

**Enclosure**

**OAK RIDGE ASSOCIATED UNIVERSITIES:  
SITE STATUS REPORT FOR THE FORMER WATERBURY CLOCK COMPANY AT  
205 CHERRY STREET, WATERBURY, CONNECTICUT**

**JUNE 19, 2017**

## EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) requested that the Oak Ridge Associated Universities (ORAU) perform a radiological survey of the property at 205 Cherry Street in Waterbury, Connecticut. This property covers part of the footprint once occupied by the former Waterbury Clock Company, which used radium paint in the manufacturing of clocks and watches into the mid-1940s. The original five-story factory is still present and currently occupied by Ville Swiss Automatics, Inc. on the first and second floors. The third, fourth, and fifth floors are unoccupied and used for storage. The objective of this survey was to locate possible discrete sources of radium-226, if any, that would be associated with former Waterbury Clock Company operations.

ORAU performed the radiation survey on December 13, 2016, and February 8, 2017, and identified elevated levels of radiation throughout accessible areas of the third, fourth, and fifth floors. Based on these results, it is recommended that the NRC not perform a scoping survey at this time, but should consider offering the opportunity to perform scoping survey activities if areas with equipment are cleared on the fourth and fifth floors. For the third floor, as conservatively modeled, the contamination identified does not exceed the NRC's dose limit of 25 millirem per year for unrestricted use in 10 CFR 20.1402.

## SITE STATUS REPORT

Property: Waterbury Clock Company  
205 Cherry Street  
Waterbury, CT 06702

Docket Number: 3038962

Current Property Name(s): Ville Swiss Automatics, Inc.

Current Property Owner(s): Don Fournier

Inspection Dates: December 13, 2016 and February 8, 2017

Attendee(s): Laurie Kauffman/ NRC and Briana DeBoer/ NRC, Don Fournier/ Site Owner, George (no last name given)/ Site Manager, Mike Firsick/ CT DEEP, and Brian Tool/ CT Department of Health, supported by Kaitlin Engel/ Oak Ridge Associated Universities (ORAU) and Tom Hills/ ORAU, (12/13/2016).

Laurie Kauffman/ NRC and Katherine Warner/ NRC, Don Fournier/ Site Owner and George/ Site Manager, supported by Kaitlin Engel/ ORAU and Stephen Pittman/ ORAU (02/08/2017).

### 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 U.S. Nuclear Regulatory Commission (NRC) regulatory authority as byproduct material. The property at 205 Cherry Street in Waterbury, Connecticut (CT), was identified as part of the former Waterbury Clock Company, a former manufacturing facility, which operated from the 1920s to mid-1940s (ORNL 2015). Additional information on the site is also available in the Agency for Toxic Substances and Disease Registry (ATSDR) report (ATSDR 1999). The objectives of the initial site visit were to determine if discrete sources of Ra-226 and/or distributed Ra-226 contamination are present, to identify the areas of highest contamination, to determine if there are any current health and safety concerns, and to determine if a scoping survey is needed.

Data collected during the initial site visit is used 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) (Agencywide Documents Access and Management System (ADAMS) Accession number ML16035A053).

### 2.0 PROPERTY DESCRIPTION AND INITIAL SITE VISIT CONSIDERATIONS

#### 2.1 Property Description and History

The Waterbury Clock Company was founded in 1857 and moved its base of operations in 1873 to the corner of Cherry Avenue and North Elm Street where it operated until being purchased by the Bensusan Clock Company in 1944. From 1873 to 1910, Waterbury added several five-story

buildings to accommodate expanding work activities and in 1919 began manufacturing time pieces painted with radium (ATSDR 1999).

The building located at 205 Cherry Street in Waterbury, CT, is a five-story structure which may be the original combination of brick and poured concrete walls and wooden floors in most areas. Ville Swiss Automatics, Inc. occupies the first and second floors, while the other three floors are unoccupied and used mostly for storage. The first floor is currently the main area for workers and is occupied mostly by machinery used for shaving metal. Machine oil and Oil-Dry (absorbent) cover the majority of the wooden floor. The second floor is the main area for office workers, with added drywall dividers separating office space and porcelain tile flooring in some offices. Approximately 75% of the first and second floors are accessible. The third floor is used mostly for storage, except for the eastern portion bordering Cherry Street, which has been converted into a living space. This space was previously occupied by the site owner years ago, but has since been unused. Approximately 50% of the third floor is accessible. Access to the third floor is limited due to items stored by the owner, especially in the middle rooms and western portion of the floor. Approximately 90% of the fourth and fifth floors are inaccessible due to items stored by the site owner. The site visit described in the following discussion confirmed results from the extensive historical surveys indicating that Ra-226 is present at the site.

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. ATSDR 1999 identifies small areas of elevated radiation levels on the third, fourth and fifth floors, with a maximum contact reading of 100 microRoentgen per hour ( $\mu\text{R/h}$ ). No radium of note is reported on the first and second floors (ATSDR 1999).

## 2.2 Initial Site Visit Considerations

Prior to commencing survey activities, the general building layout was examined for consistency with historical information and to identify impediments to conducting the survey and/or health and safety considerations. The five-story building appears to be the original facility, and the structural integrity is sound, including floors, and walls.

## 3.0 SITE OBSERVATIONS AND FINDINGS

### 3.1 Summary of Activities

Inspection teams conducted site visits at the Waterbury property on December 13, 2016 and February 8, 2017. Kaitlin Engel and Tom Hills (ORAU) and Laurie Kauffman and Briana DeBoer (NRC) held a pre-inspection meeting on December 13, 2016, with Don Fournier (Site Owner), George (Site Manager), Mike Firsick (Connecticut Department of Energy and Environmental Protection [CT DEEP]), and Brian Tool (Connecticut Department of Health). Likewise, Kaitlin Engel and Stephen Pittman (ORAU) and Laurie Kauffman and Katherine Warner (NRC), held a pre-inspection meeting on February 8, 2017 with Don Fournier (Site Owner) and George (Site Manager). On both occasions, participants discussed the inspection teams’ intention to re-visit some of the locations identified as potentially contaminated with radium in the historical assessment and to perform general area scans in other areas of the building. The inspection teams were granted permission to survey all accessible levels/areas of the building.

Radiological surveys performed by the inspection team consisted of gamma radiation scans within the building using a Ludlum model 44-10 2-inch by 2-inch (2×2) sodium iodide detector connected to a Ludlum model 2221 ratemeter/scaler, alpha-plus-beta radiation direct measurements using a Ludlum model 44-142 plastic scintillator connected to a Ludlum model 2221 ratemeter/scaler, and radiation exposure rate measurements using a Ludlum model 192 NaI-based  $\mu$ R ratemeter<sup>1</sup>. Field gamma spectrum measurements were made with a SAM-940 gamma spectrum analyzer. Table 1 presents the specific instruments used during the site visit. Smear samples were also collected at selected locations to quantify the removable surface activity levels.

#### Summary of Daily Activities – December 13, 2016:

After concluding the pre-inspection meeting, survey activities began around 09:40 on the first floor using the 2×2 sodium iodide detector for gamma scans and Model 192 exposure ratemeter for direct exposure measurements. Measurements were documented at regular intervals between aisles of running equipment, which comprised roughly 75% of the accessible floor space. No locations of elevated response that were distinguishable from background were found. Material composition for the floor and outer walls appeared to be the original wood and red brick from the former Waterbury Clock Company.

At 10:10, survey activities began on the second floor. Measurements were documented for various locations within office spaces, hallways, and other work areas, which comprised roughly 75% of the accessible floor space. No discrete locations of elevated response as distinguishable from background were found. Material composition for the floor and outer walls appeared to be the original wood and red brick from the former Waterbury Clock Company, except for offices in the northeastern corner with recently installed (approximately 8 years prior) porcelain tile flooring.

At 10:50, survey activities began on the third floor. Measurements were documented for various locations within rooms created by drywall installations, a converted bathroom area with tile flooring, and open spaces used mostly for storage. Although unoccupied at the time of the survey, the eastern portion of the third floor appeared to have been used as a residence at one time, and could readily be used for that purpose in the future. Approximately 50% of the third floor was surveyed. Multiple highly localized (less than 0.05 meters in diameter) locations were identified with elevated radiation levels (see locations 22-24, 26, 27, 29-32, 35, 36, and 38 from Table B-3). Of these, nine smears (R0024 – R0032) were taken from locations with elevated on-contact exposure readings. One-minute static measurements were also made at these same locations using a Model 44-142 plastic scintillator for the purpose of documenting the alpha-plus-beta total surface activity. Material composition for the floor and outer walls appeared to be the original wood and red brick from the former Waterbury Clock Company, except for the bathroom area, which had white tile flooring (see Figure B-3).

