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July 20, 2017

Mr. David Misenhimer, P.E.
Nuclear Material Safety and Safeguards
Division of Decommissioning, Uranium Recovery, and Waste Programs
Materials Decommissioning Branch
U.S. Nuclear Regulatory Commission
11545 Rockville Pike, MS T8-F05
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SUBJECT: PROJECT-SPECIFIC PLAN FOR THE SURVEY OF THE ENTERPRISE APARTMENTS AT THE FORMER WATERBURY CLOCK FACTORY PROPERTY AT 13 CHERRY AVENUE IN WATERBURY, CONNECTICUT
CONTRACT NO. NRC-HQ-50-17-A-0001; DCN 5307-PL-01-1

Dear Mr. Misenhimer:

Oak Ridge Associated Universities (ORAU) is pleased to provide the attached plan for the survey of the Enterprise Apartments at the former Waterbury Clock Factory property at 13 Cherry Avenue in Waterbury, Connecticut. This survey plan follows a streamlined version of the outline given in the Temporary Instructions 2800/043, Appendix A.

Please feel free to contact me at 865.574.0685 or Tim Vitkus at 865.576.5073 if you have any questions.

Sincerely,

David A. King, CHP, PMP
Sr. Health Physicist/Project Manager
ORAU

DAK:lw

Attachment

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Technical/Group Manager Review	ENB

PROJECT-SPECIFIC PLAN FOR THE SURVEY OF THE ENTERPRISE APARTMENTS AT THE FORMER WATERBURY CLOCK FACTORY PROPERTY AT 13 CHERRY AVENUE, WATERBURY, CONNECTICUT

Prepared by
David A. King
ORAU

July 2017

FINAL PLAN

Prepared for the
U.S. Nuclear Regulatory Commission

This document was prepared for the U.S. Nuclear Regulatory Commission (NRC) by Oak Ridge Associated Universities under contract number NRC-HQ-50-17-A-0001.

Property:	Enterprise Apartments & Abbott Towers Former Waterbury Clock Company
Docket Number:	3038965
Current Property Name(s):	Enterprise Apartments
Current Property Owner(s):	WinnResidential
Inspection Dates:	TBD
Inspector(s):	TBD, U.S. Nuclear Regulatory Commission (NRC) Region I TBD, Oak Ridge Associated Universities (ORAU)

1.0 INTRODUCTION

The Energy Policy Act of 2005 amended section 11e.(3) of the Atomic Energy Act of 1954 to place discrete sources of radium-226 (Ra-226) under NRC regulatory authority as byproduct material. The Enterprise Apartments at 13 Cherry Avenue in Waterbury, Connecticut (CT) was identified as part of the former Waterbury Clock Company, a clock manufacturer that operated from 1857 to 1944. In 1919, the former Waterbury Clock Company began painting time pieces with luminous radium until manufacturing was relocated to Middlebury, CT; Little Rock, Arkansas; and Dundee, Scotland in 1944 (ORNL 2015). Additional information is also available in the Agency for Toxic Substances and Disease Registry (ATSDR 1999) and Scientech (2003) reports. The objectives of the survey will be to confirm previous cleanup activities and determine if discrete sources of Ra-226 and/or distributed Ra-226 contamination are still present at the Enterprise Apartments, to identify the areas of highest contamination (if any radium contamination is identified), to determine if there are any current health and safety concerns, and to determine if further action by the NRC is needed.

Data collected from the survey will be used either to eliminate the property from future NRC consideration (i.e., when exposure to Ra-226, if present, would not likely produce a radiation dose in excess of 25 mrem/yr) or to plan future actions that may be needed to reduce the exposure of Ra-226 to current or future site occupants to levels that do not exceed the applicable regulatory requirement. It is important to note that destructive testing is not generally performed as described within NRC's procedures, Temporary Instruction (TI) 2800/043 *Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources* (NRC 2016).

2.0 PROPERTY DESCRIPTION AND CONCEPTUAL MODEL

Prior to establishing its autonomy in 1857, the former Waterbury Clock Company was a department of the Benedict and Burnham Manufacturing Company, which began manufacturing brass clocks in 1850. In 1873, Waterbury separated from Benedict and Burnham and acquired its own facility at the corner of Cherry Avenue and North Elm Street (see Building A in Figure 1) where, between 1873 and 1910, the company expanded by constructing several five- and six-story buildings. In 1919, the company began using luminous radium to paint the dials of various time pieces. Although the extent of radium paint storage and/or use throughout the facility is not completely known, records indicate that the entire industrial complex on the corner of Cherry Avenue and Cherry Street was dedicated to manufacturing time pieces painted with radium until operations were relocated in 1944 (ORNL 2015).

