**Enclosure**

# OAK RIDGE ASSOCIATED UNIVERSITIES:

# SITE STATUS REPORT FOR THE FORMER LUX CLOCK COMPANY AT 95 JOHNSON STREET, WATERBURY, CONNECTICUT

**APRIL 5, 2018**

## EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) requested that Oak Ridge Associated Universities (ORAU) perform a radiation survey of the property at 95 Johnson Street in Waterbury, Connecticut. This property was formerly the Lux Clock Company, which manufactured clocks with luminous radium dials in the early 1900s. The objective of this survey was to locate possible discrete sources of radium, if any, that would be associated with former Lux Clock Company operations.

ORAU performed the radiation survey of the accessible portions of the building interior as well as the exterior land area on June 27-28, 2017. Elevated direct radiation was identified within the building although at levels that would produce a dose of less than 25 millirem per year for an industrial or residential occupant. However, because access inside the building was limited in some areas used for storage, ORAU cannot ascertain whether additional locations of elevated radiation may be present. ORAU recommends that further radiological investigations be performed when access to these other areas is made available.

SITE STATUS REPORT

| | |
|---|---|
| Property: | Former Lux Clock Company<br>95 Johnson Street<br>Waterbury, CT 06710 |
| Docket Number: | 03038982 |
| Current Property Name(s): | 95 Johnson WTB, LLC |
| Current Property Owner(s): | Brian Goldwitz |
| Inspection Dates: | June 27-28, 2017 |
| Inspector(s): | Mark Roberts and Bob Nelson/U.S. Nuclear Regulatory Commission (NRC), supported by Kaitlin Engel and Jason Lee/ 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 property at 95 Johnson Street in Waterbury, Connecticut was identified as the site of the former Lux Clock Company, which made clocks from 1914 to 1941, including some with luminous radium dials (ORNL 2015). 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 are 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 procedure, Temporary Instruction 2800/043, Revision 1, "Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources" (NRC 2017) (Agencywide Documents Access and Management System [ADAMS] Accession number ML16330A678).

## 2.0 PROPERTY DESCRIPTION AND INITIAL SITE VISIT CONSIDERATIONS

### 2.1 Property Description and History

The Lux Clock Manufacturing Company (referred to as Lux Clock Company) was founded in 1914 by Paul Lux, an employee of the Waterbury Clock Company of Connecticut who decided to start his own business (www.luxproducts.com). The company produced clocks with luminous radium dials until 1941, at which time the company made war-related products (ORNL 2015). Currently, the property is owned and occupied by New England Outdoor Products, which uses the facility as a distribution warehouse that stores products and has a few office spaces.

The 27,900 square meter (300,000-square-feet) building pictured in Figure 1 is composed of brick walls with mostly wooden (some concrete) floors. The building is being updated as of the date of this initial site visit, with new flooring and carpeting over the old flooring, and newly painted walls. The building has a sub-basement, a basement (Floor 1), and three upper floors (Floors 2, 3, and 4). Currently, Floor 3 is used as partial office space, and Floor 2 is used as the warehouse. The rest of the building is unoccupied and used for storage.

The land area surrounding the building is a combination of asphalt or unmanaged natural surfaces. A small parking lot is located to the east of the building. To the south of the building is a gravel driveway bordered by a steep drop off with trees. A chain-link fence surrounds the parking lot and driveway.

**Figure 1. Lux Clock Company Site (Google Maps, 2017)**

Radiation surveys were conducted by the Connecticut Department of Environmental Protection and the U.S. Department of Energy on April 3, 1998 (ATSDR, 1999) and CoPhysics Corporation on May 10 and 13, 1999 (CoPhysics, 1999). The CoPhysics Corporation report states the following:

> *A radiation survey was conducted by the Connecticut DEP and the US Dept. of Energy on April 3, 1998 during which a few spots of elevated radioactivity were found…*
>
> *All gamma readings on the 1st and 2nd floors were at normal background levels. Elevated gamma readings on the 3rd and 4th floors found by the Ct DEP were confirmed during this* (1999) *survey….*

*The 1st and 2nd floors, the east and west portions of the 3rd floor, and the west side of the 4th floor can be considered unaffected based on readings conducted in this survey and the 1998 survey by the Ct DEP and the US DOE. Thus, no further measurements in these areas are necessary…*

*Approximately 50 spots of beta radioactivity were found on the 4th floor in the general area of the 3 spots identified by the Ct DEP survey. These spots ranged from 10,000 to 100,000 dpm gross beta and each were less than 100 sq. cm in floor area…*

*On the 3rd floor, 3 spots of slightly elevated activity were found near elevated gamma readings found by the Ct DEP. These spots were barely above background and may have been shielded by overlaying dirt or wood.*

The Connecticut Department of Public Health recommended that individuals be disassociated from contaminated areas. It is unknown whether contaminated materials have been removed since the 1999 CoPhysics Corporation survey.

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

## 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. No health or safety issues were noted. However, it was noted that access was limited in areas used for storage.

# 3.0 SITE OBSERVATIONS AND FINDINGS

## 3.1 Summary of Activities

The inspection team conducted an initial site visit at the 95 Johnson Street property on June 27-28, 2017. A pre-inspection meeting was held on June 27, 2017 with Mark Roberts and Bob Nelson (NRC), William (Bill) Yeager III (site contact), and Kaitlin Engel and Jason Lee (ORAU). Participants discussed the inspection team's intention to perform general area surveys inside the building and outside in the surrounding land area. The team was granted access to all areas of the property, though stored materials often precluded the collection of survey data.

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 sodium iodide-based microRoentgen (μR) ratemeter[1]. Field gamma spectrum measurements

[1] NOTE: 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).

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 – June 27, 2017:*

The inspection team arrived at the site at 8:45 a.m. and met with the site contact, who provided a tour of the building. Surveys began on the fourth floor. The team used 2×2 sodium iodide detectors and model 192 exposure ratemeters to measure gamma radiation levels. Approximately 30 percent of the fourth floor was surveyed, including all accessible areas not covered by stored materials. One discrete area of elevated radiation was found under a thin tarp. Because the exposure rate was less than 40 µR/h on contact, a direct measurement and smear were not collected at this fourth floor location.

The inspection team moved to the third floor and began surveys using 2×2 sodium iodide detectors and model 192 exposure ratemeters to measure gamma radiation levels.