A post-inspection meeting between the NRC, site, and ORAU staff was held at approximately 12:45 to discuss findings. The inspection team then departed at 13:00.

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<sup>1</sup>Roentgen is a unit of exposure (energy absorbed in air), whereas a rem is a unit of dose delivered to a person (resulting from the radiation energy absorbed in that person). While Roentgen and rem are related, these are different units. Because they are similar for gamma ray energies from Ra-226, NRC makes the simplifying assumption in this case that these units are equivalent (1 Roentgen = 1 rem).

**Table 1. Ville Swiss Survey Instruments**

<b>Radiation Type (units)</b>	<b>Detector Type</b>	<b>Detector Model (Number)</b>	<b>Ratemeter (Number)</b>
Alpha plus beta (cpm)	Plastic Scintillator <sup>a</sup>	44-142 (920) Calibrated 11/03/2016	2221 (590) Calibrated 08/08/2016 Recalibrated 01/26/2017
		44-142 (1031) Calibrated 07/06/2016, Recalibrated 01/26/2017	2221 (1143) Calibrated 08/05/2016 recalibrated 01/26/2017
Gross gamma (cpm)	Sodium Iodide	44-10 (664) Calibrated 07/27/2016 Recalibrated 01/26/2017	2221 (590) Calibrated 08/08/2016 Recalibrated 01/26/2017
		44-10 (908) Calibrated 11/01/2016	2221 (1143) Calibrated 08/05/2016 01/26/2017
Gross gamma ( $\mu$ R/h)	Exposure Meter	192 (1127, 1129) Calibrated 06/03/2016	N/A
Gamma Spectrum Analyzer (SAM-940)	Lanthanum Bromide	940 (40272) <sup>b</sup>	N/A

N/A = not applicable

Number = ORAU equipment barcode

cpm = counts per minute

$\mu$ R/h = microRoentgen per hour

<sup>a</sup>Though traditionally used as a beta radiation detection, ORAU has calibrated the detector for measuring both alpha and beta radiation.

<sup>b</sup>Device performs automatic calibration upon startup and is source checked before use.

**Summary of Daily Activities – February 08, 2017:**

After concluding the pre-inspection meeting, survey activities began around 09:15 on the fourth and fifth floors using the 2x2 sodium iodide detector for gamma scans and Model 192 exposure ratemeter for direct exposure measurements. Measurements for both floors were documented at regular intervals in accessible areas, which only comprised roughly 10% of the total floor space. Two discrete locations on the fourth floor and three on the fifth floor (all less than 0.05 meters in diameter) were identified with elevated radiation levels. Smears R0070 and R0071 were collected on the fourth floor and R0069 was collected on the fifth floor, along with one-

minute static measurements using a Model 44-142 plastic scintillator to document the alpha-plus-beta total surface activity. The material composition of each floor appeared to be the original wooden floors and red brick walls from the former Waterbury Clock Company. The inspection team then returned to the third floor and began survey activities at approximately 10:00. Results were similar to the December 13, 2016, site visit with no additional discrete locations of elevated responses being identified on the third floor. At 11:30, the NRC met with the site owner and inspection team to discuss the survey results. The inspection team then departed the site at 11:40.

### 3.2 Summary of Results

Gamma spectra of smear locations R0024 and R0025 were collected on December 13, 2016, with a SAM-940 gamma spectrum analyzer, and the results are presented in Appendix A. Appendix B presents survey maps and tabulated results, including gross 2x2 sodium iodide detector responses in units of cpm, net alpha-plus-beta total surface activity results in units of disintegrations per minute per 100 cm<sup>2</sup> (dpm/100 cm<sup>2</sup>), gross exposure rates in µR/h for contact and at 1 meter, and removable alpha and beta surface activity in dpm/100 cm<sup>2</sup>, for all five floors, as applicable.

The alpha-plus-beta static measurements in cpm were converted to total surface activity units of dpm/100 cm<sup>2</sup> using the equation below:

$$dpm/100\text{ cm}^2 = \frac{C - B}{\epsilon_{tot} \times G}$$

Where:

C = measured count rate (cpm)

B = background count rate (cpm)

G = geometry factor (unitless) =  $\frac{\text{Physical Detector Area (cm}^2\text{)}}{100\text{ cm}^2} = 1.0$

ε<sub>tot</sub> = total weighted efficiency (unitless) = 1.6

Due to the number of emissions from Ra-226 and its associated progeny, multiple radiation particles are counted during the surface activity measurement. Therefore, a total weighted efficiency for Ra-226 and its associated progeny was calculated by:

$$\epsilon_{tot} = \sum_n F_n \times \epsilon_{i,n} \times \epsilon_{s,n}$$

Where:

F<sub>n</sub> = fractional abundance of n<sup>th</sup> emission

ε<sub>i,n</sub> = instrument efficiency for n<sup>th</sup> emission

ε<sub>s,n</sub> = surface efficiency (0.25 for alpha and low-energy beta particles, 0.5 for high-energy beta particles) for n<sup>th</sup> emission

Radiation measurements collected on the first floor were found to be consistent with background levels (i.e., 4-10 µR/h). A room with concrete flooring on the western end of the floor exhibited slightly higher 2x2 sodium iodide and Model 192 readings of around 12,000 cpm and 10 µR/h, respectively. This elevated response is likely due to the presence of naturally occurring radioactive materials (NORM) typically found in concrete. Figure B-1 illustrates the

locations of these measurements, and Table B-1 provides the corresponding data. Results on the first floor were consistent with those reported in ATSDR 1999: no contamination detected.

Radiation measurements collected on the second floor were also found to be consistent with background levels (i.e., 5-12  $\mu\text{R/h}$ ). Office space in the northeast corner has tile flooring, which exhibited slightly higher readings than the wooden floors. This difference in response is expected considering the concentrations of NORM typically found in construction materials. Figure B-2 illustrates the locations of these responses, and Table B-2 provides the corresponding data. Results on the second floor were consistent with those reported in ATSDR 1999: no contamination detected.

Several discrete locations (less than 0.05 meters in diameter) of elevated response as compared to background (i.e., 7-13  $\mu\text{R/h}$ ) were measured on the third floor. Smear samples R0024 through R0032 and direct measurements were collected from nine discrete locations with elevated radiation. At these locations contact measurements up to 80 and 90  $\mu\text{R/h}$  were recorded (including background), though levels drop to a gross 20  $\mu\text{R/h}$  or less at 1 m above the surface. This is below NRC's TI threshold for controls after background is considered. Figure B-3 illustrates the locations of these measurements and smear samples, and Table B-3 presents the corresponding data. Results on the third floor are generally consistent with those reported in ATSDR 1999.

Only 5-10% of the fourth floor was accessible, but two discrete locations (less than 0.05 meters in diameter) of elevated responses were identified, with a maximum contact measurement of 70  $\mu\text{R/h}$ . Smears R0070 and R0071 and direct measurements were collected from these locations. Figure B-4 illustrates the distribution of these measurements and smear locations, and Table B-4 provides the corresponding data. Results on the fourth floor were generally consistent with those reported in ATSDR 1999.

Much of the fifth floor was inaccessible due to large amounts of stored materials, though several discrete locations (less than 0.05 meters in diameter) of elevated response were identified. Smear R0069 and direct measurement data were collected from the location with the maximum contact measurement of 50  $\mu\text{R/h}$ . Figure B-5 illustrates the locations of these measurements and smear sample, and Table B-5 provides the corresponding data. Results on the fifth floor were generally consistent with those reported in ATSDR 1999.

### 3.3 Summary of Dose Assessment Results

To date, a site-specific dose assessment has not been performed for the Ville Swiss site. However, contamination identified during the initial site visit must be considered to assess potential doses to current and potential future occupants. TI 2800/043 presents two action levels (ALs) that correlate to 100 mrem/yr for a worker (1-m measurement of 40  $\mu\text{R/h}$  above background) and a resident (1-m measurement of 15  $\mu\text{R/h}$  above background). These ALs account for gamma exposure alone and may be used to quickly identify radiation levels that could conservatively produce a dose above the public dose limit in 10 CFR 20.1301. The 40  $\mu\text{R/h}$  AL is appropriate for use when the site is used/configured for industrial use; and the 15  $\mu\text{R/h}$  AL is appropriate when the site is used/configured for residential use. Contamination was identified on the third, fourth and fifth floors. A portion of the third floor is configured for residential use (but it is not currently used as a residence), thus the 15  $\mu\text{R/h}$  AL conservatively applies; and the fourth and fifth floors are used for storage, thus the 40  $\mu\text{R/h}$  AL applies.