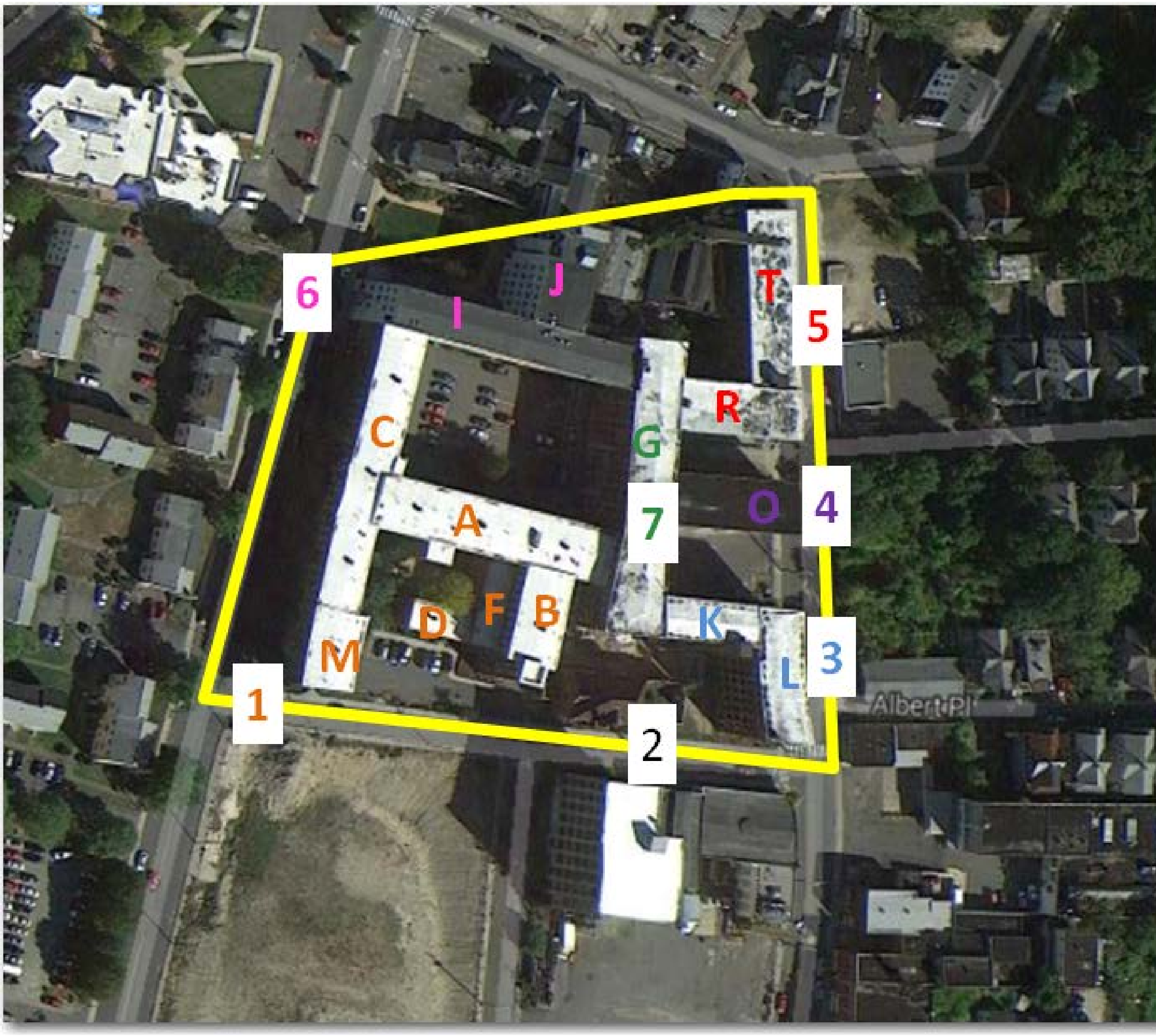

Figure 1. Former Waterbury Clock Company Facilities and Surrounding Areas

1 – 13 Cherry Ave., Buildings A, B, C, D, F, and M, Enterprise Apartments;
2 – 0 Cherry Ave, Building #7, vacant;
3 – 177 Cherry St., Buildings K and L, vacant;
4 – 205 Cherry St., Building O, Ville Swiss Automatics;
5 – 215 Cherry St., Buildings R and T, vacant;
6 – 232 N Elm St., Buildings I and J, NOW;
7 – 39 Cherry Ave., Building G, formerly Belco, now vacant and owned by NOW
(ORNL 2015)

As of spring 2017, most of the former Waterbury buildings are still standing with original floors and brick walls. Buildings A, B, C, D, F, and M from Figure 1 (aerial view) were converted to apartments in 1983 and now form one complex, Enterprise Apartments, managed by WinnResidential (ATSDR 1999; WinnResidential 2017). Figure 2 shows the apartments looking north by northwest. Previous radiological assessments by the ATSDR and Scientech identified elevated radiation levels in several discrete locations throughout the fourth and fifth floors. These results are provided in Appendices A and B, respectively. As a result, the State of Connecticut initiated cleanup efforts to remove radium contamination.

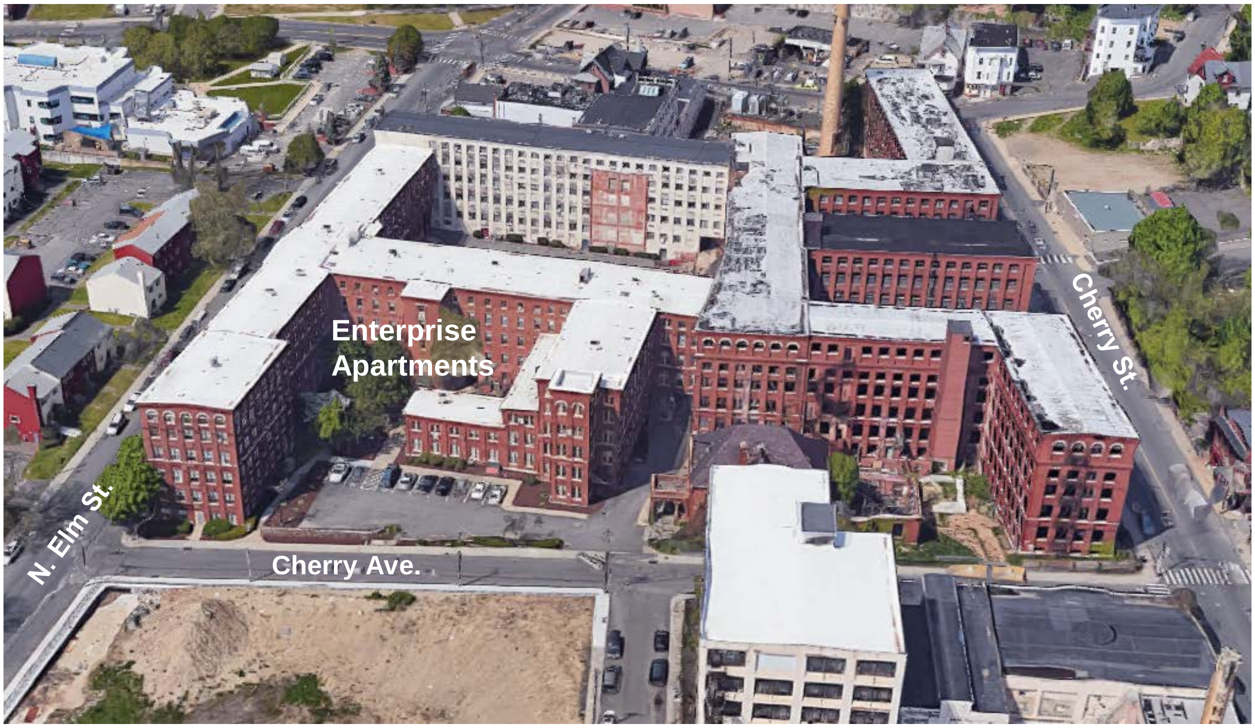

Figure 2. Enterprise Apartments at 13 Cherry Avenue

The site summary included in the *Historical Non-Military Radium Sites Research Effort Addendum* report (ORNL 2015) provides known site details about the type, form, history, potential locations, and other information related to discrete sources of Ra-226 used at the site.

3.0 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQOs) described herein are consistent with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, NUREG-1575 (NRC 2000) and provide a formalized method for planning radiation surveys, improving survey efficiency and effectiveness, and ensuring that the type, quality, and quantity of data collected are adequate for the intended decision applications. The seven steps in the DQO process are outlined below:

1. State the problem
2. Identify the decision
3. Identify inputs to the decision
4. Define the study boundaries
5. Develop a decision rule
6. Specify limits on decision errors
7. Optimize the design for obtaining data

3.1 Step 1 – State the Problem

The first step in the DQO process defines the problem that necessitates the study, identifies the planning team, and examines the budget and schedule. The Energy Policy Act of 2005 amended section 11e.(3) of the Atomic Energy Act of 1954 to place discrete sources of Ra-226 under NRC regulatory authority as byproduct material. From cleanup efforts conducted in 2004, the NRC is confirming that in the past:

1. Radium contamination was removed or did not need remediation from apartments 416 417, 505, 507, 508, 512, 513, 514, 515, 516, 517, 520, 525, and 5th floor hallway; and

2. All doses to members of the public from these areas do not exceed 25 mrem/yr.

3. As time permits, survey activities will also be performed in common areas including the facility grounds, lobbies, hallways, etc., to confirm the absence of contamination.

4. As time permits, survey activities may also be performed in additional apartments, if requested by tenants, to confirm the absence of contamination.

Based on this background information, the problem statement is as follows:

> Surveys are required to determine the extent of Ra-226 contamination and its boundary and assess the quantity of Ra-226 to determine the radiological dose from exposure to Ra-226.

Project Organization and Responsibilities. Table 1 presents the project organization across programs and departments, including key personnel, roles, and contact information.

Table 1. Key Personnel Contact Information

Name	Organization	Role	Phone	E-mail
David Misenhimer Richard Chang	NRC, HQ	Project Manager	301-415-6590 301-415-5888	David.Misenhimer@nrc.gov Richard.Chang@nrc.gov
Raymond Powell	NRC, RI	Branch Chief	610-337-6967	Raymond.Powell@nrc.gov
Todd Jackson	NRC, RI	Inspector	610-337-5308	Todd.Jackson@nrc.gov
David King	ORAU	Project Manager	865-574-0685	David.King@orau.org

HQ = Headquarters RI = Region I

The inspector will coordinate with the Office of Nuclear Material Safety and Safeguards (NMSS) and the property owner to gain site access. Project managers will coordinate with the property owner for access agreements and scheduling. The inspector will coordinate with the NMSS project manager for site coordination, state coordination, outreach, and internal NRC coordination.

