION SURVEYS

The survey protocol for building surfaces consisted of performing the scanning portion of the final status survey protocol, with judgmental smears and static measurements on areas of highest probability for residual radioactivity. Judgmental static measurements and smears were also taken on vertical surfaces as part of the Class 2 and Class 3 final status survey protocols described in section 20.3.5.

The purpose of scanning was to identify locations of elevated activity. The minimum scan percentages are presented in section 20.2. Scanning was performed by moving the probe over surfaces at a distance of approximately 0.5 cm or less and at a rate less than the maximum allowable scan rate necessary to achieve DQOs.

The survey protocol for building system surveys consisted of performing removable contamination measurements of accessible internal surfaces of ventilation, vacuum, and drain systems. Fume hood baffles were removed, and static measurements performed in addition to the removable contamination measurements. Static measurements were not possible in vacuum and drain systems due to geometry.

No elevated activity from residual licensed materials was detected during characterization surveys. However, elevated radioactivity naturally occurring radioactive materials (NORM) was identified in refractory material associated with an inactive incinerator in WOP Room

5007 and glazed ceramic tile wall located in WOP Room 5013. Chase performed gamma scans with a 2" x 2" NaI detector, gas flow scans, and removable radioactivity measurements to confirm that radioactivity was due to NORM. Radioactivity levels were evenly distributed across the surfaces, were within typical ranges associated with refractory and glazed tiles, and emitted gamma rays. Additionally, there was no removable radioactivity and these areas had no history of usage of radioactive materials.

In addition to the characterization surveys performed for impacted areas, historical Nuclear Medicine areas located on the Myers Building basement, first, and third floors were surveyed to confirm non-impacted status. The first floor area had been renovated into office space and the 3rd floor area had been renovated into patient rooms. Surveys of these areas consisted on large area wipes for removable activity, judgmental scans with a gas flow detector, and a gamma walk-through survey with a 2" x 2" sodium iodide detector. No elevated radioactivity was identified.

19.0 REMEDIATION

Remediation was not necessary.

20.0 FINAL STATUS SURVEYS

Final status surveys were performed using the DQO process to demonstrate that residual radioactivity in each survey unit satisfied the predetermined criteria for release for unrestricted use. Final status surveys were conducted by performing the appropriate combination of scan surveys, total activity measurements and removable activity measurements as discussed further in this section. All final status surveys were performed according to written instructions. Survey data were documented on survey maps and/or associated data information sheets.

20.1 Background Determination

The use of reference background areas or paired background comparisons was not necessary. Material and ambient background values were not significant in comparison to the DCGLs or ALARA goals. For direct measurements, an ambient background was determined for each survey, was subtracted from gross measurements, and was used to calculate the actual survey MDCs and associated count errors. Material-specific background determinations were not performed. Background was subtracted from removable activity measurements and all results are reported in dpm/100 cm^2.

20.2 Surface Scans

Scanning was used to identify locations within the survey unit that exceed the investigation level. The table below summarizes the minimum scan percentage of accessible building structural surfaces based on classification.

Table 20-1: Scan Survey Coverage by Classification

Structure	Class 2	Class 3
Laboratory Floors	75%	10%
Fume Hoods	100%	100%
Benchtops	75%	10%
Laboratory Walls	20%	10%
Other Laboratory Structures	50%	10%
Non-Laboratory Surfaces	10%	10%

For surfaces that received less than 100% scan survey, the surfaces scanned were those with the highest potential to contain residual radioactivity at the discretion of the surveyor.

20.3 Total Surface Activity Measurements

Direct surveys (static measurements) for total surface activity were taken on building surfaces in impacted areas utilizing instrumentation of the best geometry based on the surface at the survey location. Additionally, locations of elevated activity identified and marked during the scan survey received direct survey measurements. Static measurements were taken in impacted areas at each identified sample location. Scaler count times were determined to achieve the detection sensitivities stated in the DQOs. Field measurements were converted to activity concentrations using the following equation:

$$Activity\ (dpm/100\ cm^2) = \frac{R_{s+b} - R_b}{E_{total} \times \frac{A}{100\ cm^2}}$$

Where:

R_{s+b} = The gross count rate of the measurement in cpm
R_b = The background count rate in cpm
E_{total} = Total Efficiency
A = Area of the detector window (cm^2)

20.3.1 Determining the Number of Samples

The minimum number of samples required for the Sign Test was calculated using equations in Section 5 of MARSSIM. A conservative estimate of the standard deviation of total surface activity measurements (1,000 dpm/100 cm^2) was used. The LBGR was set at one half of the DCGL. The calculations performed to determine the required numbers of samples are provided below.