**Table 1. Lux Clock Company Survey Instruments**

| Radiation Type (units) | Detector Type | Detector Model (Number) | Ratemeter (Number) |
|---|---|---|---|
| Alpha-plus-beta (cpm) | Plastic Scintillator | 44-142 (1031)<br>Calibrated<br>03/07/2017 | 2221 (505)<br>Calibrated<br>03/16/2017 |
| Gross gamma (cpm) | Sodium Iodide | 44-10 (639)<br>Calibrated<br>04/13/2017<br><br>44-10 (1151)<br>Calibrated<br>04/13/2017 | 2221 (395)<br>Calibrated<br>04/11/2017<br><br>2221 (505)<br>Calibrated<br>03/16/2017 |
| Gross gamma (µR/h) | Exposure Meter | 192 (1127)<br>Calibrated<br>06/02/2017<br><br>192 (1128)<br>Calibrated<br>06/02/2017<br><br>192 (1129)<br>Calibrated<br>06/02/2017 | N/A |
| Gamma Spectrum Analyzer (SAM-940) | Lanthanum Bromide | 940 (40272)[a] | N/A |

N/A = not applicable
cpm = counts per minute
Number = ORAU equipment barcode
µR/h = microRoentgen per hour
[a]Device performs automatic calibration upon startup and is source checked before use.

Approximately 75 percent of the third floor was surveyed, including all accessible areas not covered by stored materials. Six discrete areas of elevated radiation were found on the third floor. Two of the locations were above 40 µR/hr on contact; therefore, direct measurements, smears, and a gamma spectrum were collected at both locations on the third floor. The inspection team departed the site at 3:30 p.m.

*Summary of Daily Activities – June 28, 2017:*

The inspection team arrived at the site at 8:15 a.m. Surveys were completed on the second and first floors and the sub-basement (including the room between the basement and sub-basement off of the stairwell). The team used 2×2 sodium iodide detectors and model 192 exposure ratemeters to measure gamma radiation levels. Surveys were completed on approximately 60 percent of the second floor, 40 percent of the first floor, and 50 percent of the sub-basement, including all accessible areas not covered by stored materials, and no discrete areas of elevated radiation were identified during the surveys.

The inspection team moved to the land area surrounding the building. The team used 2×2 sodium iodide detectors and model 192 exposure ratemeters to acquire gamma radiation data. Approximately 50 percent of the land area within the chain-link fence was surveyed. No discrete areas of elevated radiation were identified during the survey.

The inspection team returned to the fourth floor to reacquire the small areas of elevated direct radiation documented in previous reports and to survey a section of the building that was not investigated the previous day. The small areas of elevated activity identified in CoPhysics 1999, including a maximum of 150 µR/h, were not confirmed—it is possible that these locations are currently under stored items. No additional discrete areas of elevated activity were identified.

A post-inspection meeting was held with the site contact to discuss the results of the survey. The inspection team departed the site at 3:50 p.m.

## 3.2 Summary of Results

Pictures of surveyed areas throughout the building are presented in Appendix A. Appendix B presents tabulated results from the site visit. Tables B-1 through B-6 present total and removable alpha-plus-beta surface activity results in units of disintegrations per minute per 100 cm $^2$ (dpm/100 cm$^2$), 2×2 sodium iodide gross responses in counts per minute (cpm), and gross exposure rates in µR/h for contact and at 1 meter, as applicable.

Smears were submitted for gross alpha and gross beta analysis at a radio-analytical laboratory. Field measurements of total alpha-plus-beta direct measurements and the field counts of the smears for removable surface activity in cpm were converted to total surface activity units of dpm/100 cm$^2$ using the equation below:

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

Where:

C = measured count rate (cpm)
B = background count rate (cpm)
G = geometry factor (unitless) = $\frac{Physical\ Detector\ Area\ (cm^2)}{100\ cm^2}$ = 1.0

$\varepsilon_{tot}$ = 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:

$$\varepsilon_{tot} = \sum_{n} F_n \times \varepsilon_{i,n} \times \varepsilon_{s,n}$$

Where:

$F_n$ = fractional abundance of $n^{th}$ emission

$\varepsilon_{i,n}$ = instrument efficiency for $n^{th}$ emission

$\varepsilon_{s,n}$ = surface efficiency (0.25 for alpha and low-energy beta particles, 0.5 for high-energy beta particles) for $n^{th}$ emission

Figures B-1 through B-6 present floorplans containing the radiological survey data generated during the site visits.

A summary of the survey results is presented in Table 2 below. Gamma radiation levels varied based on proximity with materials typically known to contain naturally occurring radioactive material (NORM)—i.e., red bricks, concrete.

Seven discrete areas of elevated radiation were found: one location on the fourth floor and six locations on the third floor. A summary of the discrete elevated areas is presented in Table 3. A gamma spectrum using the SAM-940 was collected at smear ID locations 5307R0001 and 5307R0002. The inspector's analysis confirmed the identification of Ra-226 in both spectra. See Figures B-7 and B-8 for the SAM-940 analysis reports. The radio-analytical laboratory reported negligible counts on each smear (< 1 dpm/100 $cm^2$), so the more conservative field count results are used hereafter.

**Table 2. Summary of Survey Results for Lux Clock Company**

| Floor/Area | 2×2 Sodium Iodide Response (cpm) | Exposure Rate (µR/h at 1 meter)[a] |
|---|---|---|
| Fourth | 3,200 to 32,500 | 3 to 14 |
| Third | 3,700 to 71,000 | 3 to 13 |
| Second | 4,100 to 14,100 | 4 to 15 |
| First (Basement) | 6,400 to 13,800 | 3 to 14 |
| Sub-Basement | 10,500 to 14,500 | 10 to 14 |
| Land | 7,200 to 13,000 | 6 to 12 |

[a]Maximum values collected near brick walls and are not associated with Ra-226 contamination.

| Table 3. Summary of Discrete Areas of Elevated Radiation at Lux Clock Company | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Smear ID** | **Floor** | **2×2 Sodium Iodide Response (cpm)** | **Gross Exposure Rate (µR/h on contact)** | **Gross Exposure Rate (µR/h at 1 m)** | **Total Surface Activity, Alpha-plus-Beta (dpm/100 cm$^2$)** | **Removable Surface Activity, Alpha-plus-Beta (dpm/100 cm$^2$)[a]** | **Size (m$^2$)** |
| -- | 4 | 32,500 | 35 | 7 | -- | -- | 0.01 |
| 5307R0001 | 3 | 71,000 | 75 | 7 | 3,000 | 6.3 | 0.01 |
| 5307R0002 | 3 | 50,000 | 50 | 5 | 3,500 | -3 | 0.01 |
| -- | 3 | 17,000 | 17 | 8 | -- | -- | 0.01 |
| -- | 3 | 20,000 | 20 | 11 | -- | -- | 0.1 |
| -- | 3 | 39,000 | 37 | 12 | -- | -- | 0.25 |
| -- | 3 | 30,000 | 30 | 5 | -- | -- | 0.01 |

-- not applicable

[a]Based on field count with same detector used for direct measurement. (Due to the statistically random nature of radioactivity decays, negative numbers may be reported, but indicate that there is essentially no reportable removable radioactivity.)