Background exposure rate levels vary in the building based on the proximity to NORM-containing materials such as wood, brick and ceramic tile. Results from wooden floors generally fall in the 6-10  $\mu\text{R}/\text{h}$  range, or up to about 12  $\mu\text{R}/\text{h}$  near brick walls, so an average of 10  $\mu\text{R}/\text{h}$  is assumed for the site as a whole. Therefore, a gross 1-m measurement of 25  $\mu\text{R}/\text{h}$  is required on the third floor to exceed the residential AL, and a gross 1-m measurement of 50  $\mu\text{R}/\text{h}$  is required on the fourth and fifth floors to exceed the industrial AL. The maximum 1-m measurement on the third floor is 20  $\mu\text{R}/\text{h}$  (does not exceed the AL), and the maximum 1-m measurement on the fourth and fifth floors is 16  $\mu\text{R}/\text{h}$  (does not exceed the AL). Therefore, results do not exceed the ALs, and the 10 CFR Section 20.1301 public dose limit is satisfied considering external gamma alone.

Elevated alpha-plus-beta measurements, including maximums of 2,400 dpm/100  $\text{cm}^2$  on the third floor and 4,600 dpm/100  $\text{cm}^2$  on the fourth and fifth floors, must also be considered. Smear data show very little removable activity (on the order of 0.1% or less of the total amount). The lack of removable activity suggests that external gamma pathway doses will be the most significant as discussed below and actual reliance on gamma exposure data is acceptable. Therefore,  $\mu\text{R}/\text{h}$  data collected during the site visit are sufficient for demonstrating compliance with the 100 mrem/yr criterion.

Consideration of external exposure pathways alone is appropriate at this site because other exposure pathways are not expected to be significant contributors to a potential dose. First, the potential inhalation dose is not expected to be more than a few mrem/yr based on DandD Version 2.4 calculations. Second, the potential secondary ingestion exposure is not expected to be significant because measurements of removable contamination indicate that the existing removable contamination (on the order of 0.1% removable fraction) is less than the percentage assumed in typical screening analyses for an industrial building occupant screening scenario (i.e., 10%) and, therefore, is largely fixed and not significantly removable.

Due to the lack of removable activity, these data are also suitable to assess whether future occupants may receive a dose in excess of the 25 mrem/yr limit for unrestricted use in 10 CFR 20.1402. Assuming a 6,800-hour occupancy for a residential occupant scenario, as was considered in the TI (NRC 2016), a net (rounded) exposure rate of about 4  $\mu\text{R}/\text{h}$  (14  $\mu\text{R}/\text{h}$  gross, including background) would be required to exceed 25 mrem/yr unrestricted dose limit on the third floor. Gross exposure rates in the third floor office (See Table B-3) ranged from 12-15  $\mu\text{R}/\text{h}$  at 1 meter, including directly over the three isolated areas of elevated activity. These results suggest that a resident would likely not exceed the 25 mrem/yr limit, assuming all 6,800 hours are averaged over the third floor office where maximum gamma measurements were recorded. Because the areas of elevated exposure rates are highly localized ( $\leq 0.1 \text{ m}^2$ ) rather than uniformly distributed over a large portion of the interior building surface, it is not likely that average members of the critical group for a residential occupant scenario would spend a significant portion of their occupancy within 1 meter of the localized contamination. Exposure rates are lower on the fourth and fifth floors than the third floor (which again lack significant removable activity), indicating that measured radiation levels throughout accessible portions of the building would not produce a dose above the 25 mrem/yr unrestricted dose limit. However, it is noted that a significant portion of the fourth and fifth floor space was inaccessible during both dates on-site, so it is unclear whether the property as a whole satisfied dose requirements.

#### 4.0 OBSERVATIONS AND RECOMMENDATIONS

Based on the data collected, the portion of the former Waterbury Clock Company located at 205 Cherry Street contains discrete sources of Ra-226 but not at concentrations that would result in

a dose in excess of regulatory requirements. It is unclear, however, whether the entire property satisfies dose limits given much of the indoor area was inaccessible during the site visits. ORAU made the following observations:

- Elevated direct gamma radiation due to Ra-226 was identified on the third, fourth, and fifth floors.
- Multiple exposure rate values are significantly above background on contact, but do not exceed the ALs specified in the TI at 1 meter above the surface. The property owner was informed of these findings.
- Multiple though isolated locations with elevated alpha-plus-beta radiation levels were identified on multiple floors; noting that access was limited in some areas, so additional locations with elevated radiation levels may be present. Results from the site visit were generally consistent with those presented in ATSDR 1999.

Based on the above observations, it is recommended that the NRC not perform a scoping survey at this time, but should consider offering the opportunity to perform scoping survey activities if areas with equipment are cleared. On the third floor, as conservatively modeled, the contamination identified does not exceed the NRC's dose limit of 25 millirem per year for unrestricted use in 10 CFR 20.1402. The inspection team did not identify radium contamination on the first and second floors and not enough of the fourth and fifth floors were accessible to be surveyed to reach a conclusion on dose (ORAU identified small hotspots on the fourth and fifth floors that by themselves would be unlikely to exceed NRC's unrestricted use criterion). If the configuration and/or use of the current building significantly changes (specifically the fourth and fifth floors), NRC should consider offering to perform a more detailed survey investigating areas that were previously inaccessible.

## 5.0 REFERENCES

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*, prepared by the Connecticut Department of Public Health under Cooperative Agreement with The Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. January 29. (Agencywide Documents Access and Management System [ADAMS] Accession No. ML17038A052).

NRC 2001. *Residual Radioactive Contamination from Decommissioning – User's Manual* DandD Version 2.1. NUREG/CR-5512, Vol. 2, U.S. Nuclear Regulatory Commission, April.

NRC 2016. *Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources*, Temporary Instruction 2800/043, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Washington, D.C., October. (ADAMS Accession No. ML16035A053).

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, "Waterbury Clock Company: Site Summary," Pgs. 141-160, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488).

**APPENDIX A**  
**GAMMA SPECTRA FROM THIRD FLOOR OF WATERBURY (VILLE SWISS) SITE**

Figures A-1 and A-2 show the gamma spectra for a one minute count of the R0024 and R0025 smear locations, respectively. To ensure accurate comparison, these spectra were gain shifted to align with the 1,461 keV peak of potassium-40 (K-40). Despite the energy calibration curve diverging slightly in the higher channels, the presence of Ra-226 daughters, lead-214 (Pb-214) and bismuth-214 (Bi-214) was verified.