Project Budget and Schedule. The project is funded by the NRC, and the survey is tentatively scheduled for summer of 2017. Fieldwork is anticipated to last two days. A draft survey report will be issued within 21 business days after the completion of field work and laboratory sample analyses, as applicable.

3.2 Step 2 – Identify the Decision

The second step in the DQO process identifies the Principal Study Questions (PSQs) and Alternate Actions (AAs); develops a decision statement; and organizes multiple decisions, as appropriate. This is done by specifying AAs that could result from a "yes" response to the PSQs and combining the PSQs and AAs into a decision statement. Table 2 presents the PSQs and AAs combined into a decision statement.

Table 2. Ra-226 PSQs, AAs and Decision Statement	
Principal Study Question	Alternative Actions
PSQ1: Did the survey identify discrete sources of Ra-226?	**No**: The data will be used to support the conclusion that unidentified discrete sources of Ra-226 are not present on the property. Therefore, further consideration by the NRC is not recommended. **Yes**: Proceed to PSQ2.
PSQ2: If discrete sources of Ra-226 are identified, could the exposure reasonably produce a radiological dose above 25 mrem/yr to current or foreseeable future receptors?	**No**: The data will be used to support the conclusion that the site does not require remedial action or future radiological controls. **Yes**: The data will be used by the NRC to control and mitigate risks from exposure to Ra-226 and to plan future remedial actions.
Decision Statement	
Discrete sources of Ra-226 are (or are not) present and could (or could not) reasonably produce radiation doses above 25 mrem/yr, and the NRC does (or does not) require further action at the property.	

3.3 Step 3 – Identify Inputs to the Decision

The third step in the DQO process identifies both the information needed and the sources for this information; determines the basis for action levels; and identifies sampling and analytical methods that will meet data requirements. For this effort, information inputs include the following:

- Energy Policy Act of 2005 amended section 11e.(3) of the Atomic Energy Act of 1954, as amended
- 10 CFR Part 20, Standards for Protection Against Radiation, Sections 20.1402 and 1301
- Site summary documentation (ORNL 2015), ATSDR radiological assessment results (Appendix A), and Scientech radiological assessment results (Appendix B)
- Site access agreements and associated limitations, if any
- NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC 1998), for estimating detector-specific minimum detectable concentrations (MDCs)
- Applicable field instrumentation and survey procedures, method procedures, data/sample management procedures, and survey results

- Applicable analytical laboratory procedures, method procedures, data/sample management procedures, and analytical results

- Dose modeling data, inputs, and dose consequence outputs (NUREG/CR-5512, Vol. 3) (SNL 1999)

3.4 Step 4 – Define the Study Boundaries

The fourth step in the DQO process defines target populations and spatial boundaries; determines the timeframe for collecting data and making decisions; addresses practical constraints; and determines the smallest subpopulations, area, volume, and time for which separate decisions must be made.

Boundary conditions include physical, temporal, and practical factors that may limit an inspector's access to the property. More specifically:

- Physical boundary

    - The subject property consists of six multi-story brick buildings (A, B, C, D, F, and M – Figure 1) that have been renovated into an apartment complex, and most areas of interest should be physically accessible. Survey boundaries are limited to the apartments originally identified by ATSDR and Scientech as containing elevated radiation levels (see Appendices A and B and DQO Step 3) and the common areas.

- Temporal boundary

    - Inspectors may have limited time to survey all apartments and areas requested by the NRC, and access to each target apartment may only be available during small windows of time. Common areas (e.g., hallways and the outdoor areas) will be surveyed as time permits. Finally, tenants from apartments not identified by ATSDR and Scientech as contaminated may request their apartments be surveyed—these may be surveyed as time permits. That is, the inspection team will focus on apartments where the historical record states that Ra-226 contamination was identified but, time permitting, may also survey other accessible portions of the apartment complex.

- Practical boundary

    - Inspectors may have limited property access based on the access agreement with the property owner and/or tenants' disposition for entry into their apartments. Volumetric/destructive sampling is unlikely for this survey, though it will be considered if necessary.

To address these boundary conditions, this survey plan is based on a judgmental (rather than statistical) survey approach to target accessible locations with the highest potential for containing Ra-226 contamination. In general, the inspection team will collect as much data as possible from accessible areas with the highest potential of containing Ra-226 contamination in the time allotted to perform the survey. Inaccessible areas will not be surveyed unless there is a clear indication that the inaccessible areas may have levels of contamination critical to the PSQs. In such cases, the path forward will be discussed with the NRC management.

Decisions may be made based on any single confirmed discrete source (the smallest subpopulation) that could produce a radiological dose greater than 25 mrem/yr, assuming a plausible current-use scenario. If suspected Ra-226 is encountered, the inspection team will gather sufficient data from the area to delineate and quantify contamination levels. These data will support the dose analysis and programmatic decisions.

3.5 Step 5 – Develop a Decision Rule

The fifth step in the DQO process specifies appropriate population parameters (e.g., mean, median); confirms investigation levels are above detection limits; and develops an "if…then…" decision rule statement. The objective of the survey is to locate discrete sources of Ra-226 and, if located, determine if the sources (either individually or in combination) could result in an unacceptable dose based on current or reasonably expected future use. Inspectors are required, via implementation of this plan, to locate and collect necessary data to delineate Ra-226 contamination. This data will then be used to calculate the site-specific dose for comparison to the 25 mrem/yr limit. Specific investigations levels, therefore, are thresholds that will be used to prompt more extensive data collection in a particular area, as follows:

1. Positive identification, by visual inspection or other means, of discrete sources of Ra-226.

2. A gamma radiation measurement that is clearly above ambient background conditions. A 2-inch by 2-inch (2×2) sodium iodide (NaI) detector (Ludlum Model 44-10) will be used to identify locations with elevated gamma radiation levels, if present. Dose rate measurements will be made using an NaI, tissue-equivalent scintillator exposure ratemeter (Ludlum Model 192) that is calibrated for the measurement of Ra-226.

3. Direct measurements on a surface medium clearly above ambient background conditions. Using the methods described in NUREG-1507, the Ludlum Model 44-142 plastic scintillator detector has an estimated static MDC of 60 dpm/100 cm^2 (alpha-plus-beta). A detector response above the static MDC will prompt the inspector to collect additional data/information in the immediate area.

4. Removable surface contamination will confirm the presence of dispersible, potentially airborne, Ra-226 contamination. Smear samples will be collected and measured for gross alpha and gross beta activity to quantify the removable fraction, or more specifically, to determine if removable Ra-226 is present.

Gross gamma, exposure rates, and alpha-plus-beta measurements will be collected from locations of highest gamma response to optimize detection potential. Ra-226 and some associated decay products are alpha emitters. The alpha radiation may be easily attenuated by thin layers of dust, paint, moisture, etc. Gamma and alpha-plus-beta emissions will often provide a more accurate quantification of the total activity. In all cases, it is presumed that the resulting dose to a current or potential future receptor could reasonably exceed 25 mrem/yr if measured concentrations exceed action levels. A site-specific dose analysis may result from the confirmation of any of these items. The decision rule is, therefore:

> If Ra-226 is present above ALs and could reasonably produce radiation doses above 25 mrem/yr, then the site requires additional actions; else the data may be used to support a no-further-action decision.

3.6 Step 6 – Specify Limits on Decision Errors

The sixth step in the DQO process specifies the decision maker's limits on decision errors, which are then used to establish performance goals for the survey. The nature of this project and boundary conditions typical for surveys do not support robust decision errors as may be developed for a statistical (rather than judgmental) survey design. Statistical-based methods are routinely applied to characterization or final-status efforts and not this type of surveys, which are typically smaller scaled and rely on judgmental (rather that statistical) data. Additionally, the identification of only one discrete source of Ra-226 would result in future NRC action. Therefore, decision errors here are associated with a measurement goal of no more than 10 to 50 percent of quantifiable investigations levels, though MDCs are set at the 95 percent confidence interval, where applicable.

