Former Benrus Clock Factory Site

Radiological Final Status Survey Plan

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ACRONYM LIST

ALARA	As Low As Reasonably Achievable
D&D	Decontamination and Decommissioning
$DCGL_{EMC}$	Derived Concentration Guideline Level – Elevated Measurement Comparison
$DCGL_{W}$	Derived Concentration Guideline Level – Average Area Concentration
DQO	Data Quality Objective
DSV	Default Screening Value
GSF	Gross Square Feet
HSA	Historical Site Assessment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NRC	U.S. Nuclear Regulatory Commission
QAPP	Quality Assurance Project Plan
RSO	Radiation Safety Officer
TEDE	Total Effective Dose Equivalent

1.0 Introduction

Decontamination Decommissioning and Environmental Services (DDES), LLC was retained by Cherry Avenue Partners, LP to assemble a Radiological Final Status Survey Plan for the Former Benrus Clock Factory Site in Waterbury, Connecticut. The former clock factory is approximately 60,000 square feet. While limited historical information is available about radioactive material use onsite, the isotope of concern is thought to be Radium-226 (^{226}Ra).

This Final status survey plan is designed to identify and quantify the current contamination levels present throughout the complex. The survey is designed to identify contamination levels that would exceed a total effective dose equivalent (TEDE) of nineteen (19) millirem/year to an individual member of the public. The goal of this characterization is to identify and quantify radiological contamination on site to assemble a comprehensive cost estimate for release of the site.

This plan was developed using the guidance provided in NUREG 1727, "NMSS Decommissioning Standard Review Plan"; NUREG 1757, "Consolidated NMSS Decommissioning Guidance"; and NUREG 1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM). It provides the approach, methods, and techniques for the radiological characterization of impacted areas of the facility. Characterization surveys are designed to implement the protocols and guidance provided in MARSSIM to demonstrate compliance with the screening values generated using the default scenarios and parameters of the DandD Code v.2.1.

Characterization activities will be performed in accordance with this plan and DDES's Massachusetts Radioactive Materials License 56-0623.

2.0 Site Description

The former Benrus Clock Company Site is a 60,000-square foot structure located at 145 Cherry Avenue in Waterbury, Connecticut. This seven-story building is made up of brick and wood structure. The original building is currently owned and occupied by Bender Plumbing. According to ATSDR (1999), Bender Plumbing had extensive testing done at the Benrus factory during the purchase of the property; however, routine testing for radium was not normally part of a pre-sale environmental study.

3.0 Site History

3.1 Potential Contaminants

The Benrus Clock Company was founded in New York City in 1921. Benrus also had a factory in Waterbury, CT, which was once the Movement Factory for the Waterbury Clock Company. The Benrus Clock Company in Waterbury, CT historically produced watches with radium-luminous dials.

One Public Health Assessment Survey from 1998 issued by the Agency for Toxic Substances & Disease Registry (ATSDR) was located. This report provided limited dose rate surveys. Readings in excess of twice background were noted on the 4th, 5th and 7th floors of the facility.

A limited spot-check survey was performed on the 4th, 5th and 7th floors of the facility by Scientech in 2003. Elevated levels were noted in each of the areas previously surveyed. These areas of elevated readings will need to be quantified and areas of contamination bound to determine the level of remediation necessary to release the Site. Surveys were limited due to the amount of material presently being stored in the facility by Bender Plumbing. Prior to engaging in further characterization, Bender Plumbing will have removed its inventory from the facility. This will allow for a 100% scan of all horizontal surfaces.

Table 3-1 lists the potential radioactive contaminants based on past site operational history and information obtained from the historic site assessment.

Table 3-1
Potential Contaminants

Radionuclide	Half-Life	Dispersible Form	Half Life >120 Days
^{226}Ra	1,600 years	Yes	Yes

The site would have used radium before regulatory agencies required a radioactive materials license. No records relating to the use or storage of radium paint could be located.

Nuclides were evaluated by utilizing Default Screening Values (DSV's) generated from a screening analysis using the default parameters contained in the DandD Code v.2.1.

4.0 Current Use

Currently the Bender Plumbing company is vacating the premises to a new business facility. Bender Plumbing is a plumbing distribution company that utilized the

former clock factory as its corporate headquarters and distribution center.

5.0 Radiological Status of Facility

Currently the Site building is being vacated by Bender Plumbing as they move to a new location in Waterbury, CT. The Site is schedule to be renovated and converted into condominium and retail space.