### 3.3 Summary of Dose Assessment Results

Due to the complexity of the dose assessment described herein, more detail is necessary than is typically required under Temporary Instruction 2800/043. This detail includes descriptions of the calculation method and assumptions used to generate results. Therefore, the discussion is divided into two subsections: Dose Assessment Method and Dose Assessment Results.

**Dose Assessment Method.** Temporary Instruction 2800/043 presents two action levels (ALs) that correlate to 100 mrem/yr for a worker (1-meter measurement of 40 µR/h above background) and for a resident (1-meter measurement of 15 µR/h above background). These ALs account for external gamma exposure, but do not consider site-specific conditions or internal exposure pathways (e.g., inhalation and ingestion). Therefore, dose assessment methods described herein rely upon the *Dose Assessment Technical Basis Document for Potential Exposures to Discrete Sources of Radium-226 and Associated Contamination* (ORISE 2017) to account for site-specific conditions and all potential exposure pathways.

The Technical Basis Document (ORISE 2017) presents default concentration-based ALs based on guidance in NUREG-1757 (NRC 2006) using the Decontamination and Decommissioning (DandD) code Version 2.4 (NRC 2001). The Technical Basis Document also presents methods for developing site-specific ALs and dose estimates, assuming a default conceptual model may not apply at a given site. Although the building's current purpose is industrial, other former clock factories in Connecticut have been converted into apartments, so a reasonable foreseeable future use of the former Lux Clock Company building is residential. Therefore, two critical groups are considered for the Lux Clock Company building: an indoor industrial worker (current) and a residential building occupant (future). The industrial worker and residential building occupant are conservatively assumed to spend up to 2,340 hours and 5,770 hours, respectively,

in survey units (floors) within the building, and the potential exposure pathways include external gamma, inhalation, and secondary ingestion. The following discussion describes the dose assessment methods and results, which are presented in more detail in Appendix C.

Because measured values are preferable to modeled values, measured exposure rates in μR/h are used to estimate dose received via the external gamma pathway (assuming 1 μR/h ~ 1 μrem/h). The Technical Basis Document presents dose-to-source ratios (DSRs) for the internal exposure pathways. For the industrial worker, the DSRs are $2.5 \times 10^{-8}$ mrem/hr per dpm/100 $cm^2$ for inhalation and $4.3 \times 10^{-8}$ mrem/hr per dpm/100 $cm^2$ for secondary ingestion, for a total DSR of $6.8 \times 10^{-8}$ mrem/hr per dpm/100 $cm^2$ (see ORISE 2017, Table 4.3). For the residential building occupant, the DSRs are $1.6 \times 10^{-8}$ mrem/hr per dpm/100 $cm^2$ for inhalation and $4.3 \times 10^{-8}$ mrem/hr per dpm/100 $cm^2$ for secondary ingestion, for a total DSR of $5.9 \times 10^{-8}$ mrem/hr per dpm/100 $cm^2$ (ORISE 2017). These DSRs are selected for a small area of elevated activity on the order of 0.1 $m^2$, given only small areas of elevated activity (<0.1-0.25 $m^2$ "hot spots") were encountered during the June 2017 survey. The dose estimate method, therefore, consists of the following calculations, which include multiplying the occupancy time by the measured exposure rate (for the external dose), and by multiplying the occupancy time by the measured surface activity and the total DSR (for the internal dose):

$$\text{External Dose}\left(\frac{\text{mrem}}{\text{yr}}\right) = Time\left(\frac{h}{yr}\right) \times \frac{Measured\ Exposure\ Rate\ \left(\frac{\mu R}{hr} \sim \frac{\mu rem}{hr}\right)}{1000\ \mu rem/mrem},$$

$$\text{Internal Dose}\left(\frac{\text{mrem}}{\text{yr}}\right) = Time\left(\frac{h}{yr}\right) \times Surface\ Activity\left(\frac{dpm}{100\ cm^2}\right) \times 5.91 \times 10^{-8}\left(\frac{mrem/h}{dpm/100\ cm^2}\right),$$

and finally,

$$\text{Total Dose} = \text{External Dose} + \text{Internal Dose}.$$

Note that even when doses are averaged over a reasonably conservative area, such as a small area of a floor, the DSRs for small areas are still used given the sum of the contaminated areas is a very small percentage of the total area. For example, the third floor survey unit contains six hot spots, with a total estimated contaminated area of less than 0.5 $m^2$, compared to the total third floor area of approximately 9,000 $m^2$, assuming industrial use. Assuming the building is converted into apartments for the residential building occupant scenario, an apartment size of approximately 50 $m^2$ is assumed. Therefore, under both scenarios, an upper estimate of the contaminated area represents less than a hundredth of a percent assuming industrial use or approximately 1 percent assuming residential use.

Because only hot spots were identified at the former Lux Clock Company, the dose assessment was performed assuming two occupancy duration scenarios. The first scenario assumes an individual would spend the entire occupancy period in the room or area containing the highest-activity hot spot identified in a survey unit. This scenario is very conservative given an individual is highly unlikely to spend all modeled time in only a limited portion of the facility. The second scenario assumes an individual would spend the occupancy period averaged over the entire survey unit (e.g., the third floor). This scenario is still conservative but more closely aligns with the conceptual model described in the Technical Basis Document (ORISE 2017). Therefore, the first occupancy duration scenario is intended to generate an upper bound of the dose within a given survey unit, and the second occupancy duration scenario is intended to generate a still conservative, but more realistic representation of conditions expected to be encountered within a survey unit.

The source term for each scenario is net values (excludes background) and is also conservatively estimated. The source term in the first ("maximum") scenario is defined by the highest measured radioactivity within the survey unit. The source term in the second scenario is the average of all measured radioactivity in the survey unit. This value is conservative because results for a given hot spot are weighted equally with background measurements, though the area containing elevated activity is a very small fraction of the total surface area in any survey unit. Background is, likewise, estimated by averaging all measurements in the room or area, though excluding locations with elevated activity.

In summary, the dose assessment method described herein uses multiple conservative assumptions. For example, worst-case "maximum" doses assume the receptor spends 100 percent of the occupancy period in a hypothetical apartment. Additionally, an "average" source term is biased to the conservative by unweighted hot spot measurements though they represent a very small percentage of the total surface area. Finally, the total surface area represented by hot spots is a very small percentage of the total area, though area weighting is not used in source term calculations. As a result of this layered conservatism, dose estimates presented in the following discussion should overestimate the true value.