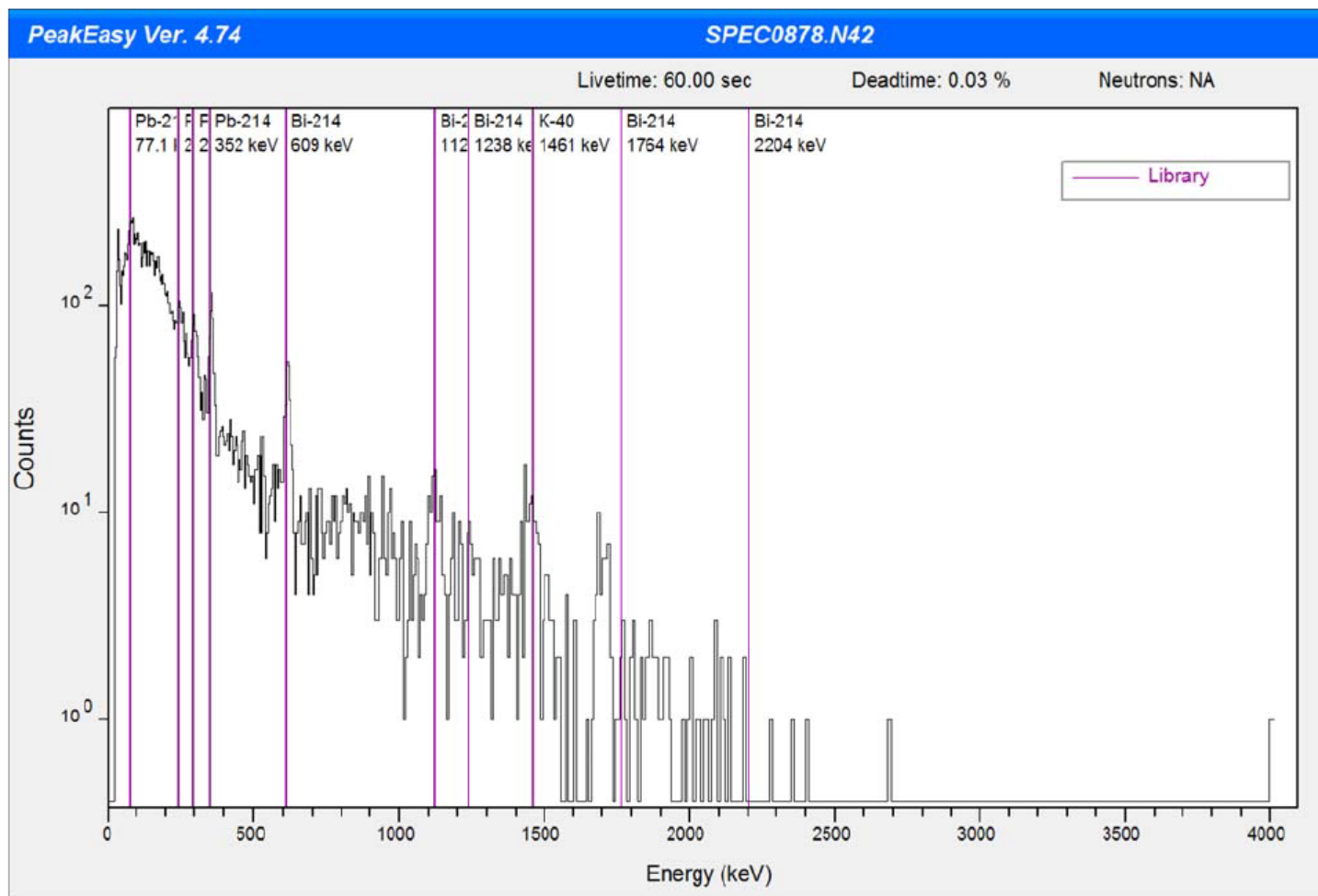


Figure A-1. Gamma Spectrum for R0024 Smear Location, 3<sup>rd</sup> Floor

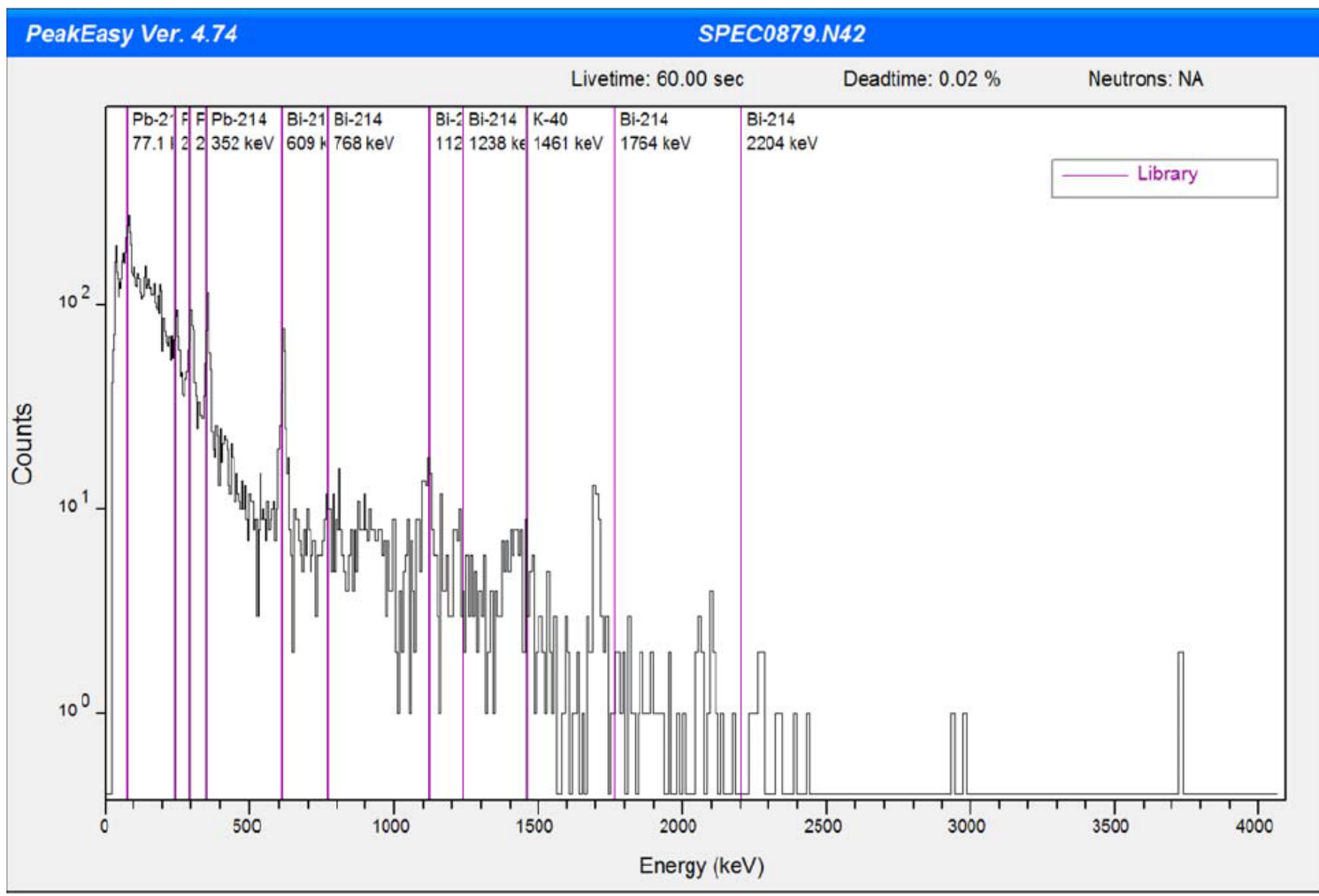


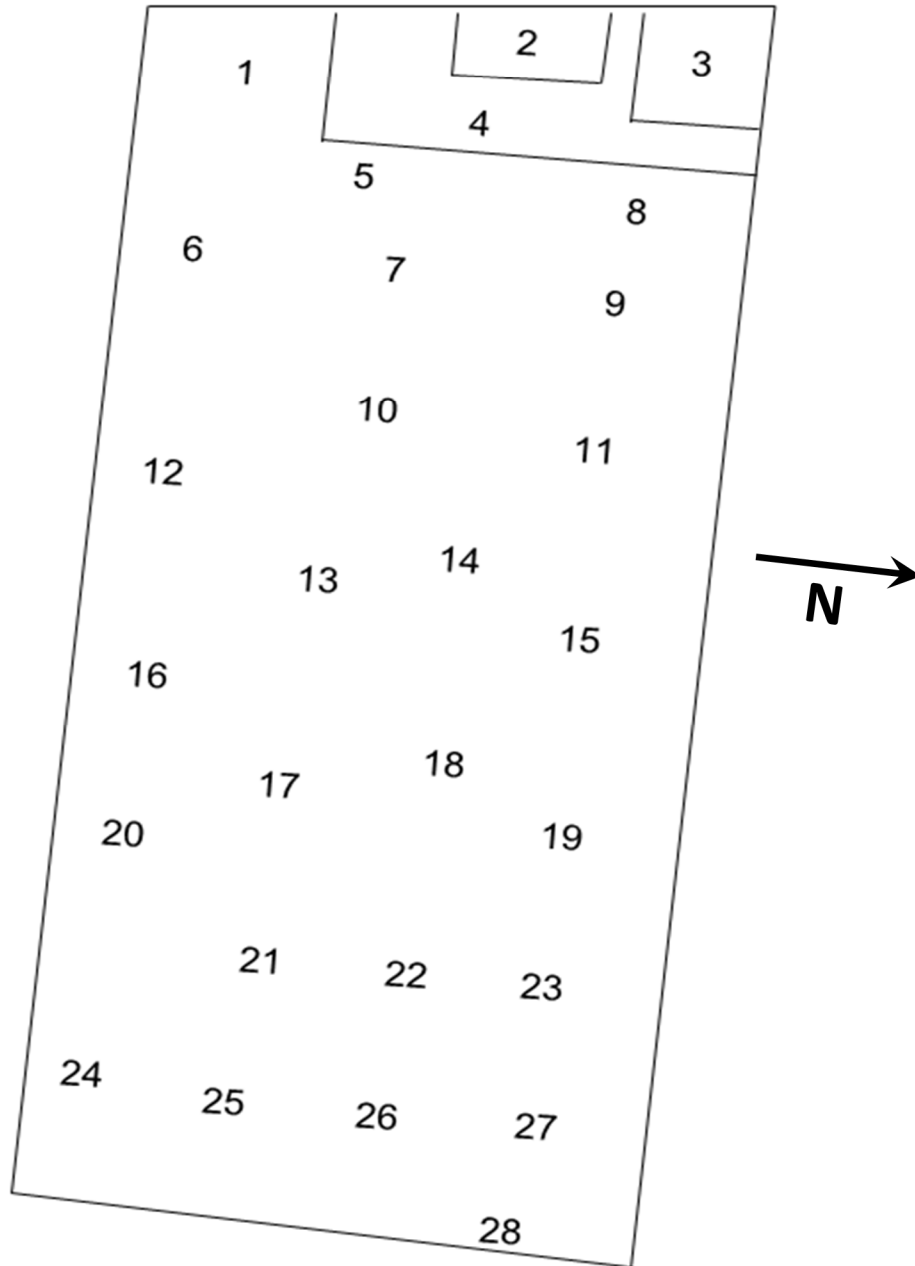
Figure A-2. Gamma Spectrum for R0025 Smear Location, 3<sup>rd</sup> Floor