20.3.2 Determination of the Relative Shift

The number of required samples depends on the ratio involving the activity level to be measured relative to the variability in the concentration. The ratio to be used is called the Relative Shift, Δ/σ_S, and is defined in MARSSIM as:

$$\Delta / \sigma_S = \frac{DCGL - LBGR}{\sigma_S}$$

Where:

DCGL = derived concentration guideline level (dpm/100 cm^2)

LBGR = concentration at the lower bound of the gray region. The LBGR is the average concentration to which the survey unit should be cleaned in order to have an acceptable probability of passing the test (dpm/100 cm^2)

σ_S = an estimate of the standard deviation of the residual radioactivity in the survey unit (dpm/100 cm^2)

The actual calculation is provided below:

$$\Delta / \sigma_S = \frac{9{,}500 - 4{,}750}{1{,}000} = 4.75$$

Since MARRSIM Table 5.5 does not include relative shifts above 3 and the number of samples required decreases with an increasing relative shift, the relative shift was conservatively set at 3.

20.3.3 Determination of Acceptable Decision Errors

A decision error is the probability of making an error in the decision on a survey unit by passing a unit that should fail (α decision error) or failing a unit that should pass (β decision error). MARSSIM uses the terminology α and β decision errors; this is the same as the more common terminology of Type I and Type II errors, respectively. The decision errors are 0.05 for Type I errors and 0.05 for Type II errors.

20.3.4 Determination of Number of Data Points (Sign Test)

The number of direct measurements for a particular survey unit, employing the Sign Test, is determined from MARSSIM Table 5.5, which is based on the following equation (MARSSIM equation 5-2):

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

Where:

N = number of samples needed in the survey unit

$Z_{1-\alpha}$ = percentile represented by the decision error α

$Z_{1-\beta}$ = percentile represented by the decision error β

SignP = estimated probability that a random measurement will be less than the DCGL when the survey unit median is actually at the LBGR

Note: SignP is determined from MARSSIM Table 5.4

MARSSIM recommends increasing the calculated number of measurements by 20% to ensure sufficient power of the statistical tests and to allow for possible data losses. MARSSIM Table 5.5 values include an increase of 20% of the calculated value. The approach for this project was to predetermine a number of samples to be applied to all survey units. This approach provides sufficient power for the statistical test while streamlining the survey planning process. The following calculations were made to determine this number:

$$N = \frac{(1.645 + 1.645)^2}{4(0.998650 - 0.5)^2} = 11$$

$Z_{1-\alpha}$ and $Z_{1-\beta}$ are equal to 1.645 using the error rate of 0.05 from MARSSIM Table 5.2. SignP is equal to 0.998650 from MARSSIM Table 5.4. Adding an additional 20% to account for data losses resulted in a value of 14.

Therefore, the determined number of samples per survey unit for the final status surveys for planning purposes was **14**.

20.3.5 Determination of Sample Locations

Class 2 and Class 3 survey units generally consist of multiple rooms. The process to identify, map and locate measurement coordinates in survey units with many rooms is complicated due to the noncontiguous nature of the survey unit once walls are “folded-out”. Therefore, the MARSSIM sample measurement locations (i.e., random static and wipe measurements) were determined only on horizontal surfaces as determined on floor plans. This protocol increases the sample density on the surfaces with the highest probability for residual contamination (floors, benchtops, fume hood working surfaces, etc.). The appropriate percentage of all survey unit surfaces (including vertical surfaces) was scanned according to the survey unit classification. In laboratory areas, permanent counter tops and other horizontal surfaces that block floor surfaces were included as a replacement to the blocked floor surface. Internal surfaces of permanent furnishings (i.e., drawer or cabinetry interior surfaces) were not included in the systematic measurement location placement. However, these surfaces were included in the scan surveys. Additional total surface activity measurements were collected at each area of elevated activity identified during the scan surveys.