Areas of elevated radioactivity are present in the horizontal floor surfaces on the 4th 5th and 7th floors of the property. These areas are currently unoccupied and currently secured against unauthorized entry.

6.0 Release Criteria

The radiological release criteria of accordance with Title 10 Code of Federal Regulations (CFR) Part 20 "*Standards for Protection Against Radiation, Subpart E – Radiological Criteria for License Termination*" will be used for decommissioning the facility. While the facility was not specifically licensed by the NRC, the regulations provide the framework to achieve unrestricted release of the site with regard to radiological controls.

Specifically, the areas of the Site being released under this decommissioning effort will be surveyed in accordance with the guidance and protocols contained in MARSSIM to demonstrate compliance with the release criteria. The criteria are that residual radioactivity results in a TEDE to an average member of the critical group that does not exceed 19 mrem per year and that the residual radioactivity has been released to levels that are as low as reasonably achievable (ALARA).

7.0 Derived Concentration Guideline Levels

The NRC has published default screening values in NUREG 1757 for commonly used radionuclides. DandD v.2.1 software was used to determine default screening values 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 19 mrem/year (i.e., when probabilistic dose assessment calculations were performed, there was a 90% probability the calculated dose would be less than 19 mrem/year).

The nuclides of concern (NOC) have been limited to ^{226}Ra. The NOC screening values for surfaces under default conditions (generic screening levels) from the NRC DandD code v.2.1 are provided in Table 7.1, while Administrative Limits are provided in Table 7.2.

Table 7.1: Established DCGLw's for 19 mrem

Isotope	Total (DPM/100 cm^2)	Removable (DPM/100 cm^2)
^{226}Ra	819	82

Table 7.2: Established Administrative Limit's for Survey

Isotope	Total Average (DPM/100 cm^2)	Removable (DPM/100 cm^2)
^{226}Ra	100	20

The default screening values are the basis for developing the derived concentration guideline levels (DCGL's) for the project. The DCGL is the radionuclide specific surface area 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, higher levels of activity are permissible over small areas. The $DCGL_{EMC}$ is derived separately for these small areas. The $DCGL_{EMC}$ is the $DCGL_W$ increased by an area factor depending on the size of the elevated area.

Additionally, a reasonable effort shall be made to decontaminate any detectable contamination in support of the ALARA principle. If simple hand wipe/scrub techniques are unsuccessful at removal of the residual contamination, then the RSO may perform a cost vs. risk analysis prior to any aggressive decontamination methods.

8.0 ALARA Analysis

Due to the extremely low doses associated with the release criteria used for this characterization project, a quantitative ALARA analysis is not required. Default screening values are being used to establish DCGLs.

NUREG 1727 states in part: "In light of the conservatism in the building surface and surface soil generic screening levels developed by the NRC staff, the staff presumes, absent information to the contrary, that licensees or responsible parties that remediate building surfaces or soil to the generic screening levels do not need to demonstrate that these levels are ALARA. However, licensees or responsible parties should remediate their facility below these levels through practices such as good housekeeping. In addition, licensees or responsible parties should provide a description in the final status survey report of how these practices were employed to achieve the final activity levels."

9.0 Project Management and Organization

Due to the defined scope of the characterization survey, a complex management organization is not required. DDES will provide radiation safety, environmental and safety management. Final status survey plan will be performed according to written survey packages and procedures approved by DDES management.

10.0 Radiation Safety and Health Program

Radiological work will be performed according to the Radiation Safety Program under the management and supervision of the DDES Radiation Safety Officer.

11.0 Radioactive Waste Management

It is anticipated that there will be no waste generated from this characterization project.

12.0 Quality Assurance Program

DDES LLC will develop a Quality Assurance Project Plan (QAPP) utilizing the guidelines of MARSSIM Section 9 for the Characterization Survey Report. The QAPP will incorporate at a minimum, the following:

- Description of the Quality Assurance and Quality Control goals, Data Quality Objectives (DQO), procedures, and plans to be implemented for all D&D activities.
- Description of the methodology to ensure that all radiological survey data meet the 95% confidence level.
- The QAPP will be developed and organized with emphasis given to maximizing worker safety, minimizing/eliminating off-site releases and minimizing overall project costs. The quality control program will control all quality documents during the performance of D&D operations. Quality documents include, but are not limited to:
- Training Records
- Survey Records
- Instrument Records
- Shipping Records
- Work Procedures and Plans

13.0 Survey Instrumentation

13.1 Instrument Calibration

Laboratory and portable field instruments will be calibrated at least annually with National Institute of Standards and Technology (NIST) traceable sources, where

feasible, and to radiation emission types and energies that will provide detection capabilities similar to the nuclides of concern.