**Dose Assessment Results.** Appendix C presents dose assessment results for maximum area and survey unit source terms. Tables C-1 through C-3 lists dose estimates for industrial use scenarios, noting that the external gamma results in Table C-1 are added to the internal dose results in Table C-2 to generate the total values in Table C-3, and represents potential doses to current occupants. Tables C-4 through C-6 lists dose estimates for indoor residential use scenarios, noting that the external gamma results in Table C-4 are added to the internal dose results in Table C-5 to generate the total values in Table C-6. As presented in Tables C-3 and C-6, the maximum estimated dose for any combination of area and receptor is 10 mrem/yr (third floor maximum area for a future indoor resident).

Two dose limits are considered in this assessment. The first dose limit is the 100 mrem/yr public dose limit in 10 CFR 20.1301. An estimated dose above 100 mrem/yr to the average member of the critical group would require immediate action, such as access controls to limit current occupant exposures to discreet sources of Ra-226. The second dose limit is the 25 mrem/yr unrestricted use limit in 10 CFR 20.1402. An estimated dose above 25 mrem/yr to the average member of the critical group would not require immediate action, though controls, additional characterization, and remediation may be required prior to unrestricted release. In any case, no action is required if the estimated dose is less than 25 mrem/yr.

These results demonstrate that current and potential future occupants are unlikely to receive a dose above either the 100 mrem/yr public dose limit in 10 CFR 20.1301 or the 25 mrem/yr unrestricted use limit in 10 CFR 20.1402. Therefore, although discrete sources of Ra-226 were identified within several survey units at the former Lux Clock Company, none are present at concentrations that would reasonably produce a dose above regulatory limits.

Finally, ATSDR 1999 notes that location-specific radiation levels measured in the late 1990s could exceed 15 mrem/yr, the cleanup level applied at that time. However, the record suggests, but does not definitively confirm, that at least some of the hot spots were subject to a remedial action. ATSDR 1999 does, for example, contain language describing the remedial plan, and a picture of an individual wearing Tyvek and using a vacuum on the floor, presumably to remove a hot spot. This information appears to support the above dose calculations, thus supporting the assertion that estimated doses, when identified by the inspection team, are below regulatory limit.

## 4.0 OBSERVATIONS AND RECOMMENDATIONS

Based on the data collected, the former Lux Clock Company property located at 95 Johnson Street contains discrete sources of Ra-226. However, the discrete sources identified are not at concentrations or configured in a manner that would result in a dose in excess of regulatory requirements. It is unclear, however, whether the entire property satisfies dose limits considering that much of the fourth floor and the western portion of the third floor were inaccessible during the initial site visit.

ORAU made the following observations:

- Elevated direct gamma radiation due to small areas of Ra-226 activity was identified on the third and fourth floors ("hot spots" generally less than 0.1 $m^2$).
    - 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.
    - Multiple isolated locations with elevated alpha-plus-beta radiation levels were identified; noting that access was limited in some areas, additional locations with elevated radiation levels may be present.
- Results from the site visit were generally consistent with those presented in CoPhysics 1999—elevated levels of radiation present on the third and fourth floors.
- Dose estimates show that current and future occupant would receive an estimated dose less than the 25 mrem/yr unrestricted use limit in 10 CFR 20.1402, even if spending up to 5,770 h/yr in a room containing the maximum-activity "hot spot" in a survey unit.

Based on these observations, it is recommended that the NRC not perform a scoping survey at this time. NRC should, however, communicate to the owner that because the western portion of third floor space and a significant portion of the fourth floor were inaccessible during the site visit, the surveying was limited and it is unclear whether the property as a whole satisfies dose requirements. The inspection team did not identify radium contamination on the second, first (basement), or sub-basement floors nor in the land area. Portions of the fourth and third floor were found to have elevated levels of radiation suggesting that more Ra-226 contamination may be present in the areas not surveyed on those floors. The survey performed in 1999 found "approximately 50" small areas of elevated activity on the fourth floor and additional elevated locations on the third floor (ATSDR 1999). If the configuration and/or use of the current building significantly changes (specifically the fourth and third floors), NRC should consider performing a more detailed survey investigating areas that were inaccessible during the June 2017 initial site visit.

## 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).

CoPhysics 1999. *Radiological Survey Report of the Former Lux Clock Company Building, Waterbury, CT*, CoPhysics Corporation, Monroe, New York, May. (ADAMS Accession No. ML17215A276).

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

NRC 2006. *Consolidated Decommissioning Guidance – Characterization, Survey, and Determination of Radiological Criteria.* NUREG-1757, Vol. 2, Rev. 1. U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. Washington, D.C. September.

NRC 2017. *Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources*, Temporary Instruction 2800/043, Revision 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Washington, D.C., October. (ADAMS Accession No. ML16330A678).

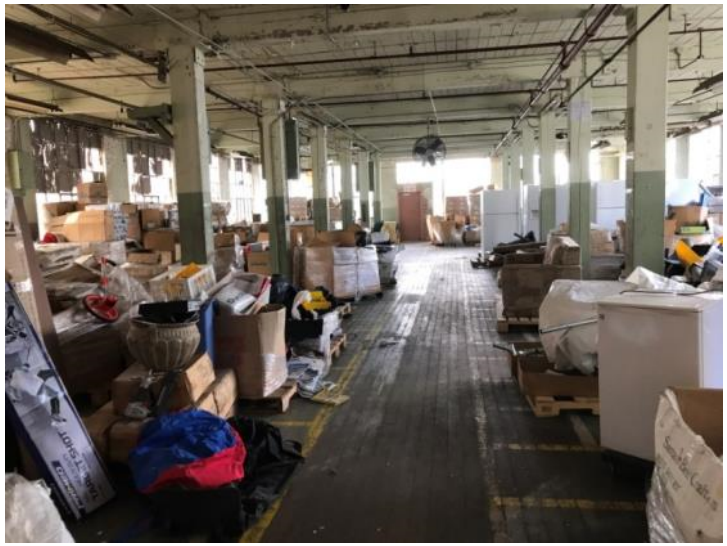
ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, "Lux Clock Company: Site Summary," pp. 82-88, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488).

ORISE 2017. *Dose Assessment Technical Basis Document for Potential Exposures to Discrete Sources of Radium-226 and Associated Contamination*, DCN 5289-TR-01-2, Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, May 30. (ADAMS Accession No. ML17152A204).