As part of characterization, the survey technician judgmentally selected locations with the highest probability of contamination on vertical surfaces for a static measurement and smear, such as light switches, door knobs, door pulls, push plates, and other locations. These measurements were in addition to and were not included in the statistical analysis of the locations selected by MARSSIM protocols.

Determination of Class 2 survey unit sample locations was accomplished by first determining sample spacing and then systematically plotting the sample locations from a randomly generated start location. MARSSIM recommends random sampling (random x, random y) for Class 3 areas. However, in this survey design, Class 3 areas are sampled on a systematic grid pattern in the same manner as MARSSIM recommends for Class 1 and Class 2 areas. Sample spacing was determined from MARSSIM equation 5-8:

$$L = \sqrt{\frac{A}{N}} \text{ for a square grid}$$

Where:

L = sample spacing interval
A = the survey unit floor area
N = number of samples needed in the survey unit

A random starting point was determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid was plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location was plotted at each intersection of the grid. Maps of final status survey locations for all survey units are included in Appendix E.

20.4 Removable Contamination Measurements

Removable contamination measurements were collected by wiping an area of approximately 100 cm^2 on structural surfaces, ventilation systems, and drain systems. An area of approximately 10 cm^2 was wiped inside building vacuum nozzles, therefore results were multiplied by a factor of 10. The smears/swabs were counted to achieve the detection sensitivities stated in the DQOs. The LSC was set up for three channels without background subtraction at the following energies:

Channel 1 (^{3}H cpm):	3.0 – 18.6 keV
Channel 2 (^{14}C cpm):	18.6 – 169 keV
Channel 3 (cpm):	170 – 2,000 keV

20.5 Surveys of Building Mechanical System Internals

Surveys of various building system components were performed. Survey design for these systems is out of the scope of MARSSIM. For the purposes of identifying potential residual contamination within these systems, a survey protocol was established and is presented in the table below.

Table 20-2: System Survey Coverage

System Component	Coverage
Vacuum Nozzles, Pumps, Accumulators	100% Class 2, 10% Class 3
Fume Hood Vent Ducts and Fans	100% Class 2, 10% Class 3
Drain Openings/Traps	100% Class 2, 10% Class 3

20.6 Survey Documentation

A survey package was developed for each survey unit containing the following:

- Survey Unit number (e.g., Building and Room Number, System Number, etc.)
- Survey Instruction Sheets
- General survey requirements
- Percentage of surfaces requiring scan surveys
- Number of total and removable contamination measurements required, instrument requirements with associated MDCs, count times and scan rates
- Overview maps detailing survey locations and placement methodology
- Survey Data Sheets
- Any additional specific survey instruction
- Signature of Data Collector and Reviewer

To ensure proper data management and organization, a unique location code system was used so that survey data could be properly entered and organized in the Final Status Survey Database. A breakdown of the location code and specific code components are provided in the table below.

Table 20-3: Location Code Description

A unique location code was assigned to each individual survey location to ensure proper data management of the survey results. The following format was used to ensure consistency throughout the final status survey process:

BBB-RRRR-SS-M-LLL

Where:

BBB:	=	Building Code. This field represents the building number. (3 characters) EOP: East Outpatient Building MYR: Myers Building WOP: West Outpatient Building
RRRR:	=	Survey Unit Number. This is the assigned survey unit number. (4 characters)
SS:	=	Structural Surface Code. This field represents the structural surface such as floor, wall, ceiling, etc. (2 characters) B1 = Benchtop; F1 = Floor; O1 = Other D1 = Fumehood Drains; D2 = Floor Drains; D3 = Sink Drains; D4 = Other Drains E1 = Hood Exhaust Duct; E3 = Hood Exhaust Fan / Component; V1 = Vacuum Nozzle; V2 = Vacuum Component
M:	=	Structural Material Code. This field represents the type of structural material on which a particular measurement is taken. (1 character) C = Concrete; E = Epoxied Concrete; M = Miscellaneous V = Vinyl Tile; W = Wood; T = Tile
LLL:	=	Numerical Identifier. This field represents the survey location number. The field "001" means survey point location number 1. Numerical identifiers are unique within a survey unit. (3-characters)

21.0 SURVEY RESULTS AND DATA QUALITY ASSESSMENT

The statistical guidance contained in Section 8 of MARSSIM was used to determine if areas are acceptable for unrestricted release and whether additional surveys or sample measurements were required.