13.2 Functional Checks

Functional checks will be performed at least daily when in use. The background, source check, and field measurement count times for radiation detection instrumentation will be specified by procedure to ensure measurements are statistically valid. Background readings will be taken as part of the daily instrument check and compared with the acceptance range for instrument and site conditions. If an instrument fails a functional check, all data obtained with the instrument since the last satisfactory check will be invalidated.

13.3 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and counting times for measurement of total and removable contamination will be chosen to provide a minimum detectable concentration (MDC) that meets the criteria specified in this Plan. MARSSIM equations relative to building surfaces have been modified to convert to units of dpm/100cm^2. Count times and scanning rates are determined using the following equations:

13.3.1 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):

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

Where:

MDC_{Static}	=	Minimum detectable concentration level in dpm/100 cm^2
Br	=	background count rate in counts per minute
t_b	=	Background count time in minutes
t_s	=	Sample count time in minutes
E_{tot}	=	Total detector efficiency for radionuclide emission of interest (includes combination of instrument survey

2π efficiency and 0.25 surface efficiency)
A = Detector probe area in cm^2

13.3.2 Ratemeter Scanning

Scanning Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation that 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 level in dpm/100 cm^2
d' = desired performance variable (1.38)
bi = background counts during the residence interval
i = residence interval
p = surveyor efficiency (0.5)
E_{tot} = total detector efficiency for radionuclide emission of interest (includes combination of instrument efficiency and 0.25 surface efficiency)
A = detector probe area in cm^2

13.3.3 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 in dpm/smear
Br = background count rate in counts per minute

t_b = background count time in minutes
t_s = sample count time in minutes

13.4 Instrumentation Specifications

The instrumentation used for facility decommissioning surveys is summarized in the following tables. Table 13.1 lists the standard features of each instrument such as probe size and efficiency. Table 13.2 lists the typical operational parameters such as scan rate, count time, and the associated Minimum Detectable Concentrations (MDC).

Table 13-1 Radiological Field Instruments

Detector Model	Detector Type	Detector Area	Meter Model	Window Thickness	Typical Total Efficiency
Ludlum43-37 Floor Monitor	Gas Flow Proportional	582 cm^2	Ludlum 2221	0.4 mg/cm^2	38.1 % (^{99}Tc) 2pi
Ludlum 43-93	Alpha Beta Scintillation	100 cm^2	Ludlum 2224	0.8 mg/cm^2	37.9% (^{230}Th) 2pi
Ludlum 3030	Alpha/Beta	2 in	Ludlum 3030	0.4 mg/cm^2	37.7% (^{230}Th) 2pi
Ludlum 44-10	Gamma	2 x 2 in.	Ludlum 2221	2 in.	900 cpm/uR/hr

NOTES: These are approximate values based primarily on manufacturer's ratings. Sensitivities depend on background, count time, and other factors.

To assist with current planning activities, estimated scanning MDCs for the radionuclides of interest were obtained for field survey instruments by reviewing available information, and these values are listed in Table 13-2.

Table 13-2 Typical Operating Instrument Operating Parameters

Measurement Type	Detector Model	Meter Model	Scan Rate	Count Time	Background (cpm)	MDC (dpm/100cm^2)
Surface Scans	Ludlum 43-37 Floor Monitor	Ludlum 2224	4 in/sec	N/A	820	4,545 (^{99}Tc)
Surface Scans	Ludlum 43-93	Ludlum 2224-1	2 in/sec	N/A	334 (beta)	3,600 (^{99}Tc)
Total Surface Activity	Ludlum 43-93	Ludlum 2224-1	N/A	1 Min	1 (alpha)	88 (^{230}Th)
Removable Activity	Ludlum 3030 Alpha/Beta	N/A	N/A	1 Min	1 (alpha)	16 (^{230}Th)

Measurement Type	Detector Model	Meter Model	Scan Rate	Count Time	Background (cpm)	MDC (dpm/100cm^2)
Gamma Scans	Ludlum 44-10	Ludlum 2221	2 ft/sec	N/A	10,000	2.8 pCi/g

The scanning MDCs presented in Table 13-2 are representative of those that reasonably can be expected to be obtained with currently available instruments under conditions typically encountered in the field. These values were obtained from reported values.