**APPENDIX A**
**PHOTOS FROM THE FORMER LUX CLOCK COMPANY SITE VISIT**

**A-1. Former Lux Clock Company Looking West**

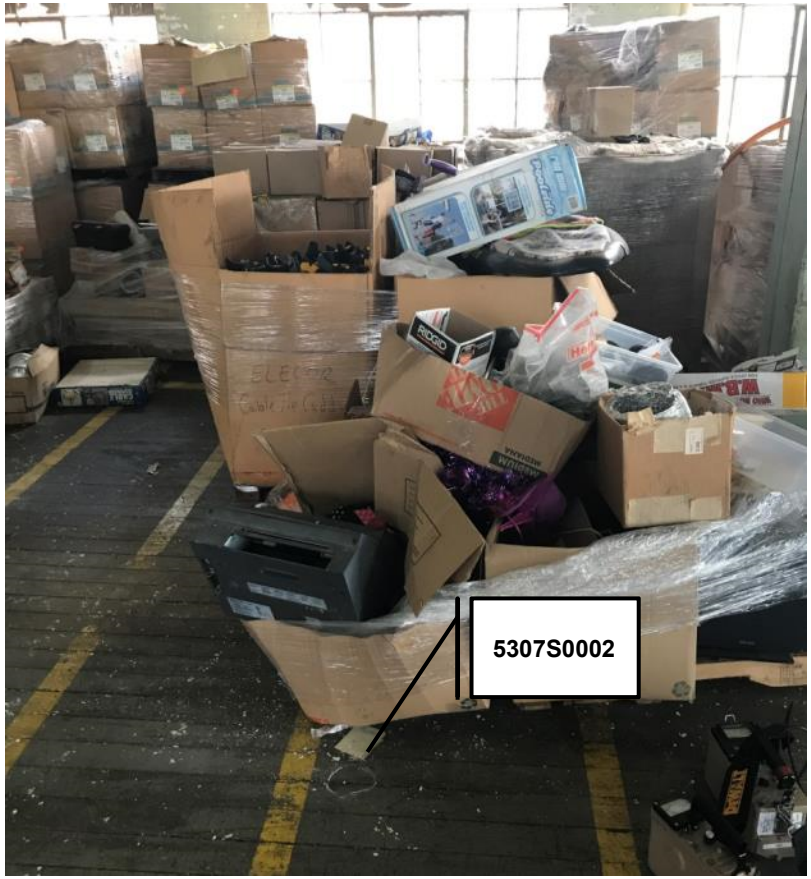
**A-2. Former Lux Clock Company South of Building Looking West**



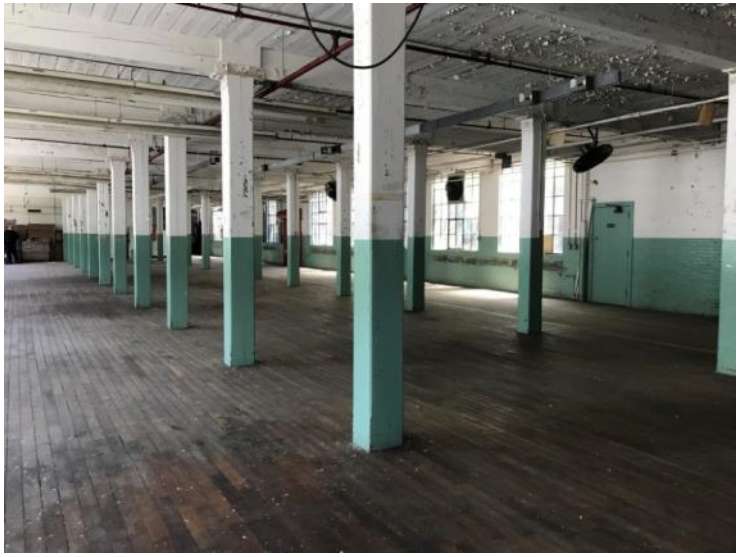
**A-3. Former Lux Clock Company Fourth Floor**

**A-4. Former Lux Clock Company Fourth Floor**

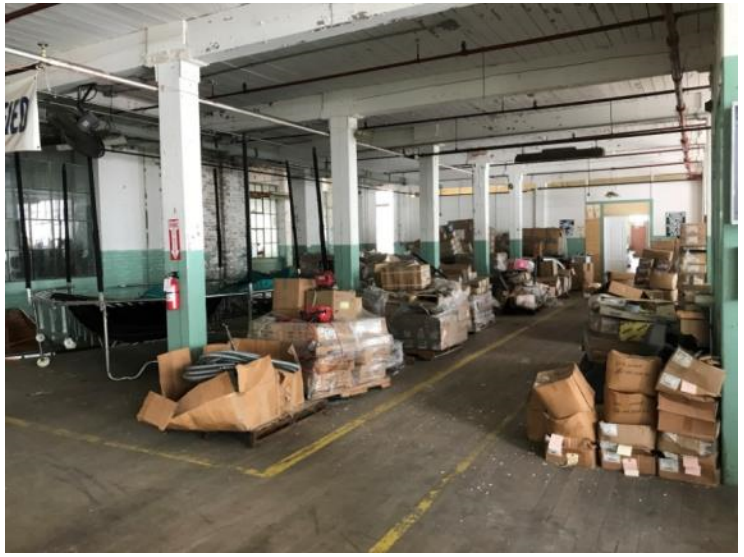

**A-5. Former Lux Clock Company**
**Third Floor Elevated Area**




**A-6. Former Lux Clock Company**
**Third Floor Elevated Area**



**A-7. Former Lux Clock Company Third Floor**



**A-8. Former Lux Clock Company Third Floor**

**A-9. Former Lux Clock Company Second Floor**

**A-10. Former, Lux Clock Company Second Floor**

**A-11. Former Lux Clock Company First Floor (Basement)**

**A-12. Former Lux Clock Company First Floor (Basement)**

**A-13. Former Lux Clock Company Sub-Basement**

**A-14. Former Lux Clock Company Sub-Basement**

**APPENDIX B**
**SURVEY RESULTS FROM THE FORMER LUX CLOCK COMPANY SITE VISIT**

| Site: Lux Clock Co | Area: Fourth Floor | Date(s): 6/27/2017 and 6/28/17 | Time: 1020 – 1140 and 1430 - 1445 |
|---|---|---|---|
| Surveyor(s): JDL / KME | | Purpose: Site Visit | |

| Radiation Type | Instrument | Detector | Background |
|---|---|---|---|
| Alpha-plus-beta | NA | NA | NA |
| Gamma | 2221 No.505, No.395 | 44-10 No.1151, No.639 | 3 - 14 kcpm[a] |
| Gamma | 192 No.1128, No.1129 | NA | 3- 14 µR/h[a] |

[a]Background varied depending on naturally occurring radioactive material in the area.