**APPENDIX B  
SURVEY MAPS AND DATA TABLES**

<b>Site:</b> Waterbury	<b>Area:</b> Ville Swiss (1st Floor)	<b>Date(s):</b> 12/13/2016	<b>Time:</b> 09:40 – 10:10
<b>Surveyor(s):</b> KME/JTH		<b>Purpose:</b> Site Visit	

<b>Radiation Type</b>	<b>Instrument</b>	<b>Detector</b>	<b>Background</b>
Gamma	2221 No.590	44-10 No.908	4 - 12 kcpm <sup>a</sup>
Gamma	192 No.1127	NA	4 - 10 $\mu$ R/h <sup>a</sup>

<sup>a</sup>Background varied depending on naturally occurring radioactive material in the area.



○ = smear location  
 # = measurement location number  
 See attached table for measurement results

**Figure B-1. Survey Results First Floor**

**Table B-1. Waterbury Measurement & Smear Results - Ville Swiss, 1st Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	µR/hr		µR/hr
1	—	—	—	—	—	6,500	—	5	wooden floor
2	—	—	—	—	—	12,000	—	10	concrete floor
3	—	—	—	—	—	8,500	—	8	wooden floor
4	—	—	—	—	—	10,000	—	6.5	wooden floor
5	—	—	—	—	—	7,000	—	6	wooden floor
6	—	—	—	—	—	6,500	—	5.5	wooden floor
7	—	—	—	—	—	5,500	—	5	wooden floor
8	—	—	—	—	—	6,000	—	5	wooden floor
9	—	—	—	—	—	8,000	—	7	wooden floor
10	—	—	—	—	—	6,000	—	5.5	wooden floor
11	—	—	—	—	—	6,000	—	5	wooden floor
12	—	—	—	—	—	10,500	—	10	near red brick wall
13	—	—	—	—	—	5,600	—	5	wooden floor
14	—	—	—	—	—	6,000	—	5	wooden floor
15	—	—	—	—	—	7,000	—	6	wooden floor
16	—	—	—	—	—	7,500	—	6	wooden floor
17	—	—	—	—	—	5,500	—	5	wooden floor
18	—	—	—	—	—	4,500	—	5	wooden floor
19	—	—	—	—	—	6,500	—	5.5	wooden floor
20	—	—	—	—	—	6,500	—	5.5	wooden floor
21	—	—	—	—	—	6,000	—	5	wooden floor
22	—	—	—	—	—	5,500	—	4.5	wooden floor
23	—	—	—	—	—	7,000	—	6	wooden floor
24	—	—	—	—	—	8,000	—	7.5	wooden floor
25	—	—	—	—	—	7,500	—	6	wooden floor



**Table B-1. Waterbury Measurement & Smear Results - Ville Swiss, 1st Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	μR/hr		μR/hr
26	—	—	—	—	—	6,500	—	5	wooden floor
27	—	—	—	—	—	7,500	—	6	wooden floor
28	—	—	—	—	—	10,000	—	10	near red brick wall

a) As reported by the Radiochemistry and Environmental Analytical Laboratory in Oak Ridge, Tennessee

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

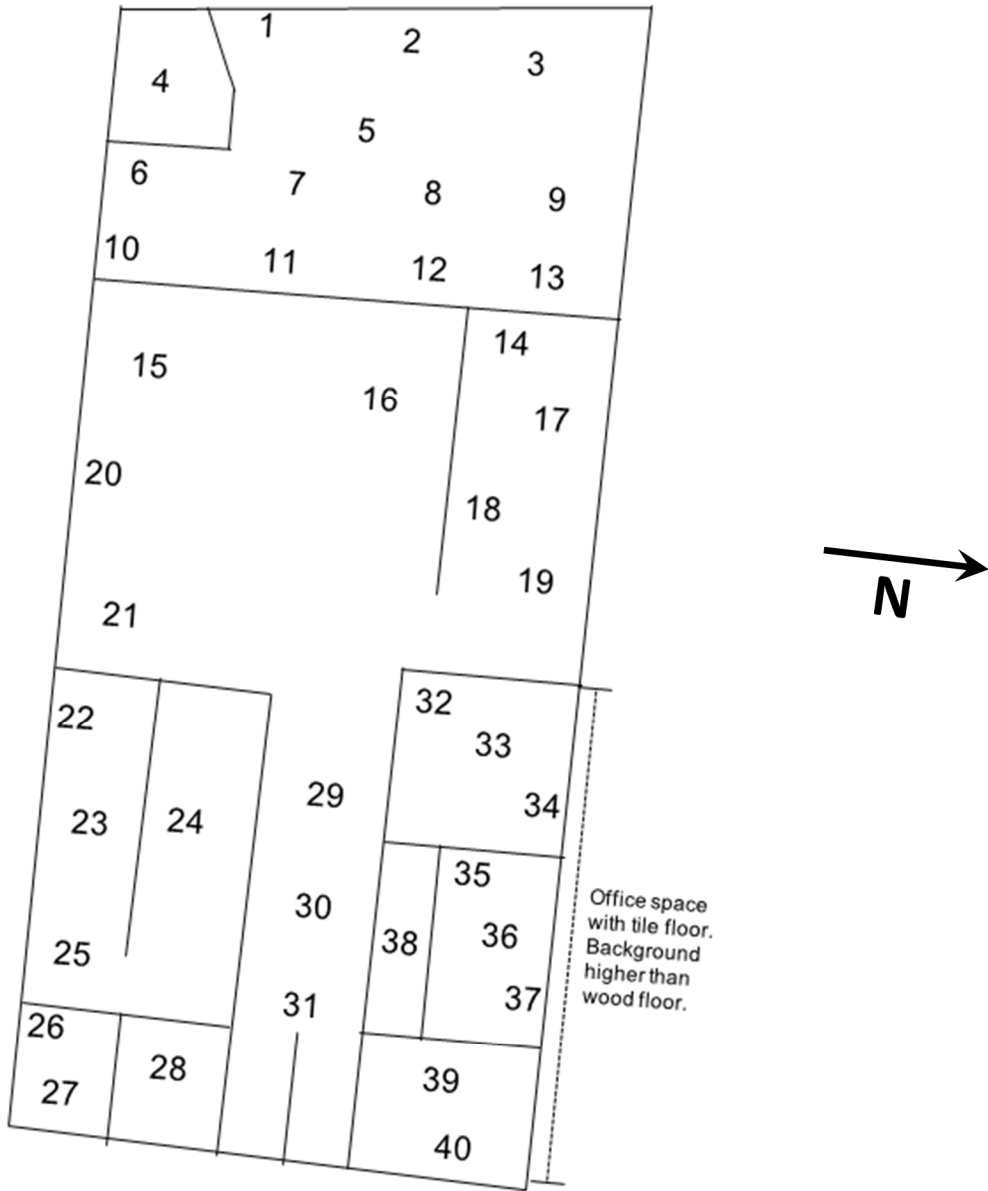
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

<b>Site:</b> Waterbury	<b>Area:</b> Ville Swiss (2nd Floor)	<b>Date(s):</b> 12/13/2016	<b>Time:</b> 10:10 – 10:43
<b>Surveyor(s):</b> KME/JTH		<b>Purpose:</b> Site Visit	

<b>Radiation Type</b>	<b>Instrument</b>	<b>Detector</b>	<b>Background</b>
Gamma	2221 No.590	44-10 No.908	6 - 16 kcpm <sup>a</sup>
Gamma	192 No.1127	NA	5 - 12 $\mu$ R/h <sup>a</sup>

<sup>a</sup>Background varied depending on naturally occurring radioactive material in the area.