1. The positive identification of Ra-226 through visual inspection or other means is not associated with a quantifiable AL and is simply a presence/absence determination. Thus, false positive/false negative decisions are a function of area accessibility.

2. The exposure ratemeter produces a stable response at ambient levels, on the order of 10 µR/h. The TI specifies an "action level" (AL) for controls of 15 µR/h above background for residential properties, associated with a dose of 100 mrem/yr. In this case, however, decisions are associated with the unrestricted release dose criterion of 25 mrem/yr, thus instrumentation will ideally measure gamma radiation levels no more than 50 percent of 3-4 (rather than 15) µR/h. Background radiation levels in the 5-15 µR/h are anticipated, depending on the proximity to naturally occurring radioactive materials (e.g., brick). While limits on technology precludes achievement of the 10 to 50 percent measurement goal, ORAU and the inspection team is experienced in identifying Ra-226 contamination at similar sites, and will use other instrumentation as described in this plan to investigate and delineate potential contamination, when identified.

3. Direct measurement MDCs at the 95 percent confidence interval using a plastic scintillator detector are dependent on background/medium-specific and instrument-specific inputs. However, some direct measurements for alpha-plus-beta activity may be used to support site-specific dose analysis when required. The alpha-plus-beta static MDCs are less than 50 percent of the interim 300 dpm/100 cm^2 total AL (NUREG/CR-5512, Vol. 3) (SNL 1999), assuring that both false positive and false negative errors are minimized.

4. The MDC for smears, also based on the 95 percent confidence interval, is less than 10 dpm/smear for gross alpha and less than 15 dpm/smear for gross beta (100 cm^2 per smear is presumed for standard smears). A project-specific AL has not been established, but an interim AL of 30 dpm/100 cm^2 is presumed to represent the 10 percent removable fraction as defined in the derivation of the 300 dpm/100 cm^2 total AL (NUREG/CR-5512, Vol. 3) (SNL 1999).

Hand-held instruments may be used to locate and delineate contamination associated with Ra-226. Table 3 presents example MDCs for a Ludlum Model 44-142 plastic scintillator detector, assuming an alpha-plus-beta background response of 350 cpm. A 2×2 NaI detector may also be used to locate and delineate Ra-226 contamination. Using the default methods described in NUREG-1507, the scan MDC for Ra-226 is estimated at 2.8 pCi/g, as presented in Table 3, though this concentration is derived for volumetric contamination and not surfaces. For this effort the 2×2 NaI detector will be used qualitatively to locate and delineate gross radium contamination, if present. Property-specific MDCs will be established based on site-specific background conditions and instrumentation.

Table 3. Example Minimum Detectable Concentrations					
Gross Activity	Instrument[a]	Typical Bkg (cpm)	Typical Total Eff.[b]	Detector Area (cm^2)	Static MDC
Alpha-plus-beta	Plastic Scintillator	350	1.6	100	60 dpm/100 cm^2
Gamma	2×2 NaI	10,000	N/A	N/A	2.8 pCi/g[c]

[a]2×2 NaI = 2-inch by 2-inch sodium iodide
[b]Assumes equilibrium with progeny
[c]Default scan MDC from NUREG-1507 for soil or soil-like (bulk) materials

3.7 Step 7 – Optimize the Design for Obtaining Data

The seventh step in the DQO process is used to review DQO outputs; develop data collection design alternatives; formulate mathematical expressions for each design; select the sample size to satisfy DQOs; decide on the most resource-effective design of agreed alternatives; and document requisite details. The overall approach is to collect as much data as possible given the boundary conditions identified in Section 3.4. The survey approach is divided into several general steps, starting with property reconnaissance and the division of accessible areas into logical Survey Units (SUs). The inspector should clearly specify which areas are accessible and which are not (and for what reasons).

It is presumed that Ra-226 will generate a detectable gamma radiation signal and is most easily located in the field using gamma radiation instrumentation. Therefore, inspectors will initially screen the property using hand-held 2×2 NaI detectors. Locations with a maximum gamma radiation signature, potentially containing Ra-226, may then be prioritized for further evaluation using dose-rate and alpha/beta instruments, and/or may be sampled as deemed necessary.

Within each SU, and considering Figure 3, the inspector shall:

- Perform a survey using a 2×2 NaI detector and exposure ratemeter to locate areas of elevated gamma radiation. In each room, one to five 1-meter general area exposure rate measurements will be collected to estimate the average exposure rate. Measurement locations will target the center of each quadrant of the room plus the middle of the room (locations may be moved to avoid large obstacles). The number of measurements will be scaled to the size of the room (i.e., small rooms such as bathrooms may have only one measurements location).

- In addition to the background measurements, based on professional judgment, collect measurements at the locations with the highest gamma radiation levels or if a potential Ra-226 source is identified:

    - Delineate the contaminated area via surface scans and static alpha-plus-beta or gamma measurements and specify location, including whether structural surface or system/equipment, boundaries, and magnitude of contamination including "hot spots." Illustrate this information in a logbook or annotate a map for future reference—note approximate or actual floor/ceiling coordinates to the southwest corner of the room or lower left corner of a wall.

- Collect a 2×2 NaI direct measurement and an exposure rate measurement on contact and at one meter from the surface.

- Collect alpha-plus-beta direct measurements (static measurements).

- Collect sufficient smear samples to estimate the removable activity fraction in the area.

- Note the proximity of the contaminant relative to habitable spaces and the hours of occupancy for those spaces.

- If possible, collect a volumetric sample (i.e., paint scrapings) for off-site laboratory analysis. However, sample collection must be non-destructive and not cause damage to the area of collection.

This information will be used, if required, to conduct a property-specific dose assessment.

In general, no surveys or sampling requiring destruction of property should be performed. If destruction of property is necessary to obtain critical measurements, then the inspector shall consult with regional management for guidance.

A detailed logbook will be maintained, which will provide a comprehensive description of field activities. Inspectors, at a minimum, will clearly document the following:

- Dates, times, and individuals performing the survey
- Instrumentation type and identification numbers
- Site and environmental conditions and instrument background measurement data
- 2×2 NaI screening results by room, area, or other logical property division
- Exposure measurement results
- Direct measurement results
- Sample (smear and volumetric) identification numbers and proposed analyses
- Detailed maps or drawings documenting measurement and sample location information
- Detailed description of the location, physical characteristics, radiation levels, and occupant (adult/minor) and their time in the area associated with confirmed discrete sources, if identified
- Relevant discussions or interactions with non-project personnel/stakeholders
- Details regarding any deviation from the plan

Survey forms and annotated maps may also be used to record radiation measurement and location information.