14.0 Characterization Survey Design

Characterization scan surveys will be performed on horizontal surfaces (flooring, window sills, etc.) to identify areas exceeding the established DCGL for total contamination. The characterization survey will be performed so that the data produced will meet the DQOs of the Final Status Survey. The final status survey protocol, with judgmental smears and static measurements on the highest probability areas for residual radioactivity.

The purpose of scanning is to identify and delineate areas of elevated radioactivity. Where elevated radioactivity is identified, a static measurement and smear will be taken at the location of highest reading identified during the scan. The boundaries of these areas will be marked with permanent paint/markers to aid in future remediation efforts.

If the initial characterization survey results indicate that contamination is not present in excess of the DCGLs, then data from the characterization survey will be used as part of the final status survey. For areas that are partially contaminated, the characterization survey data may be used as part of the final status survey measurements provided that 1) the data used is only from areas with contamination levels below the release criteria, and 2) decontamination work is controlled such that the survey location could not have become cross-contaminated.

Each survey unit will have an independent survey package that has specific survey instructions. The survey package will contain, at a minimum:

- Survey Unit number (e.g., Building and Room Number, System Number, etc.)
- Percentage of surface requiring scan surveys
- Number of removable contamination measurements
- Instrumentation to be used with static count times and scan rates
- Any additional specific survey instruction
- Maps of the survey unit surfaces

Surveys are performed to demonstrate that residual radioactivity in each survey unit satisfies the predetermined criteria for release for unrestricted use. The final status survey will be conducted using the Data Quality Objective (DQO) process. Characterization and remedial action survey data will be used as final status survey data to the maximum extent possible in order to minimize overall project costs.

Characterization surveys will be conducted by performing required scan surveys, total direct measurements, removable contamination measurements and soil sampling as discussed further in this section. All survey data shall be documented on survey maps and associated survey data information sheets.

14.1 Background Determination

Surface material reference backgrounds will be performed due to the high variability of background radiation in brick and wood building materials. Surface background will be determined for each survey to calculate the actual survey MDCs and associated count errors.

14.2 Area Classifications

Due to the limited information obtained about areas of us and given the number of years that radium based paints were used, most facility areas have been classified as potentially impacted. All the flooring and support structures that have been replaced with new materials and are considered to be non-impacted.

14.2.1 Non-Impacted Area

Non-impacted areas are areas without the potential for residual radioactivity above the site DCGLs. These areas will not be surveyed. The following areas are classified as non-impacted:

- Vertical surfaces
- Areas completely rebuilt after 1960

14.2.2 Impacted Areas

Impacted areas are those areas that have 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, for the purposes of this plan are as follows:

14.2.3 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.

14.2.4 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.

14.2.5 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.

14.3 Survey Units

A survey unit is a geographical area of specified size and shape for which a separate decision will be 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 plan, areas of similar construction and composition will be grouped together as survey units and tested individually against the DCGLs and the null hypothesis to show compliance with the release criteria. Survey units will be 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 will be sized according to the potential for small-elevated areas of residual radioactivity.

Survey units will be established to meet MARSSIM recommendations.

Table 14.1: MARSSIM Recommended Maximum Survey Unit Sizes

Type of Survey Unit	Class 1	Class 2	Class 3
Structures*	Up to 100 m^2	100 m^2 to 1,000 m^2	No limit

Table 14.2 lists the areas of the building that have been potentially impacted by the use of radioactive material and were evaluated against the decommissioning criteria.

Table 14.2 Potentially Impacted Areas

Floor	Survey Unit Classification	Nuclides of Concern
1st	III	^{226}Ra
2nd	III	^{226}Ra
3rd	III	^{226}Ra
4th	I	^{226}Ra
5th	I	^{226}Ra
6th	III	^{226}Ra
7th	I	^{226}Ra

14.4 Gamma Walkover Survey

Health physics personnel will use a Ludlum 44-10 (or equivalent) 2x2 NaI scintillation detector coupled with a Trimble GPS GEOEXPLORER 6000, or equivalent to perform a gamma walkover survey of the exterior soils area. The detector will be paired with a Ludlum 2350-1 (or equivalent) survey meter. Readings will be counted automatically every 1-2 seconds and data logged for retrieval. Technicians utilized headphones in order to gauge the increased counts over background. The gamma scan sensitivity for ^{226}Ra using this instrumentation is 2.8 pCi/g based on NUREG 1575 MARSSIM Rev. 1, Table 6.7.