21.1 Data Validation

Field data were reviewed by the Project Manager and validated to ensure:

- Completeness of forms
- Proper types of surveys were performed
- The MDCs for measurements met the established data quality objectives
- Independent calculations were performed on a representative sample of data sheets
- Satisfactory instrument calibrations and daily functionality checks were performed as required

Additionally, all final status survey data were entered into the Final Status Survey Database. This provided the means to sort survey data, verify activity calculations, and to compute the associated MDC and counting errors. Once data entry for a survey unit was complete, a verification report was printed and compared to original data sheets to ensure correct data entry.

21.2 Preliminary Data Review

A preliminary data review was performed for each survey unit to identify any patterns, relationships or anomalies. Additionally, measurement data were reviewed and compared with the DCGLs and investigation levels to confirm the correct classification of survey units.

21.2.1 Review of 4-Plots

A 4-Plot was produced for each survey instrument used within each survey unit. 4-plots are separated in this manner because combining all populations into one 4-plot for each survey unit introduces additional variability in the results due to instrument-specific systematic errors (i.e., differences in calibration efficiency, background count rate, etc.). This additional variability reduces the usefulness of the 4-Plot for identifying anomalies in the scan data.

4-Plots indicate that all scan survey results are less than the Investigation Level. 4-Plot graphs are provided in Appendix F.

21.2.2 Data Summary Tables

All calculations of means, standard deviations, minimum and maximum values and comparisons between survey data and investigation levels are presented in the following tables. Building structural surface activity reports for each survey unit are included as Appendix G. Reports for building systems surveys are presented in Appendix H.

Table 21-1: Structural Surfaces Total Beta Surface Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
EOP-3201	20	346	914	182	38	639	5,000	NO
EOP-3301	13	-130	1,038	189	-451	113	5,000	NO
MYR-B201	12	97	875	181	-188	414	5,000	NO
MYR-B301	14	8	875	96	-150	150	5,000	NO
WOP-3201	18	69	1,059	296	-363	645	5,000	NO
WOP-3202	14	-66	1,059	166	-484	242	5,000	NO
WOP-3203	17	308	917	212	0	686	5,000	NO
WOP-3301	12	-128	1,149	398	-686	403	5,000	NO
WOP-4201	18	184	1,021	317	-202	1,049	5,000	NO
WOP-4202	15	210	939	222	-81	565	5,000	NO
WOP-4301	11	4	1,021	235	-282	484	5,000	NO
WOP-5201	20	83	1,005	200	-338	451	5,000	NO
WOP-5202	14	247	895	187	0	564	5,000	NO
WOP-5301	13	-43	1,215	401	-645	807	5,000	NO

Table 21-2: Building Structural Surfaces Removable H-3 Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2)					
EOP-3201	20	9	2	4	13	200	NO
EOP-3301	13	10	4	4	18	200	NO
MYR-B201	12	9	3	5	14	200	NO
MYR-B301	14	9	3	5	14	200	NO
WOP-3201	18	10	3	6	17	200	NO
WOP-3202	14	10	4	4	17	200	NO
WOP-3203	17	11	3	5	15	200	NO
WOP-3301	12	11	2	7	14	200	NO
WOP-4201	18	8	3	4	13	200	NO
WOP-4202	15	8	3	2	12	200	NO
WOP-4301	11	10	2	5	13	200	NO
WOP-5201	20	9	3	5	17	200	NO
WOP-5202	14	9	2	4	13	200	NO
WOP-5301	13	9	3	4	14	200	NO