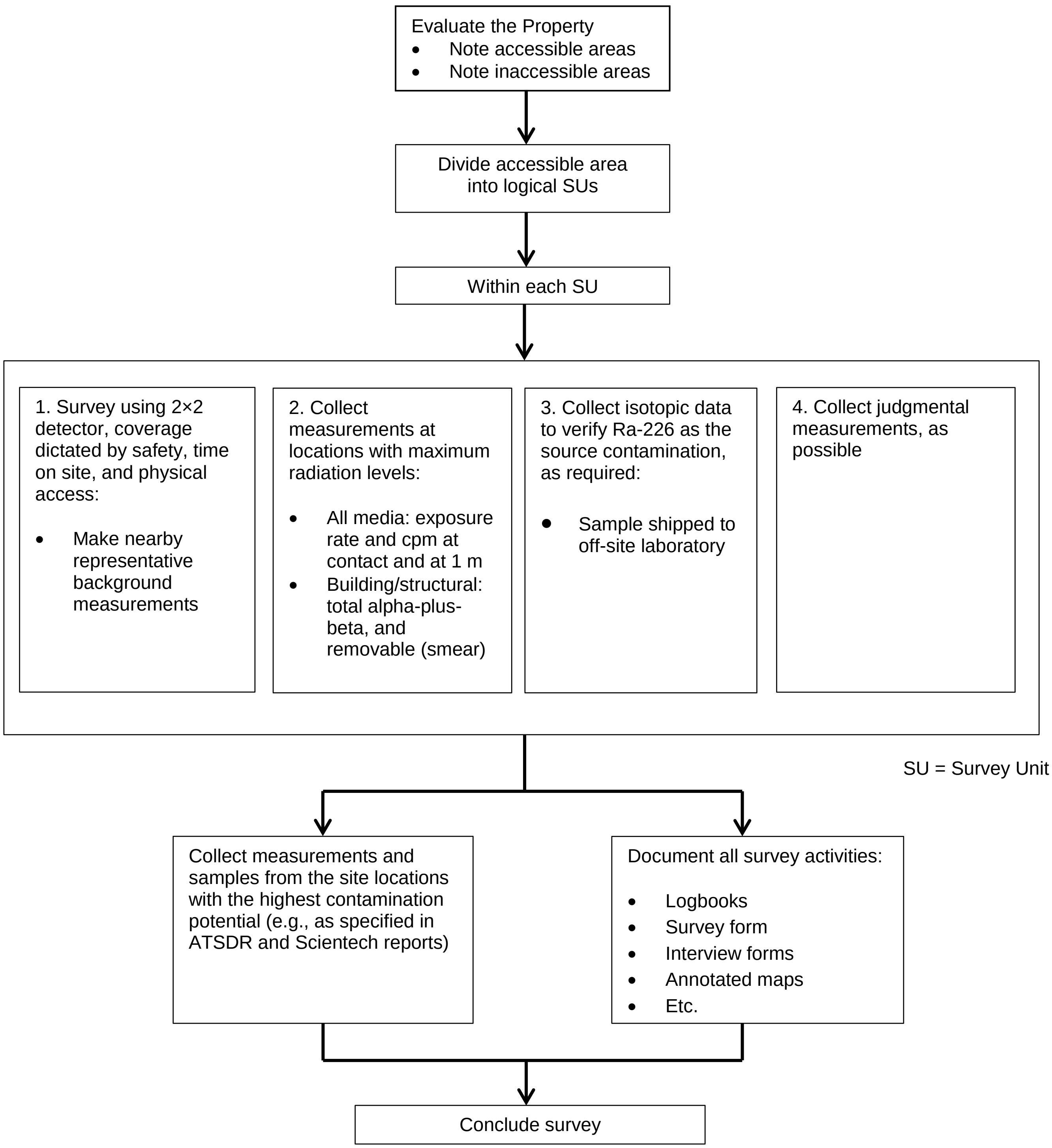

Figure 3. Survey Overview

4.0 HEALTH AND SAFETY

Because the level of contamination, if any, is unknown, inspectors will need to be flexible and prepared to upgrade personal protective equipment (PPE), if needed. Initial PPE will be minimal and will be adjusted as necessary.

- Appropriate PPE for this survey consists of sturdy work shoes. Consult the *Health and Safety and Waste Management Work Instructions for Scoping Surveys at Sites Potentially Contaminated by Discrete Sources of Radium* (ORAU 2017).

- If an exposure rate is encountered greater than 2 mrem/hr at one meter, or if the area is suspected of containing airborne contamination, then:

  - Coordinate/plan with regional management should significant contamination be encountered, as well as coordination with the property owners.

  - Consider how best to delineate and control the area, and, if appropriate, clearly post the area to limit public access during and after sampling activities.

  - Inspectors may be required to upgrade the level of PPE while sampling.

  - Any waste (e.g., PPE and sampling equipment) will be managed according to the waste management plan (see Section 5.0).

Note that a state representative may request to accompany the inspector during the survey. It should be clearly communicated that these individuals are responsible for their own health and safety.

5.0 WASTE MANAGEMENT

Survey activities have the potential for generating waste containing non-trivial levels of Ra-226 activity. Types of waste include PPE, sampling equipment (e.g., scrapers), and the sampled media (e.g., smears). ORAU will implement a waste management plan prepared for these activities to assure that potentially contaminated materials, generated during the survey, are safely removed and ultimately dispositioned at an appropriate facility.

6.0 ANALYTICAL REQUIREMENTS

All samples, including smears, will be assigned a unique sample identification number and will be maintained under chain-of-custody for transfer to the contract analytical laboratory. The analytical laboratory will perform analyses in accordance with:

- U.S. NRC, *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards*;

- ASME-NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*; and

- U.S. NRC, *Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)*, NUREG-1576.

Table 4. Example Sample and Analytical Parameters						
Analyte	Matrix	Container	Preserv.	Hold Time	Method	MDC
Ra-226	Surface	Smear	None	180 d	Gross α/β	10-15 dpm/smear

7.0 REFERENCES

ASME 1994. *Quality Assurance Program Requirements for Nuclear Facilities*, American Society of Mechanical Engineers, New York, New York.

ATSDR 1999. *Public Health Implications of Radiation Contamination at Former Clock Factories Located in Bristol (Hartford County), New Haven, (New Haven County), Thomaston (Litchfield County), and Waterbury (New Haven County), Connecticut*. U.S. Department of Health and Human Services, January 29. (Agencywide Documents Access and Management System [ADAMS] Accession No. ML17038A052).

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ORAU 2017. *Health and Safety and Waste Management Work Instructions for Scoping Surveys at Sites Potentially Contaminated by Discrete Sources of Radium*, 5307-PL-02-0, Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, July.

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, “Waterbury Clock Company: Site Summary,” pp. 142-160, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488).

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SNL 1999. *Residual Radioactive Contamination from Decommissioning Parameter Analysis.* NUREG/CR-5512, Vol. 3, U.S. Nuclear Regulatory Commission, Washington, D.C., October.

WinnResidential 2017. Enterprise Apartments and Abbott Towers. Boston, Massachusetts. http://www.enterpriseabbott.com/.