In order to provide maximum efficiency, and a consistent source to detector distance, a gamma scintillation detector will be attached to a rope that will allow the technician to swing the detector left and right in a two (2) foot arc while walking forward at a scan rate of two (2) feet per second and maintain a detector distance-to-surface of approximately 6 inches. Technicians will pass the detector over the surface in a serpentine traverse pattern. Technicians will maintain a course within the established roped-in survey areas from one end to the other covering the designated survey area.

Typical background measurements for the Ludlum 44-10 are 10,000 counts per minute (cpm). For this survey, greater than 2x background will be considered the "action level." Any measurements greater than 2x background will be marked for a more thorough follow up survey. The exterior gamma survey data will be overlaid on a map of the site.

14.5 Surface Scans

Scanning for ^{226}Ra will be performed to verify that the presence this nuclide is not present above the DCGL.

Typically, scanning is used to identify locations within the survey unit that exceed the investigation level. These locations are marked and receive additional investigations to determine the concentration, area, and extent of the contamination. Scanning surveys are designed to detect small areas of elevated activity that are not detected by the measurements using the systematic pattern. Table 14.3 summarizes the percentage of accessible building structural surfaces to be scanned based on classification.

Table 14.3 Scan Survey Coverage by Classification

Classification	Percentage of Surface Area Requiring Scan Coverage (MARSSIM)	Benrus Clock Factory Surface Area Scan Coverage
1	100%	100%
2	10 – 100% (Judgmental)	50%
3	Judgmental	20%

The percentage of survey area scan surveyed may be increased based on suspected elevated activity. For Class 2 and Class 3 areas, the surfaces to be scan surveyed will be those with the highest potential to contain residual contamination.

Floor areas near entrances, windows and exits will receive a 100% scan survey regardless of the area classification. These surveys will provide indications of potential migration of residual contamination to other areas. Heavily travelled areas like stairways and isle ways will also receive a 100% scan.

If elevated activity is detected during the scan surveys, then the location shall be marked and total and removable surface activity measurements will be taken to quantify the activity.

14.6 Total Surface Activity Measurements

Total activity measurements will be obtained on building surfaces and system internals to the extent practical in impacted areas utilizing instrumentation of the best geometry based on the surface at the survey location. Locations of elevated activity will be identified and marked during the scan survey. Total surface activity measurements will be taken at each determined sample location. Hand-held monitor count times will be determined based on the MDC_{static} of the applicable survey instrument.

14.6.1 Determining the Number of Samples

A minimum number of samples are needed to obtain sufficient statistical confidence that the conclusions drawn from the samples are correct. The number of samples will depend on the Relative Shift (the ratio of the concentration to be measured relative to the statistical variability of the contaminant concentration).

The minimum number of samples is obtained from MARSSIM tables or calculated using equations in Section 5 of MARSSIM.

14.6.2 Determination of the Relative Shift

The number of required samples will depend 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 and is defined in MARSSIM as:

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

Where:

DCGL = Derived concentration guideline level
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.
σ_s= An estimate of the standard deviation of the residual radioactivity in the survey unit.

14.6.3 Determination of Acceptable Decision Errors

A decision error is the probability of making an error in the decision on a survey unit by failing a unit that should pass (ß decision error) or passing a unit that should fail (α decision error). MARSSIM uses the terminology α and ß 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.

14.6.4 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.

14.6.5 Determination of Sample Locations

Determination of Class 1 survey unit sample locations is accomplished by first determining sample spacing and then systematically plotting the sample locations from a randomly generated start location. The random starting point of the grid provides an unbiased method for obtaining measurement locations to be used in the statistical tests. Class 1 survey units have the highest potential for small areas of elevated activity, so the areas between measurement locations may be adjusted to ensure that these areas can be detected by scanning techniques.

Similar systematic spacing methods are used for Class 2 survey units because there is an increased probability of small areas of elevated activity. The use of a systematic grid allows the decision-maker to draw conclusions about the size of the potential areas of elevated activity based on the area between measurement locations.

Class 3 survey locations are determined from computer selected randomly generated x and y coordinates. Survey protocols for all areas are summarized in Table 14.4.

Table 14.4 Survey Sample Placement Overview

Survey Unit Classification		**$DCGL_w$ Comparison**	**Elevated Measurement Comparison**	**Measurement Locations**
Impacted	Class 1	Yes	N/A	Systematic random
	Class 2	Yes	N/A	Systematic random
	Class 3	Yes	N/A	Random
Non-Impacted		None	None	None

Permanent counter tops and other horizontal surfaces, which block floor surfaces, will be included as a replacement to the blocked floor surface.