Table 21-3: Building Structural Surfaces Removable C-14 Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2)					
EOP-3201	20	9	2	5	13	200	NO
EOP-3301	13	9	2	4	12	200	NO
MYR-B201	12	6	3	2	12	200	NO
MYR-B301	14	8	4	4	16	200	NO
WOP-3201	18	9	3	2	13	200	NO
WOP-3202	14	7	2	4	13	200	NO
WOP-3203	17	8	3	3	16	200	NO
WOP-3301	12	9	2	6	13	200	NO
WOP-4201	18	9	3	4	14	200	NO
WOP-4202	15	9	3	6	15	200	NO
WOP-4301	11	9	3	3	15	200	NO
WOP-5201	20	9	3	3	17	200	NO
WOP-5202	14	10	3	4	13	200	NO
WOP-5301	13	9	3	6	14	200	NO

Table 21-4: Building Structural Surfaces Removable Open Channel Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2)					
EOP-3201	20	10	5	3	20	200	NO
EOP-3301	13	11	4	7	20	200	NO
MYR-B201	12	9	3	4	14	200	NO
MYR-B301	14	9	3	6	16	200	NO
WOP-3201	18	10	3	5	16	200	NO
WOP-3202	14	9	3	4	14	200	NO
WOP-3203	17	9	3	5	17	200	NO
WOP-3301	12	10	2	6	14	200	NO
WOP-4201	18	9	4	2	16	200	NO
WOP-4202	15	9	3	5	16	200	NO
WOP-4301	11	10	4	5	19	200	NO
WOP-5201	20	9	3	4	17	200	NO
WOP-5202	14	7	2	2	10	200	NO
WOP-5301	13	9	2	6	13	200	NO

Table 21-5: Building Systems Total Beta Surface Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
MYR-VE01	2	94	1,162	1,037	-639	827	5,000	NO
WOP-VE01	31	205	855	237	-113	714	5,000	NO

Table 21-6: Building Systems Removable H-3 Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2) [6]					
EOP-DR01	2	7	7	2	12	200	NO
MYR-DR01	4	12	4	6	16	200	NO
MYR-VA01	3	87	42	40	120	200	NO
MYR-VE01	2	10	3	8	12	200	NO
WOP-DR01	114	10	3	4	19	200	NO
WOP-VA01	68	99	35	40	200	200	NO[7]
WOP-VE01	31	9	4	4	20	200	NO

Table 21-7: Building Systems Removable C-14 Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2) [6]					
EOP-DR01	2	12	1	11	13	200	NO
MYR-DR01	4	8	2	5	10	200	NO
MYR-VA01	3	70	26	50	100	200	NO
MYR-VE01	2	5	2	3	6	200	NO
WOP-DR01	114	9	3	2	17	200	NO
WOP-VA01	68	84	27	10	130	200	NO
WOP-VE01	31	10	2	4	14	200	NO

[6] Vacuum nozzle removable activity results were multiplied by a factor of 10 to correct for the area wiped (10 cm^2).
[7] One result was equal to the investigation level. Because the result includes background, the net activity is less than the investigation level.

Table 21-8: Building Systems Removable Open Channel Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2) [6]					
EOP-DR01	2	10	3	8	12	200	NO
MYR-DR01	4	9	3	5	12	200	NO
MYR-VA01	3	80	10	70	90	200	NO
MYR-VE01	2	12	1	11	12	200	NO
WOP-DR01	114	9	3	3	17	200	NO
WOP-VA01	68	84	31	30	150	200	NO
WOP-VE01	31	8	3	4	14	200	NO

21.3 Determining Compliance for Building Surfaces and Structures

Final status survey results were initially compared to the investigation levels. All total and removable surface activity results on building structural surfaces were less than investigation levels. Because all measurements are less than the DCGL, all survey units pass the Sign Test. Therefore, the null hypothesis can be rejected and all survey units meet the release criterion and are suitable for release for unrestricted use.

The results of the data quality assessment and calculations of the dose from each structural surface survey unit are presented in the table below.