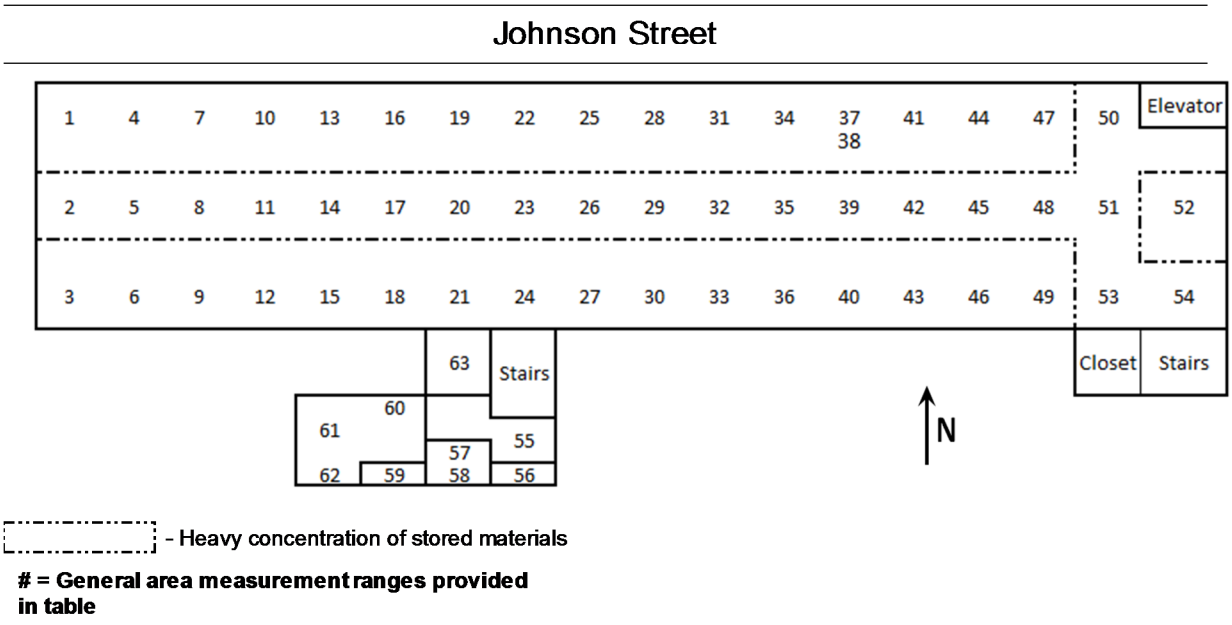



**Figure B-1. Survey Results for Fourth Floor**

| Table B-1. Lux Clock Company Measurement Results - Fourth Floor | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 1 | — | — | — | — | — | 8,500 | — | 8 | |
| 2 | — | — | — | — | — | 8,000 | — | 8 | |
| 3 | — | — | — | — | — | 10,000 | — | 10 | |
| 4 | — | — | — | — | — | — | — | 5 | |
| 5 | — | — | — | — | — | 4,000 | — | 4 | |
| 6 | — | — | — | — | — | 14,000 | — | 14 | |
| 7 | — | — | — | — | — | 3,200 | — | 3 | |
| 8 | — | — | — | — | — | 4,000 | — | 4 | |
| 9 | — | — | — | — | — | 5,000 | — | 5 | |
| 10 | — | — | — | — | — | 6,000 | — | 6 | |
| 11 | — | — | — | — | — | 3,900 | — | 4 | |
| 12 | — | — | — | — | — | 7,600 | — | 7 | |
| 13 | — | — | — | — | — | 7,200 | — | 7 | |
| 14 | — | — | — | — | — | 3,800 | — | 4 | |
| 15 | — | — | — | — | — | 4,300 | — | 4 | |
| 16 | — | — | — | — | — | 4,600 | — | 4 | |
| 17 | — | — | — | — | — | 3,700 | — | 4 | |
| 18 | — | — | — | — | — | 4,500 | — | 4 | |
| 19 | — | — | — | — | — | 7,400 | — | 8 | |
| 20 | — | — | — | — | — | 4,500 | — | 5 | |
| 21 | — | — | — | — | — | 5,800 | — | 4 | |
| 22 | — | — | — | — | — | 6,200 | — | 5 | |
| 23 | — | — | — | — | — | 6,300 | — | 5 | |
| 24 | — | — | — | — | — | 5,800 | — | 5 | |
| 25 | — | — | — | — | — | 6,300 | — | 6 | |
| 26 | — | — | — | — | — | 6,200 | — | 5 | |
| 27 | — | — | — | — | — | 7,300 | — | 5 | |
| 28 | — | — | — | — | — | 8,200 | — | 6 | |
| 29 | — | — | — | — | — | 8,300 | — | 5 | |
| 30 | — | — | — | — | — | 6,700 | — | 5 | |
| 31 | — | — | — | — | — | 8,200 | — | 5 | |
| 32 | — | — | — | — | — | 5,700 | — | 5 | |
| 33 | — | — | — | — | — | 5,900 | — | 5 | |
| 34 | — | — | — | — | — | 8,000 | — | 6 | |
| 35 | — | — | — | — | — | 5,900 | — | 5 | |
| 36 | — | — | — | — | — | 8,300 | — | 5 | |
| 37 | — | — | — | — | — | 8,500 | — | 5 | |
| 38 | — | — | — | — | — | 32,500 | 35 | 7 | Elevated area approximately 0.1 m$^2$ |
| 39 | — | — | — | — | — | 5,200 | — | 5 | |
| 40 | — | — | — | — | — | 6,500 | — | 5 | |
| 41 | — | — | — | — | — | 8,600 | — | 7 | |
| 42 | — | — | — | — | — | 6,600 | — | 5 | |
| 43 | — | — | — | — | — | 7,500 | — | 5 | |
| 44 | — | — | — | — | — | 8,200 | — | 7 | |
| 45 | — | — | — | — | — | 6,100 | — | 5 | |
| 46 | — | — | — | — | — | 6,900 | — | 5 | |
| 47 | — | — | — | — | — | 8,500 | — | 7 | |
| 48 | — | — | — | — | — | 6,700 | — | 5 | |
| 49 | — | — | — | — | — | 7,300 | — | 6 | |
| 50 | — | — | — | — | — | 8,900 | — | 7 | |