Internal surfaces of permanent furnishings (i.e., drawer or cabinetry interior surfaces) are not included in the systematic measurement location placement. However, these surfaces will be included in the scan surveys and judgmental measurements may be taken.

Additional total surface activity measurements will be collected at each area of elevated activity identified during the scan surveys.

14.6.5.1 Determining Class 1 and 2 Sample Locations

For this survey, all impacted areas will be considered Class 1. In Class 1 survey units, the sampling locations are established in a unique pattern beginning with the random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing is determined from MARSSIM Equation 5-8:

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

Where:

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

Maps will be generated of the survey unit's permanent surfaces included in the statistical tests. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid is plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location is plotted at each intersection of the grid plot.

14.6.5.2 Determining Class 3 Sample Locations

Class 3 areas sample locations will be selected randomly with additional biased sample locations where the highest potential of residual contamination exists. Each chosen location will be plotted on the applicable survey map.

14.7 Removable Contamination Measurements

Removable contamination measurements (smears) will be collected on surfaces at each sample location. Additionally, removable contamination measurements will be

collected for building system internals. An area of approximately 100 cm^2 shall be wiped wherever possible. If an area of less than 100 cm^2 is wiped, a comment shall be added to the survey data sheet estimating the surface area wiped to allow for area correction of the results. Swabs may be used when system or component access points are not large enough to allow for a wipe of a 100 cm^2 surface area.

14.8 Survey Documentation

A survey package will be developed for each survey unit containing the following:

- Survey Instruction Sheets
- General survey requirements
- Instrument requirements with associated MDCs, count times and scan rates
- Survey Maps
- Overview maps detailing survey locations and placement methodology
- Survey sub-unit maps with additional sample location information, as needed
- Survey Data Sheets
- Signature of Data Collector and Reviewer

14.9 Data Validation

Field data will be reviewed and validated to ensure:

- Completeness of forms and that the type of survey has correctly been assigned to the survey unit.
- The MDCs for measurements meet the established data quality objectives; independent calculations will be performed for a representative sample of data sheets and survey areas.
- Instrument calibrations and daily functional checks have been performed accurately and at the required frequency.

15.0 Data Quality Assessment (DQA) and Interpretation of Survey Results

The statistical guidance contained in Section 8 of MARSSIM will be used to determine if areas are acceptable for unrestricted release, and whether additional surveys or sample measurements are needed.

15.1 Preliminary Data Review

A preliminary data review will be performed for each survey unit to identify any patterns, relationships or potential anomalies. Additionally, measurement data is reviewed and compared with the DCGLs and investigation levels to identify areas of elevated activity and confirm the correct classification of survey units. If an area is

misclassified with a less restrictive classification, the area will be upgraded and surveyed accordingly.

The following preliminary data reviews will be performed for each survey unit:

- Calculations of the survey unit mean, median, maximum, minimum, and standard deviation for each type of reading.
- Comparison of the actual standard deviation to the assumed standard deviation used for calculating the number of measurements. If the actual standard deviation is greater than estimated, the minimum number of samples shall be calculated using the actual standard deviation to ensure a sufficient number of samples have been obtained.
- Comparison of survey data with applicable investigation levels.

15.2 Determining Compliance

For Class 1 areas, if it is determined that all total activity results are less than the applicable DCGL, then no further statistical tests are required. If any of the total activity measurements are greater than the DCGLW, then the survey unit fails and the null hypothesis is not rejected. The survey unit is determined to meet the release criterion provided that the application of any unity rules result in values less than 1.

The Sign test is used to determine the minimum number of sample locations. However, the Sign test is not performed in this survey design because the total activity DCGL is used as a maximum. If all measurements are less than the DCGL, performance of the Sign test is not necessary because the survey unit will pass the Sign test by definition.

Removable contamination measurements will be compared directly to the applicable DCGL. No contingency is established for elevated removable contamination. Therefore, if any removable contamination is detected which exceeds the removable contamination DCGL, the survey unit is determined not to meet the release criterion. However, if all removable contamination measurements are less than the removable contamination DCGL, then compliance shall be determined based on total activity measurements.

Compliance will be determined for each applicable type of total activity measurement performed in each survey unit (i.e., gross beta total activity measurements and gross gamma total activity measurements).

A Characterization Report summarizing the current conditions and a remediation plan at the Former Benrus Clock Factory Site will be prepared and submitted for

review and comment.

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