○ = smear location  
 # = measurement location number  
 See attached table for measurement results

**Figure B-2. Survey Results Second Floor**

**Table B-2. Waterbury Measurement & Smear Results - Ville Swiss, 2nd Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )	Gross	Total	Contact		1 m		
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	µR/hr		µR/hr
1	—	—	—	—	—	11,500	—	9	near red brick wall
2	—	—	—	—	—	9,000	—	8.5	wooden floor
3	—	—	—	—	—	9,000	—	9	wooden floor
4	—	—	—	—	—	9,500	—	9	wooden floor
5	—	—	—	—	—	6,500	—	6	wooden floor
6	—	—	—	—	—	8,000	—	7	wooden floor
7	—	—	—	—	—	8,000	—	7	wooden floor
8	—	—	—	—	—	7,500	—	6.5	wooden floor
9	—	—	—	—	—	8,000	—	7	wooden floor
10	—	—	—	—	—	12,500	—	10	red brick wall
11	—	—	—	—	—	7,000	—	7	wooden floor
12	—	—	—	—	—	6,000	—	6	wooden floor
13	—	—	—	—	—	7,500	—	6	wooden floor
14	—	—	—	—	—	8,000	—	7	wooden floor
15	—	—	—	—	—	9,500	—	8	wooden floor
16	—	—	—	—	—	8,000	—	7.5	wooden floor
17	—	—	—	—	—	9,000	—	10	wooden floor
18	—	—	—	—	—	7,000	—	7	wooden floor
19	—	—	—	—	—	7,800	—	6	wooden floor
20	—	—	—	—	—	16,000	—	12	red brick wall
21	—	—	—	—	—	8,000	—	6	wooden floor
22	—	—	—	—	—	11,500	—	10	red brick wall
23	—	—	—	—	—	8,000	—	7.5	wooden floor
24	—	—	—	—	—	6,500	—	5	wooden floor
25	—	—	—	—	—	7,000	—	8	wooden floor
26	—	—	—	—	—	11,000	—	10	red brick wall
27	—	—	—	—	—	8,000	—	8	wooden floor

**Table B-2. Waterbury Measurement & Smear Results - Ville Swiss, 2nd Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	μR/hr		μR/hr
28	—	—	—	—	—	7,500	—	8	wooden floor
29	—	—	—	—	—	6,000	—	5.5	wooden floor
30	—	—	—	—	—	6,500	—	5	wooden floor
31	—	—	—	—	—	6,000	—	6	wooden floor
32	—	—	—	—	—	8,500	—	7	tile floor
33	—	—	—	—	—	10,500	—	8	tile floor
34	—	—	—	—	—	14,000	—	11	red brick wall
35	—	—	—	—	—	8,500	—	7	tile floor
36	—	—	—	—	—	10,500	—	9	tile floor
37	—	—	—	—	—	12,500	—	11	red brick wall
38	—	—	—	—	—	7,500	—	8.5	tile floor
39	—	—	—	—	—	8,500	—	8	tile floor
40	—	—	—	—	—	10,000	—	10	tile floor

a) As reported by the Radiochemistry and Environmental Analytical Laboratory in Oak Ridge, Tennessee

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

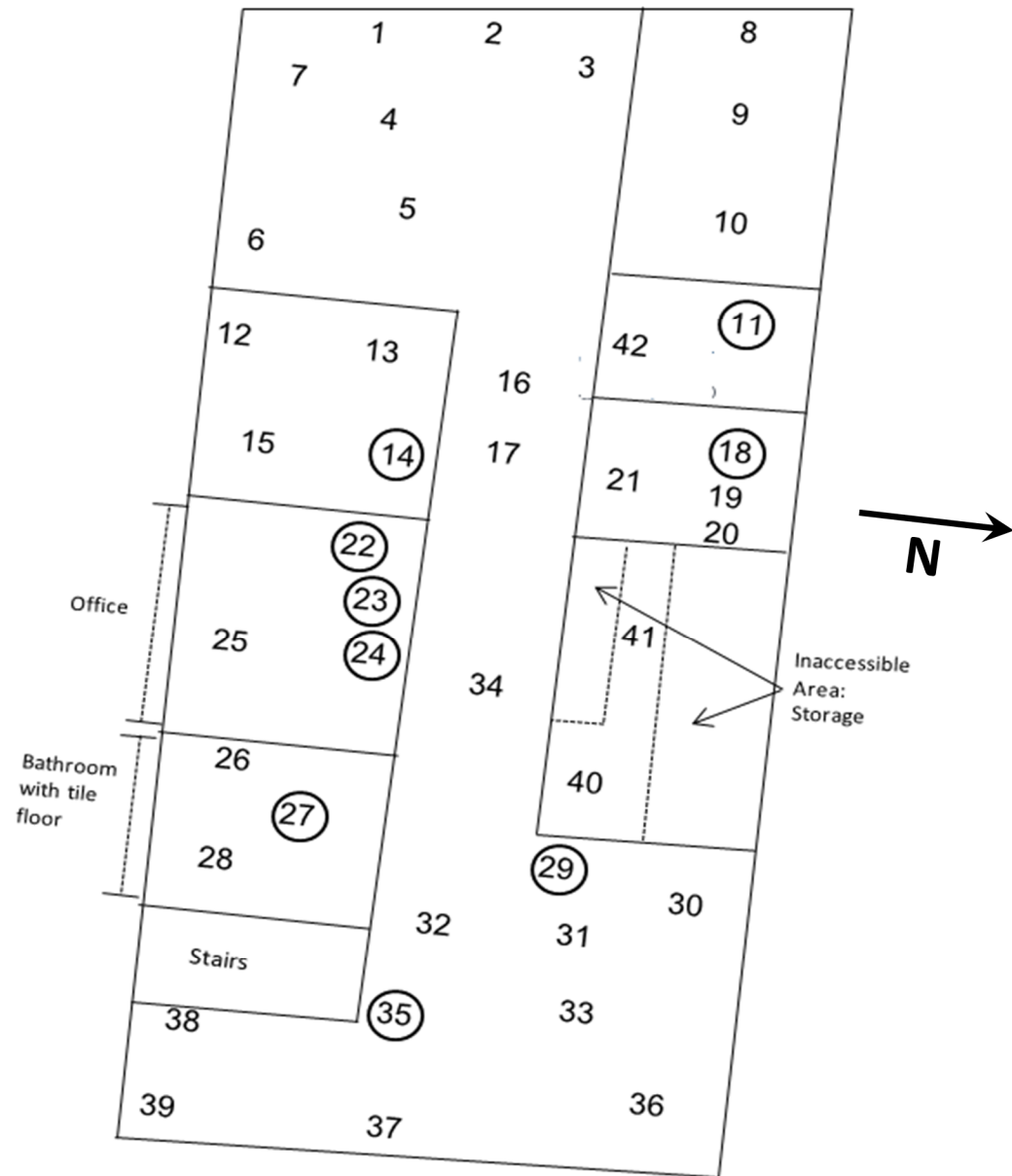
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

<b>Site:</b> Waterbury	<b>Area:</b> Ville Swiss (3rd Floor)	<b>Date(s):</b> 12/13/2016; 02/08/17	<b>Time:</b> 10:50 – 13:00; 10:30 - 11:15
<b>Surveyor(s):</b> KME/JTH (12/13/16); KME/STP (02/08/17)		<b>Purpose:</b> Site Visit	

Radiation Type	Instrument	Detector	Background
Alpha-plus-beta	2221 No. 1143	44-142 No. 920	439 cpm <sup>a</sup>
Gamma	2221 No.590	44-10 No.908	8 - 16 kcpm <sup>a</sup>
Gamma	192 No.1127	NA	7 - 13 μR/h <sup>a</sup>

<sup>a</sup>Background varied depending on naturally occurring radioactive material in the area.



○ = smear location  
 # = measurement location number  
 See attached table for measurement results

**Figure B-3. Survey Results Third Floor**

**Table B-3. Waterbury Measurement & Smear Results - Ville Swiss, 3rd Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	μR/hr		μR/hr
1	—	—	—	—	—	15,000	—	11	wooden floor
2	—	—	—	—	—	10,000	—	8	wooden floor
3	—	—	—	—	—	8,000	—	7	wooden floor
4	—	—	—	—	—	11,500	—	8.5	wooden floor
5	—	—	—	—	—	12,000	—	10	wooden floor
6	—	—	—	—	—	14,000	—	11	wooden floor
7	—	—	—	—	—	11,000	—	8	wooden floor
8	—	—	—	—	—	16,000	—	11	wooden floor
9	—	—	—	—	—	40,000	33	11	wooden floor, hotspot <sup>d</sup>
10	—	—	—	—	—	57,000	40	11	wooden floor, hotspot <sup>d</sup>
11	R0032	1.92	-2.16	2,274	1,100	60,000	45	12	wooden floor, hotspot <sup>d</sup>
12	—	—	—	—	—	37,000	30	12	wooden floor, hotspot <sup>d</sup>
13	—	—	—	—	—	49,000	38	12	wooden floor, hotspot <sup>d</sup>
14	R0031	1.92	0.29	2,652	1,400	70,000	60	16	wooden floor, hotspot <sup>d</sup>
15	—	—	—	—	—	16,000	—	12	wooden floor
16	—	—	—	—	—	30,000	25	10	wooden floor, hotspot <sup>d</sup>
17	—	—	—	—	—	11,000	—	9	wooden floor
18	R0030	-0.37	0.29	4,225	2,400	105,000	75	16	wooden floor, hotspot <sup>d</sup>
19	—	—	—	—	—	50,000	40	18	wooden floor, hotspot <sup>d</sup>
20	—	—	—	—	—	70,000	47.5	17	wooden floor, hotspot <sup>d</sup>
21	—	—	—	—	—	10,000	—	10	wooden floor
22	R0028	-0.37	-0.93	2,501	1,300	64,000	48	14	wooden floor, hotspot <sup>d</sup>
23	R0027	-0.37	2.75	4,310	2,400	104,000	90	15	wooden floor, hotspot <sup>d</sup>
24	R0029	-0.37	1.52	2,641	1,400	65,000	60	14	wooden floor, hotspot <sup>d</sup>
25	—	—	—	—	—	14,000	—	12	wooden floor