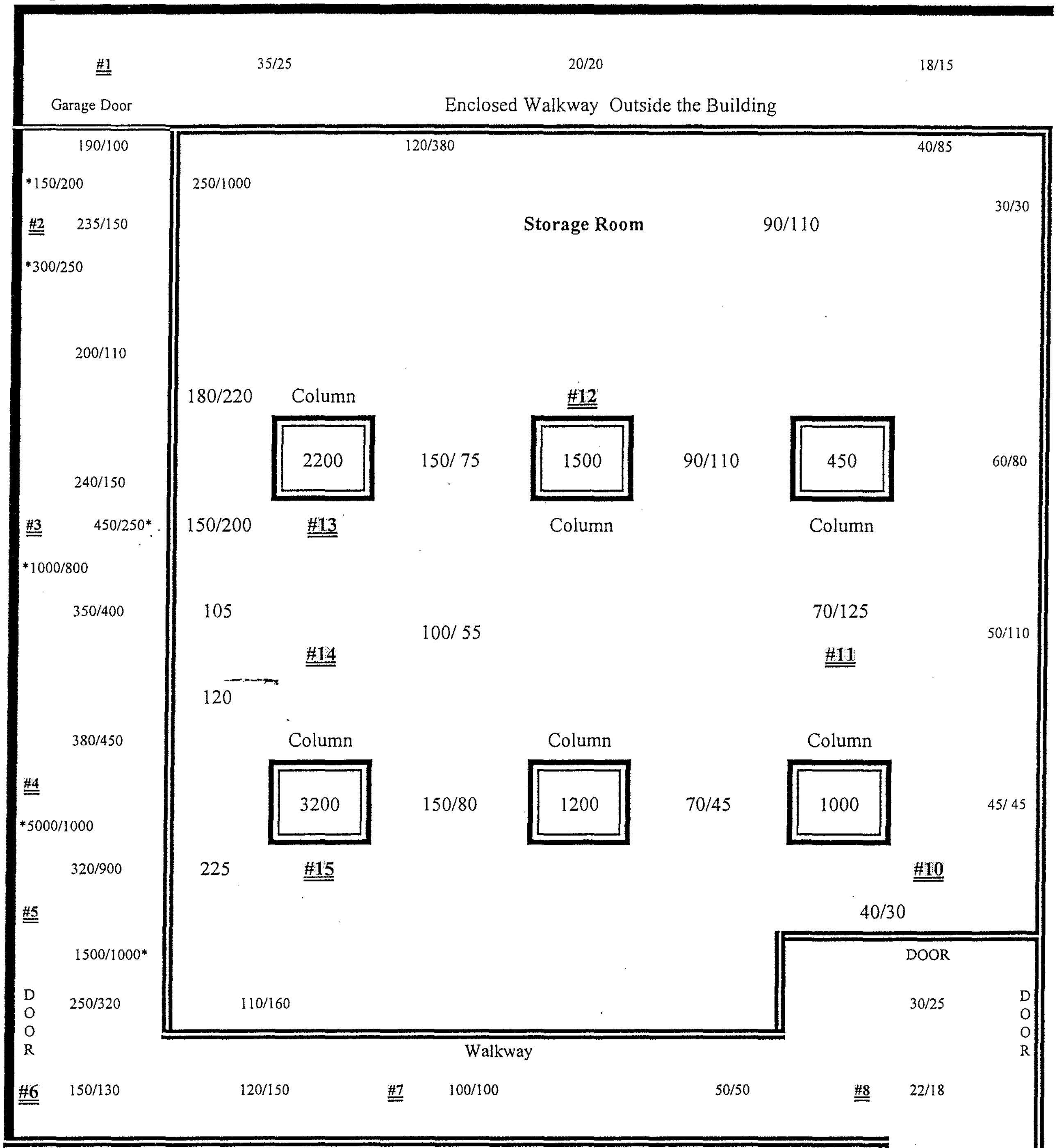
APPENDIX A
ATSDR RADIOLOGICAL ASSESSMENT RESULTS

Date: March 17, 1998

Location: First Suspected Dial Painting Salon Located

Map: Number 1

Survey Results



SMEAR RESULTS

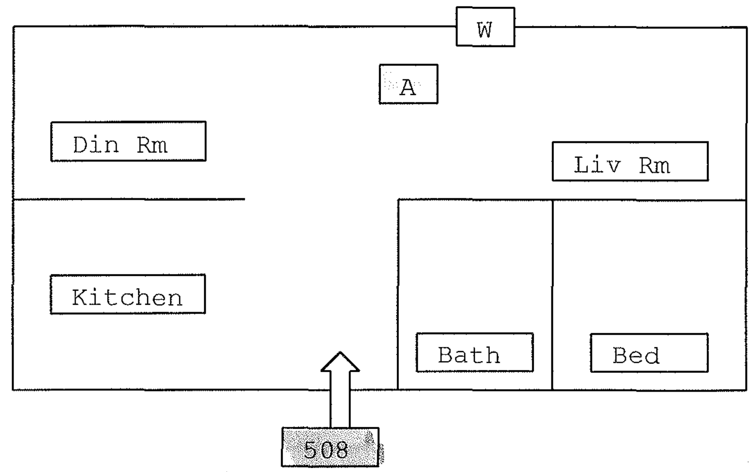
#1: < 200 (dpm/100cm^2)	#6: < 200 (dpm/100cm^2)	#11: 500 (dpm/100cm^2)
#2: < 200 (dpm/100cm^2)	#7: 200 (dpm/100cm^2)	#12: 4,000 (dpm/100cm^2)
#3: 1,000 (dpm/100cm^2)	#8: < 200 (dpm/100cm^2)	#13: 2,000 (dpm/100cm^2)
#4: 25,000 (dpm/100cm^2)	#9: < 200 (dpm/100cm^2)	#14: 1,000 (dpm/100cm^2)
#5: < 200 (dpm/100cm^2)	#10: 500 (dpm/100cm^2)	#15: 14,000 (dpm/100cm^2)

Notes: 100/100, First number denotes Waist Level Reading & the second denotes Ground Level Reading in μR/hr. All readings were taken with the Ludlum Model 19 μR meters.
Stand alone numbers are waist level readings, except at the columns where the values are at ground level.
* = Ground Level readings on contact and at 18 inches at the joint of the floor and the wall at that l

Instruments Used: 2 Ludlum Model 19 μR meters; S.N. # 120857 (cal. 5/7/98) & 138422 (cal. 4/17/98)
Eberline RO-20; S.N. # 1739 (cal. 3/26/98) used at smear location #4: 4 mR/hr (C.W.) & 50 mR/hr (O.W.) on contact & 0.1 mR/hr (C.W.) & 0.5 mR/hr (O.W.) at waist level.
Ludlum Model 14C with a pancake probe; S.N. # 103919 (cal. 9/9/98) used to count smears