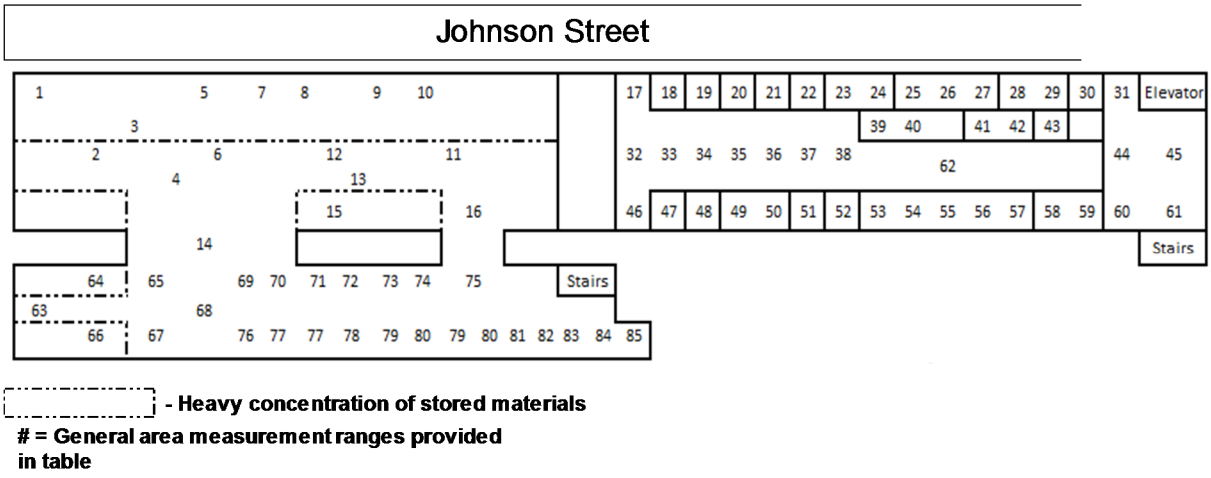
a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter
b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI
— indicates measurement not collected at this location

| Table B-1. Lux Clock Company Measurement Results - Fourth Floor | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 51 | — | — | — | — | — | 4,000 | — | 7 | |
| 52 | — | — | — | — | — | 7,700 | — | 7 | |
| 53 | — | — | — | — | — | 7,700 | — | 7 | |
| 54 | — | — | — | — | — | 9,500 | — | 8 | |
| 55 | — | — | — | — | — | 9,500 | — | 10 | |
| 56 | — | — | — | — | — | 14,000 | — | 14 | |
| 57 | — | — | — | — | — | 8,600 | — | 8 | |
| 58 | — | — | — | — | — | 10,000 | — | 10 | |
| 59 | — | — | — | — | — | 9,400 | — | 9 | |
| 60 | — | — | — | — | — | 9,000 | — | 9 | |
| 61 | — | — | — | — | — | 8,500 | — | 9 | |
| 62 | — | — | — | — | — | 10,300 | — | 10 | |
| a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | | |
| b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI | | | | | | | | | |
| — indicates measurement not collected at this location | | | | | | | | | |

| Site: Lux Clock Co | Area: Third Floor | Date(s): 6/27/2017 | Time: 1230 – 1420 |
|---|---|---|---|
| Surveyor(s): JDL / KME | | Purpose: Site Visit | |

| Radiation Type | Instrument | Detector | Background |
|---|---|---|---|
| Alpha-plus-beta | 2221 No. 505 | 44-142 No. 1031 | NA |
| Gamma | 2221 No.505, No.395 | 44-10 No.1151, No.639 | 3 - 16 kcpm[a] |
| Gamma | 192 No.1127, No.1128 | NA | 5 - 13 µR/h[a] |

[a]Background varied depending on naturally occurring radioactive material in the area.




- Heavy concentration of stored materials

# = General area measurement ranges provided in table

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

| Table B-2. Lux Clock Company Measurement Results - Third Floor | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location No. | Removable[a] | | Alpha-plus-Beta[b] | | Gamma[c] | | | Comments |
| | Smear No. | (dpm/100 $cm^2$) | Gross | Total | Contact | | 1 m | |
| | | Alpha-plus-Beta | cpm | dpm/100 $cm^2$ | cpm | µR/hr | µR/hr | |
| 1 | — | — | — | — | 5,200 | — | 5 | |
| 2 | 5307R0002 | -3 | 5,858 | 3,500 | 50,000 | 50 | 5 | Elevated area less than 100 $cm^2$ |
| 3 | — | — | — | — | 4,000 | — | 5 | |
| 4 | — | — | — | — | 5,900 | — | 3 | |
| 5 | — | — | — | — | 3,700 | — | — | |
| 6 | — | — | — | — | 3,900 | — | 3 | |
| 7 | — | — | — | — | 39,000 | 37 | 12 | Elevated area approximately 0.25 $m^2$; near brick wall |
| 8 | — | — | — | — | 17,000 | 17 | 8 | Elevated area less than 100 $cm^2$ |
| 9 | — | — | — | — | 20,000 | 20 | 11 | Elevated area approximately 0.1 $m^2$; near brick wall |
| 10 | — | — | — | — | 30,000 | 30 | 5 | Elevated area less than 100 $cm^2$ |
| 11 | 5307R0001 | 6.3 | 5335 | 3,000 | 71,000 | 75 | 7 | Elevated area less than 100 $cm^2$ |
| 12 | — | — | — | — | 6,100 | — | 6 | |
| 13 | — | — | — | — | 5,600 | — | 5 | |
| 14 | — | — | — | — | 12,000 | — | 12 | |
| 15 | — | — | — | — | 6,100 | — | 6 | |
| 16 | — | — | — | — | 5,200 | — | 5 | |
| 17 | — | — | — | — | 8,000 | — | 7 | |
| 18 | — | — | — | — | 7,500 | — | 8 | |
| 19 | — | — | — | — | 7,900 | — | 9 | |
| 20 | — | — | — | — | 9,000 | — | 8 | |
| 21 | — | — | — | — | 7,100 | | 6 | |
| 22 | — | — | — | — | 6,500 | — | 6 | |
| 23 | — | — | — | — | 6,600 | — | 6 | |
| 24 | — | — | — | — | 7,200 | — | 6 | |
| 25 | — | — | — | — | 7,500 | — | 6 | |
| 26 | — | — | — | — | 7,300 | — | 6 | |
| 27 | — | — | — | — | 8,200 | — | 6 | |
| 28 | — | — | — | — | 7,300 | — | 6 | |
| 29 | — | — | — | — | 6,900 | — | 6 | |
| 30 | — | — | — | — | 7,400 | — | 6 | |
| 31 | — | — | — | — | 8,100 | — | 8 | |
| 32 | — | — | — | — | 6,700 | — | 5 | |
| 33 | — | — | — | — | 7,900 | — | 5 | |
| 34 | — | — | — | — | 7,600 | — | 5 | |
| 35 | — | — | — | — | 7,300 | — | 5 | |
| 36 | — | — | — | — | 6,700 | — | 5 | |
| 37 | — | — | — | — | 6,700 | — | 5 | |
| 38 | — | — | — | — | 6,900 | — | 6 | |
| 39 | — | — | — | — | 6,500 | — | 5 | |
| 40 | — | — | — | — | 6,400 | — | 5 | |
| 41 | — | — | — | — | 6,200 | — | 5 | |
| 42 | — | — | — | — | 6,900 | — | 6 | |
| 43 | — | — | — | — | 7,300 | — | 6 | |
| 44 | — | — | — | — | 8,100 | — | 8 | |
| 45 | — | — | — | — | 9,500 | — | 11 | |
| 46 | — | — | — | — | 7,200 | — | 5 | |
| 47 | — | — | — | — | 7,500 | — | 6 | |
| 48 | — | — | — | — | 7,300 | — | 6 | |
| 49 | — | — | — | — | 8,200 | — | 7 | |
| 50 | — | — | — | — | 7,800 | — | 5 | |
| a) Field Counted Using Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | |
| b) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | |
| c) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI | | | | | | | | |
| — indicates measurement not collected at this location | | | | | | | | |