Table 21-9: Structural Surfaces Total Beta Surface Activity Dose Calculations

Survey Unit	Standard Deviation (dpm/100 cm^2)	# Samples Required	Actual # of Samples	Adequate # of Samples?	Mean (dpm/100 cm^2)	Calculated Annual TEDE[8] (mrem/yr)
EOP-3201	182	11	20	YES	346	0.91
EOP-3301	189	11	13	YES	-130	-0.34
MYR-B201	181	11	12	YES	97	0.26
MYR-B301	96	11	14	YES	8	0.02
WOP-3201	296	11	18	YES	69	0.18
WOP-3202	166	11	14	YES	-66	-0.17
WOP-3203	212	11	17	YES	308	0.81
WOP-3301	398	11	12	YES	-128	-0.34
WOP-4201	317	11	18	YES	184	0.48
WOP-4202	222	11	15	YES	210	0.55
WOP-4301	235	11	11	YES	4	0.01
WOP-5201	200	11	20	YES	83	0.22
WOP-5202	187	11	14	YES	247	0.65
WOP-5301	401	11	13	YES	-43	-0.11
					Maximum:	**0.91**

21.4 Determining Compliance for Building Systems

Final status survey results were initially compared to the investigation levels. The geometry of vacuum and drain system internals precluded scanning and total activity measurements. All total and removable surface activity measurements were less than the investigation level. Therefore, all systems survey units meet the release criteria and are suitable for release.

[8] The TEDE shown is conservatively calculated by multiplying 25 mrem/yr by the ratio of the mean total surface activity to the limiting nuclide (Na-22) DCGL of 9,500 dpm/100 cm^2.

22.0 QUALITY ASSURANCE SURVEYS

Quality assurance surveys consisted of re-performing the FSS protocol for building structural surfaces to achieve a minimum of 5% duplication of scans, static measurements and smears. The Project Manager implemented QA surveys by re-performing judgmentally selected survey locations as survey unit QA01. The locations of QA survey total and removable surface activity measurements are presented in the table below.

Table 22-1: QA Survey Locations

QA Survey Location	FSS Location
WOP-QA01-F1-M-001	WOP-5201-F1-M-006
WOP-QA01-F1-M-002	WOP-5201-F1-M-014
WOP-QA01-F1-C-003	WOP-5301-F1-C-008
WOP-QA01-F1-M-004	WOP-5202-F1-M-010
WOP-QA01-B1-W-005	WOP-4202-B1-W-006
WOP-QA01-F1-V-006	WOP-4202-F1-V-010
WOP-QA01-F1-V-007	WOP-4201-F1-V-017
WOP-QA01-F1-V-008	WOP-4201-F1-V-009
WOP-QA01-F1-V-009	WOP-3201-F1-V-011
WOP-QA01-F1-V-010	WOP-3201-F1-V-016
WOP-QA01-F1-C-011	WOP-3203-F1-C-001
WOP-QA01-F1-C-012	WOP-3203-F1-C-003
EOP-QA01-F1-V-013	EOP-3201-F1-V-015
EOP-QA01-F1-V-014	EOP-3201-F1-V-002

22.1 QA Survey Results

All QA survey results were similar to FSS data and the conclusions were the same as those based on the initial surveys. QA survey results are presented in Appendix I and are summarized in the tables below.

Table 22-2: QA Survey Building Structural Surfaces Total Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
QA01	14	39	403	107	-148	257	5,000	**NO**

Table 22-3: QA Survey Building Structural Surfaces Removable H-3 Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2)					
QA01	14	9	3	5	18	200	**NO**

Table 22-4: QA Survey Building Structural Surfaces Removable C-14 Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2)					
QA01	14	10	3	4	13	200	**NO**

Table 22-5: QA Survey Building Structural Surfaces Removable Open Channel Summary

Survey Unit	# of Sample Locations	Mean	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(gross cpm/100 cm^2)					
QA01	14	8	3	2	14	200	**NO**

23.0 REFERENCES

- NRC Regulations 10 CFR 20 Subpart E
- NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM)
- NUREG-1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Decommissioning Surveys"
- NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions"
- NUREG 1757, Volume 1 "Consolidated NMSS Decommissioning Guidance," September, 2002
- ISO-7503-1, "Evaluation of Surface Contamination – Part 1: Beta Emitters and Alpha Emitters." 1988
- IUPUI/IUMC Wishard Hospital Decommissioning Work Plan
- IUPUI/IUMC Radioactive Materials License Number 13-02752-03
- Chase Kentucky License Number 201-605-90
- NUREG 1556, Volume 7, Table Q.2, "Acceptable Surface Contamination Levels for Equipment," December 1999