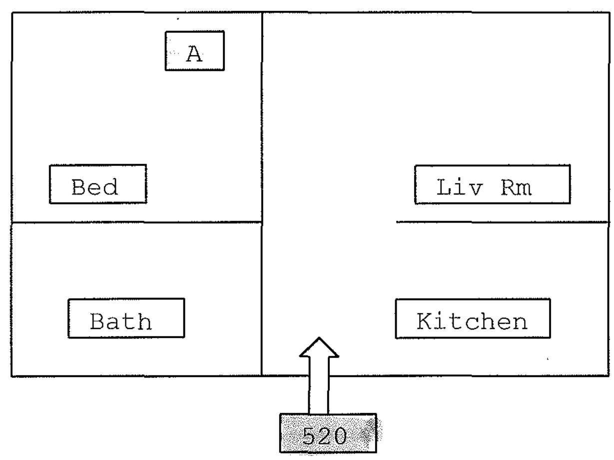
Apt No 508

Loc	CPM	V	H
A	500	42	42
BG	200		



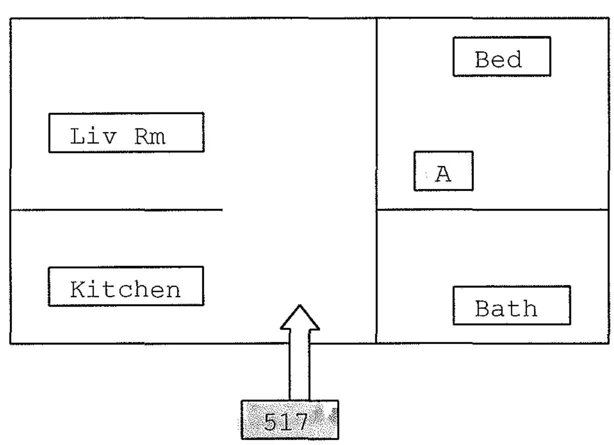
Apt No 520

Loc	CPM	V	H
A	700	16	24
BG	150		



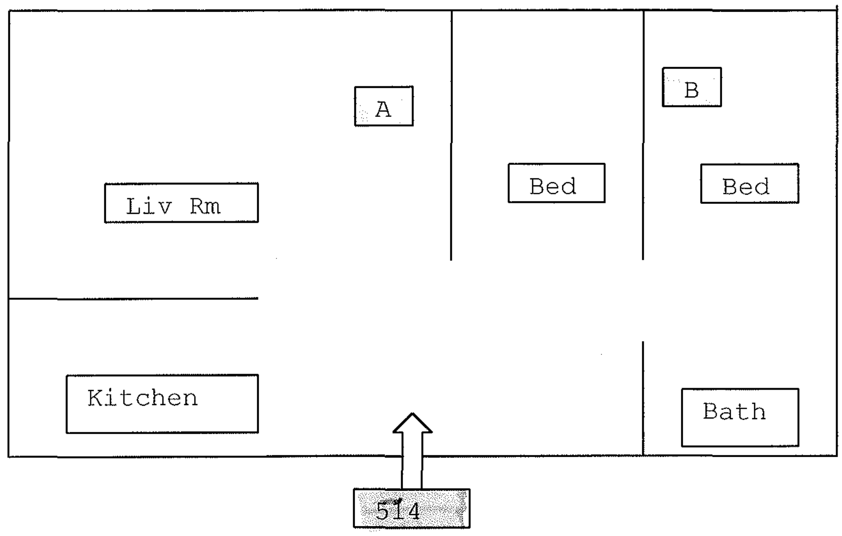
Apt No 517

Loc	CPM	V	H
A	3000	15	37
BG	300		



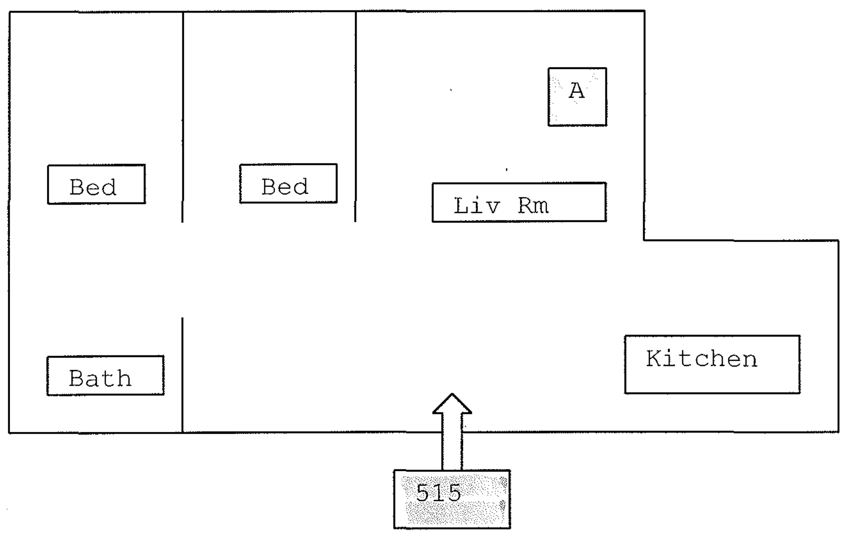
Apt No 514

Loc	CPM	V	H
A	2200	55	30
B	2000	35	22
BG	200		



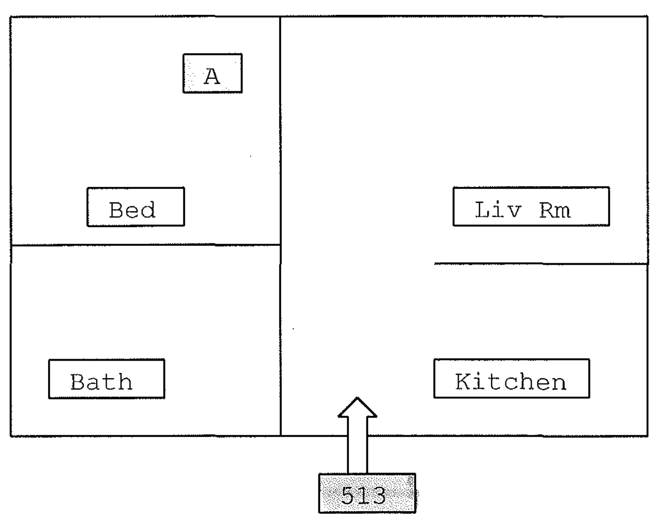
Apt No 515

Loc	CPM	V	H
A	1300	36	27
BG	200		



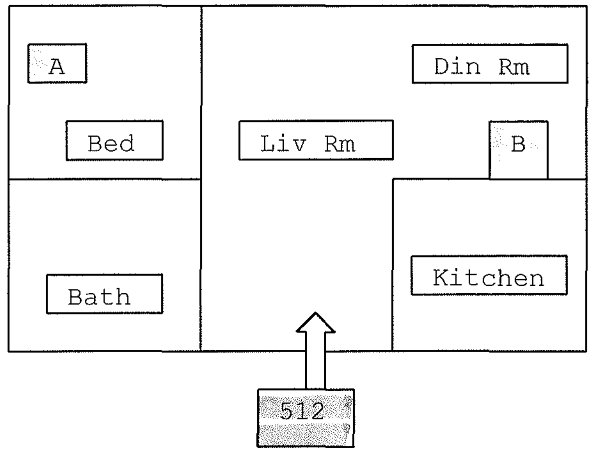
Apt No 513

Loc	CPM	V	H
A	1700	30	55
BG	170		



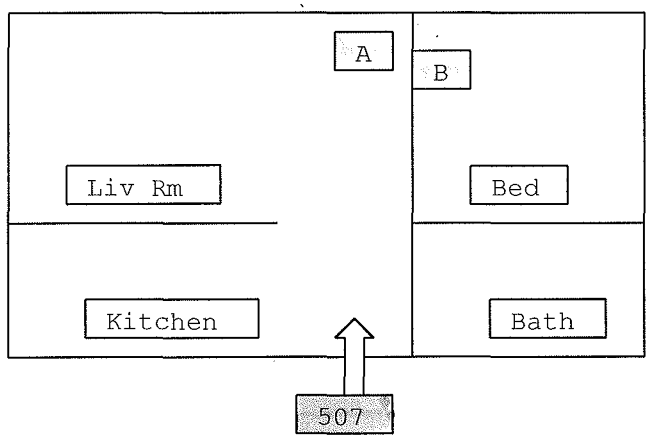
Apt No 512

Loc	CPM	V	H
A	600	22	30
B	800	0	34
BG	200		



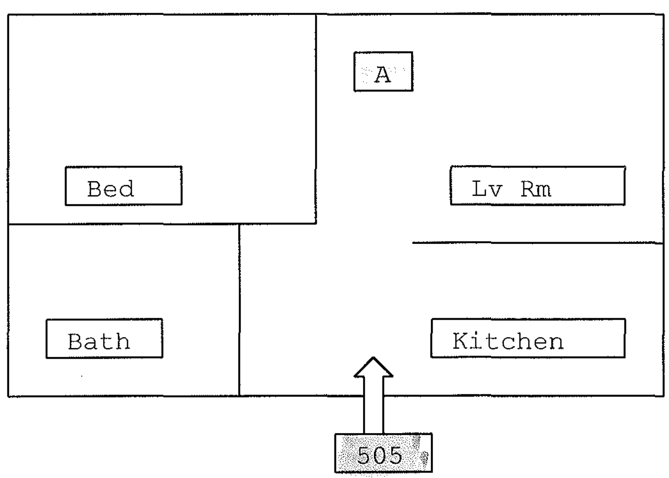
Apt No 507

Loc	CPM	V	H
A	1900	2	2
B	1800	6	0
BG	180		



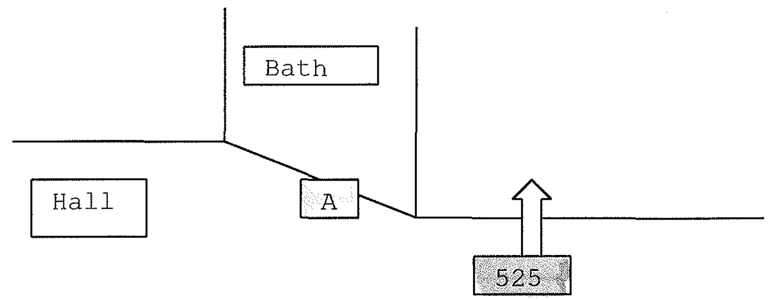
Apt No 505

Loc	CPM	V	H
A	500	60	48
BG	200		



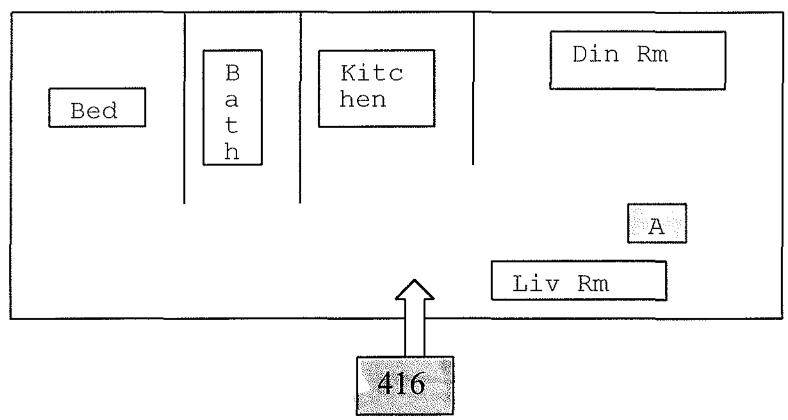
Apt No 525

Loc	mR	V	H
Hall	0.4	0	24
BG	.02		



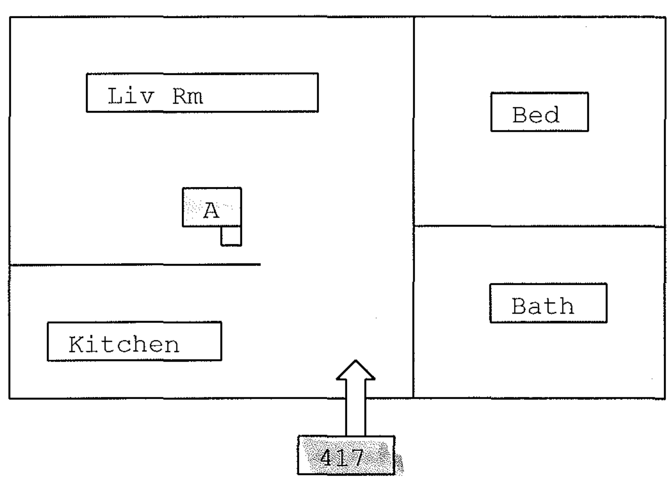
Apt No 416

Loc	CPM	V	H
A	800	60	90
BG	300		



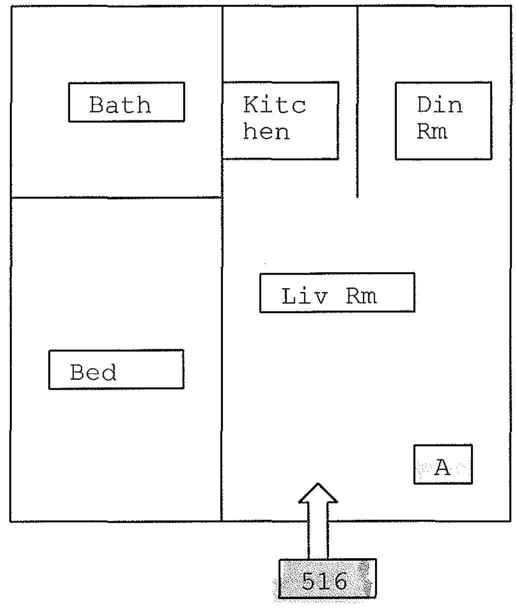
Apt No 417

Loc	CPM	V	H
A	2500	2	2
BG	300		



Apt No 516

Loc	CPM	V	H
A	500	30	20
BG	180		



ENTERPRISE APARTMENTS

Room		Space	Contact	Waist
417		Living	240	15
505		Living	30, 25	11, 12
507	VCT	Living	90, 70	30, 10
		Bed	45, 35, 70	15, 15, 20
508		Kitchen	28	12
512		Dining	30	15
		Bed	30	15
513		Bed	45	15
514	VCT	Bed	100	30
		Living	70, 20	25, 15
515		Living	110	20
516		Living	25	15
517		Bed	120	18
520		Bed	30	15
525	NO	Bath	70	12
Floor 5		Hall	800	80

JEROMED

NOTES:

1) Units are μR/hr

2) "Space" descriptions correspond to "Loc" locations in apartment maps.

19 m/yr

19000

3,60
25
9000

2 m/hr

APPENDIX B
SCIENTECH RADIOLOGICAL ASSESSMENT RESULTS

SCIENTECH

Suspect Areas

10/9/2003

VCOG Connecticut Radium D&D Project
Verification Survey

Areas not mentioned were not surveyed due to time limitations. Areas in Ville Automatics (antiques) and Bristol Instrument Gears are agreed upon.

Enterprise Apartments