**Table B-3. Waterbury Measurement & Smear Results - Ville Swiss, 3rd Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	μR/hr		μR/hr
26	—	—	—	—	—	25,000	—	15	bathroom, tile floor, hotspot <sup>d</sup>
27	R0025	-0.37	-0.93	1,399	600	115,000	80	20	bathroom, tile floor, hotspot <sup>d</sup>
28	—	—	—	—	—	15,000	—	13	bathroom, tile floor
29	R0026	-0.37	0.29	1,137	440	21,000	15	11.5	wooden floor, hotspot <sup>d</sup>
30	—	—	—	—	—	23,000	18	13	wooden floor, hotspot <sup>d</sup>
31	—	—	—	—	—	24,000	20	13	wooden floor, hotspot <sup>d</sup>
32	—	—	—	—	—	28,000	22	12	wooden floor, hotspot <sup>d</sup>
33	—	—	—	—	—	14,000	—	12	wooden floor
34	—	—	—	—	—	12,000	—	10	wooden floor
35	R0024	-0.37	5.20	1,993	970	40,000	45	12	wooden floor, hotspot <sup>d</sup>
36	—	—	—	—	—	40,000	27	13	wooden floor, hotspot <sup>d</sup>
37	—	—	—	—	—	13,000	—	12.5	wooden floor
38	—	—	—	—	—	17,000	—	13	wooden floor, hotspot <sup>d</sup>
39	—	—	—	—	—	19,500	—	16	wooden floor, near red brick wall
40	—	—	—	—	—	14,000	—	12	wooden floor
41	—	—	—	—	—	12,000	—	11	wooden floor
42	—	—	—	—	—	10,000	—	10	wooden floor

a) As reported by the Radiochemistry and Environmental Analytical Laboratory in Oak Ridge, Tennessee

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

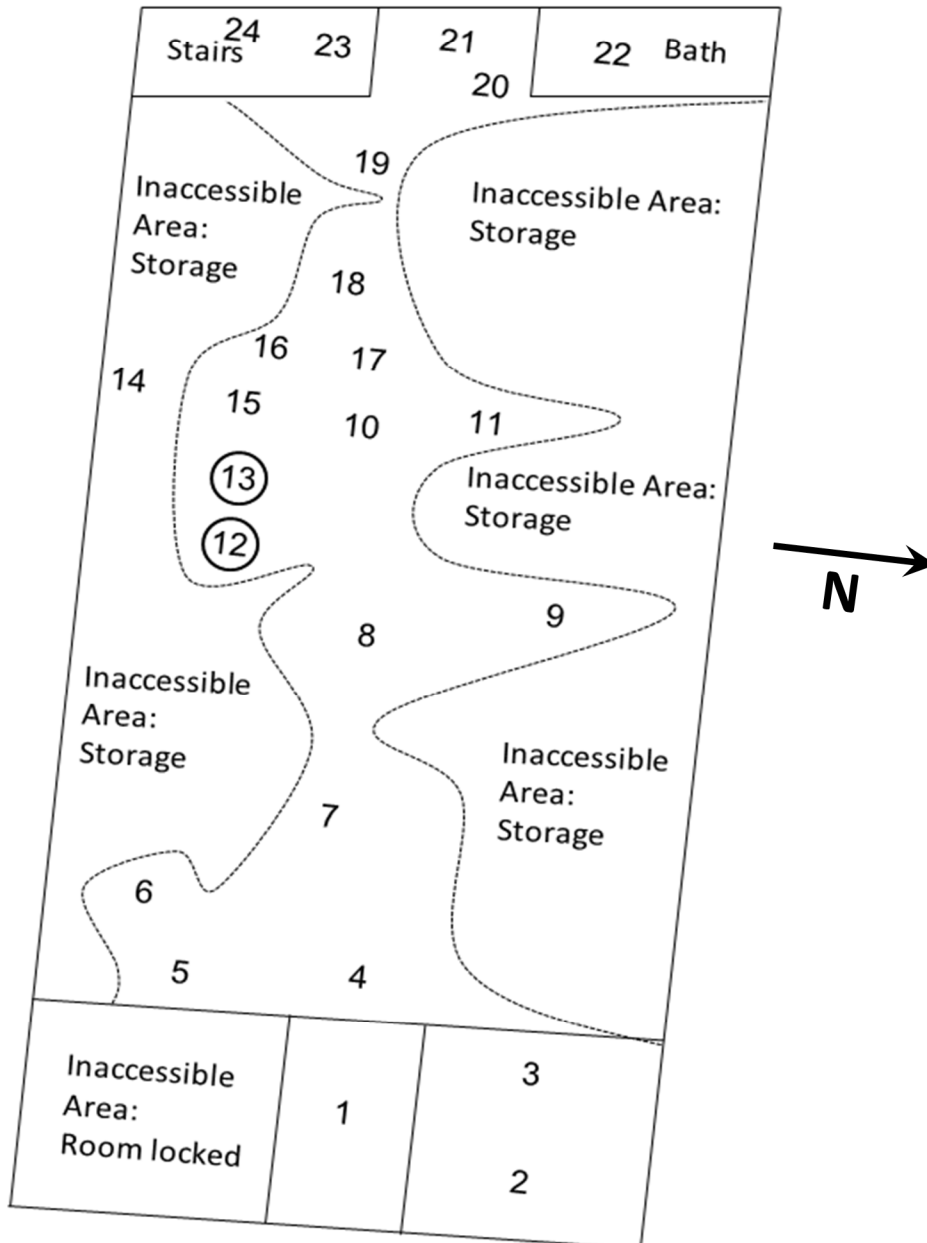
d) On average, hotspots ≤ 0.1 m<sup>2</sup>.

— indicates measurement not collected at this location

<b>Site:</b> Waterbury	<b>Area:</b> Ville Swiss (4th Floor)	<b>Date(s):</b> 02/08/17	<b>Time:</b> 09:15 – 10:45
<b>Surveyor(s):</b> STP		<b>Purpose:</b> Site Visit	

<b>Radiation Type</b>	<b>Instrument</b>	<b>Detector</b>	<b>Background</b>
Alpha-plus-beta	2221 No. 590	44-142 No. 1031	439 cpm <sup>a</sup>
Gamma	2221 No.1143	44-10 No.664	9 - 18 kcpm <sup>a</sup>
Gamma	192 No.1129	NA	7 - 11 $\mu$ R/h <sup>a</sup>

<sup>a</sup>Background varied depending on naturally occurring radioactive material in the area.