12 apartments are considered to be affected in
The Enterprise Apartments. Apt. 507, 514 and 525 are vacant and all others are occupied.
All spots are small and discrete either in the bedrooms or Living Rooms, except for
#525 where the bathroom is shine from an area in the hallway on the 5th floor. There is a small spot by the baseboard that requires remediation.
All apartments are carpeted over lay subflooring.

Photo Page	Town	Building	Location	Contamination Area	Surface	Approximate Area Size	Background Counts	Maximum Gross Counts (on contact)	18" Gross Count	Comments
EA-2	Waterbury	Enterprise	Apt 507 (Vacant)	Corner of Living Room floor	Carpet over lay subflooring	1 ft x 1 ft	8,000	80,000		
EA-2	Waterbury	Enterprise	Apt 507 (Vacant)	Corner of Bedroom floor	Carpet over lay subflooring	1 ft x 1 ft	8,000	100,000		
EA-3	Waterbury	Enterprise	513-514 Hallway	Hallway floor	Carpet over lay subflooring	Spot	7,500	45,000		
EA-3	Waterbury	Enterprise	513-514 Hallway	Floor area inside waste storage room.	Tile	Spot	7,500	27,000		
EA-4	Waterbury	Enterprise	Apt 514 (Vacant)	Living Room floor	Carpet over lay subflooring	4 ft x 3 ft	8,000	70,000		
EA-4	Waterbury	Enterprise	Apt 514 (Vacant)	Bedroom 2 floor	Carpet over lay subflooring	3 ft x 3 ft	8,000	76,000		
EA-5	Waterbury	Enterprise	Apt 514 (Vacant)	Hallway floor by kitchen	Carpet over lay subflooring	Spot	7,500	10,000		
EA-6	Waterbury	Enterprise	514 Hallway	Floor area along window	Carpet over lay subflooring	Series of floor spots	7,500	28,000 - 38,000		
EA-7	Waterbury	Enterprise	Apt 515 (Occupied)	Living Room floor along windows	Carpet over lay subflooring	Spots	8,000	28,000 - 58,000		
EA-8	Waterbury	Enterprise	525 Hallway	Hallway floor	Carpet over lay subflooring	Spot (source)	8,000	960,000		
EA-9	Waterbury	Enterprise	Apt 520 (Occupied)	Bedroom floor corner	Carpet over lay subflooring	Spot	8,000	22,000		
EA-10	Waterbury	Enterprise	Apt 417 (Occupied)	Living Room pillar	Carpet over lay subflooring	Spot	8,000	225,000		