○ = smear location  
 # = measurement location number  
 See attached table for measurement results

**Figure B-4. Survey Results Fourth Floor**



**Table B-4. Waterbury Measurement & Smear Results - Ville Swiss, 4th Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	μR/hr		μR/hr
1	—	—	—	—	—	16,000	—	11	wooden floor, sheetrock walls nearby
2	—	—	—	—	—	15,000	—	11	wooden floor, sheetrock walls nearby
3	—	—	—	—	—	35,000	—	12	wooden floor, hotspots ≤ 0.1 m <sup>2</sup>
4	—	—	—	—	—	13,000	—	9	wooden floor, sheetrock walls nearby
5	—	—	—	—	—	17,300	—	9.5	wooden floor, sheetrock walls nearby
6	—	—	—	—	—	12,500	—	10	wooden floor
7	—	—	—	—	—	10,500	—	—	wooden floor
8	—	—	—	—	—	10,000	—	8	wooden floor
9	—	—	—	—	—	22,000	—	10	wooden floor, hotspots ≤ 0.1 m <sup>2</sup>
10	—	—	—	—	—	11,000	—	8	wooden floor
11	—	—	—	—	—	9,500	—	10	wooden floor
12	R0071	1.39	2.35	5163	3,000	46,000	40	15	wooden floor, hotspots ≤ 0.1 m <sup>2</sup>
13	R0070	-0.71	-2.35	7771	4,600	65,000	70	16	wooden floor, hotspots ≤ 0.1 m <sup>2</sup>
14	—	—	—	—	—	13,000	—	10	window
15	—	—	—	—	—	23,000	—	9	wooden floor, hotspots ≤ 0.1 m <sup>2</sup>
16	—	—	—	—	—	12,500	—	—	wooden floor
17	—	—	—	—	—	12,000	—	—	wooden floor
18	—	—	—	—	—	9,500	—	8	wooden floor
19	—	—	—	—	—	9,200	—	7	wooden floor
20	—	—	—	—	—	12,000	—	9	wooden floor
21	—	—	—	—	—	12,000	—	9	floor composition unknown
22	—	—	—	—	—	11,000	—	11	bath
23	—	—	—	—	—	14,000	—	11	--
24	—	—	—	—	—	14,500	—	11	stairs

a) As reported by the Radiochemistry and Environmental Analytical Laboratory in Oak Ridge, Tennessee

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

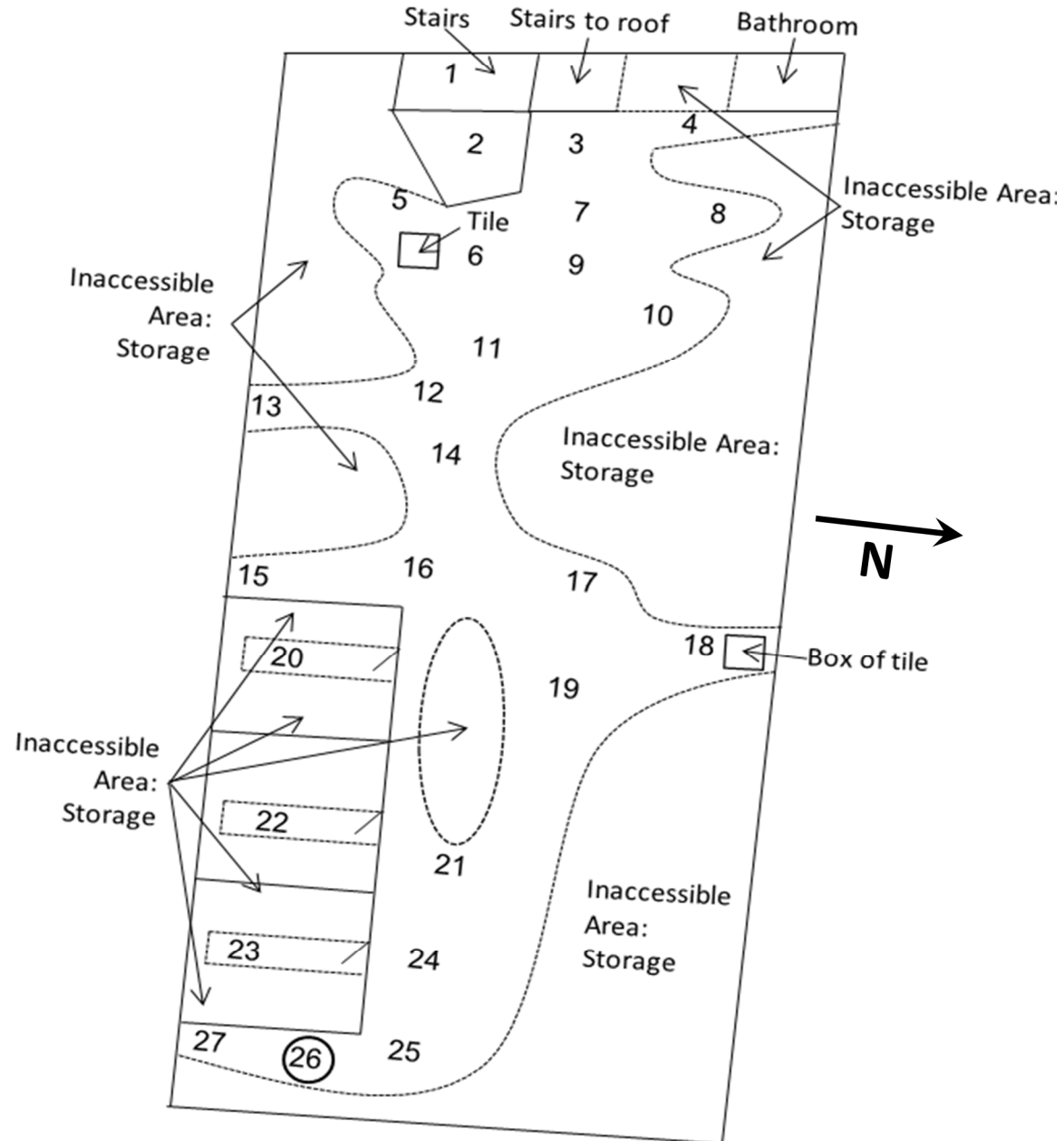
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

Site: Waterbury	Area: Ville Swiss (5th Floor)	Date(s): 02/08/17	Time: 09:15 – 10:30
Surveyor(s): KME		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Alpha-plus-beta	2221 No. 590	44-142 No. 1031	438 cpm <sup>a</sup>
Gamma	2221 No.590	44-10 No.908	7 - 14 kcpm <sup>a</sup>
Gamma	192 No.1127	NA	7 - 10 $\mu$ R/h <sup>a</sup>

<sup>a</sup>Background varied depending on naturally occurring radioactive material in the area.



○ = smear location  
 # = measurement location number  
 See attached table for measurement results

Figure B-5. Survey Results Fifth Floor

**Table B-5. Waterbury Measurement & Smear Results - Ville Swiss, 5th Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )	Gross	Total	Contact		1 m		
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	µR/hr		µR/hr
1	—	—	—	—	—	13,000	—	10	concrete floor
2	—	—	—	—	—	8,500	—	8	wooden floor
3	—	—	—	—	—	9,000	—	7	wooden floor
4	—	—	—	—	—	13,000	—	10	wooden floor
5	—	—	—	—	—	7,500	—	7	wooden floor
6	—	—	—	—	—	10,000	—	8	tile
7	—	—	—	—	—	8,500	—	7	wooden floor
8	—	—	—	—	—	9,000	—	9	wooden floor
9	—	—	—	—	—	8,000	—	7	wooden floor
10	—	—	—	—	—	9,000	—	7	wooden floor
11	—	—	—	—	—	35,000	26	8	wooden floor, hotspots ≤ 0.01 m <sup>2</sup>
12	—	—	—	—	—	26,000	25	8	wooden floor, hotspots ≤ 0.01 m <sup>2</sup>
13	—	—	—	—	—	13,000	—	9	wooden floor, near red brick wall
14	—	—	—	—	—	10,000	—	9	wooden floor
15	—	—	—	—	—	12,000	—	10	wooden floor, near red brick wall
16	—	—	—	—	—	10,000	—	7	wooden floor
17	—	—	—	—	—	8,000	—	7	wooden floor
18	—	—	—	—	—	14,000	—	10	box of tile
19	—	—	—	—	—	8,500	—	8	wooden floor
20	—	—	—	—	—	12,000	—	10	wooden floor
21	—	—	—	—	—	7,500	—	7	wooden floor
22	—	—	—	—	—	12,000	—	8	wooden floor
23	—	—	—	—	—	10,000	—	8	wooden floor

**Table B-5. Waterbury Measurement & Smear Results - Ville Swiss, 5th Floor**

Location No.	Removable <sup>a</sup>		Alpha-plus-Beta <sup>b</sup>		Gamma <sup>c</sup>			Comments	
	Smear No.	(dpm/100 cm <sup>2</sup> )		Gross	Total	Contact			1 m
		Alpha	Beta	cpm	dpm/100 cm <sup>2</sup>	cpm	μR/hr		μR/hr
24	—	—	—	—	—	8,000	—	8	wooden floor
25	—	—	—	—	—	18,000	—	10	wooden floor, hotspots ≤ 0.01 m <sup>2</sup>
26	R0069	-0.71	1.17	4181	2,300	63,000	50	13	wooden floor, hotspots ≤ 0.01 m <sup>2</sup>
27	—	—	—	—	—	14,000	—	10	wooden floor, near red brick wall

a) As reported by the Radiochemistry and Environmental Analytical Laboratory in Oak Ridge, Tennessee  
 b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter  
 c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI  
 — indicates measurement not collected at this location