| Table B-2. Lux Clock Company Measurement Results - Third Floor | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location No. | Removable[a] | | Alpha-plus-Beta[b] | | Gamma[c] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | Gross | Total | Contact | | 1 m | |
| | | Alpha-plus-Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 51 | — | — | — | — | 6,700 | — | 6 | |
| 52 | — | — | — | — | 7,000 | — | 6 | |
| 53 | — | — | — | — | 6,800 | — | 6 | |
| 54 | — | — | — | — | 6,500 | — | 6 | |
| 55 | — | — | — | — | 7,000 | — | 6 | |
| 56 | — | — | — | — | 6,700 | — | 6 | |
| 57 | — | — | — | — | 7,600 | — | 7 | |
| 58 | — | — | — | — | 7,800 | — | 7 | |
| 59 | — | — | — | — | 8,300 | — | 7 | |
| 60 | — | — | — | — | 9,000 | — | 8 | |
| 61 | — | — | — | — | 9,300 | — | 7 | |
| 62 | — | — | — | — | 6,300 | — | 5 | |
| 63 | — | — | — | — | 10,000 | — | 9 | |
| 64 | — | — | — | — | 5,500 | — | — | |
| 65 | — | — | — | — | 5,300 | — | — | |
| 66 | — | — | — | — | 4,500 | — | 5 | |
| 67 | — | — | — | — | 6,100 | — | 6 | |
| 68 | — | — | — | — | 8,000 | — | 9 | |
| 69 | — | — | — | — | 15,900 | — | 13 | |
| 70 | — | — | — | — | 14,500 | — | 12 | |
| 71 | — | — | — | — | 10,500 | — | 10 | |
| 72 | — | — | — | — | 9,600 | — | 9 | |
| 73 | — | — | — | — | 10,500 | — | 9 | |
| 74 | — | — | — | — | 8,000 | — | 8 | |
| 75 | — | — | — | — | 11,500 | — | 10 | |
| 76 | — | — | — | — | 15,700 | — | 13 | |
| 77 | — | — | — | — | 15,300 | — | 12 | |
| 78 | — | — | — | — | 11,700 | — | 10 | |
| 79 | — | — | — | — | 11,600 | — | 9 | |
| 80 | — | — | — | — | 10,200 | — | 10 | |
| 81 | — | — | — | — | 11,500 | — | 10 | |
| 82 | — | — | — | — | 10,500 | — | 9 | |
| 83 | — | — | — | — | 11,500 | — | 11 | |
| 84 | — | — | — | — | 11,500 | — | 10 | |
| 85 | — | — | — | — | 12,000 | — | 11 | |

a) Field Counted Using Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter
c) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI
— indicates measurement not collected at this location

| Site: Lux Clock Co | Area: Second Floor | Date(s): 6/28/2017 | Time: 0855 – 1010 |
|---|---|---|---|
| Surveyor(s): JDL / KME | | Purpose: Site Visit | |

| Radiation Type | Instrument | Detector | Background |
|---|---|---|---|
| Alpha-plus-beta | NA | NA | NA |
| Gamma | 2221 No.505, No.395 | 44-10 No.1151, No.639 | 4 - 14 kcpm[a] |
| Gamma | 192 No.1127, No.1129 | NA | 4 - 15 µR/h[a] |

[a]Background varied depending on naturally occurring radioactive material in the area.

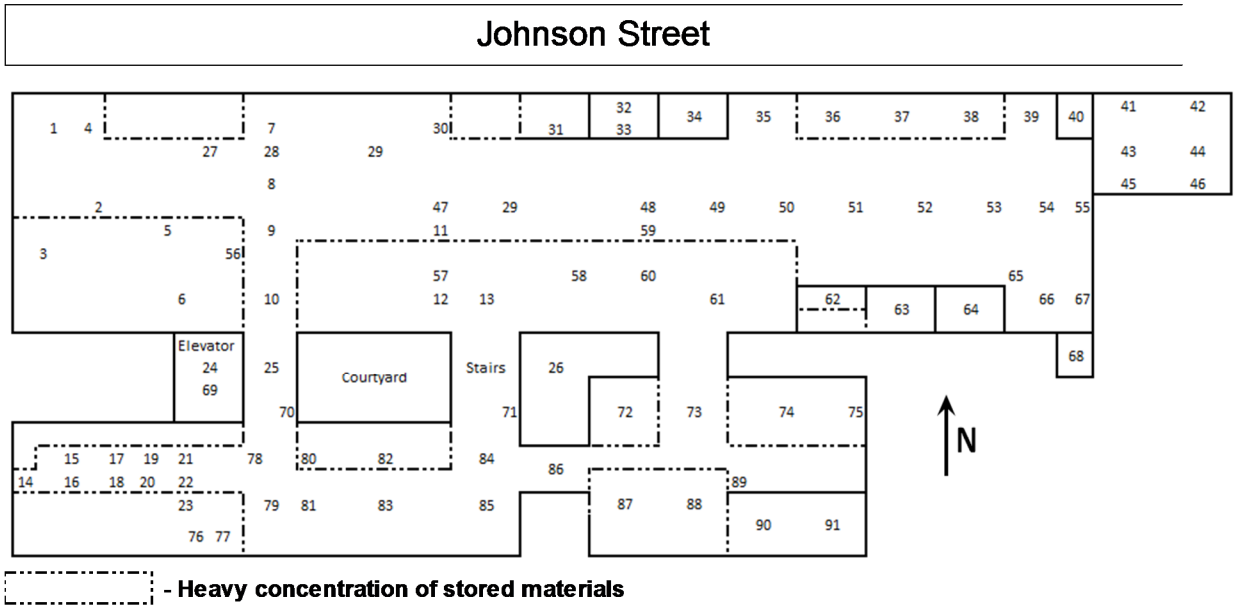



**Figure B-3. Survey Results Second Floor**

| Table B-3. Lux Clock Company Measurement Results - Second Floor | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 1 | — | — | — | — | — | 7,500 | — | 7 | |
| 2 | — | — | — | — | — | 4,400 | — | 5 | |
| 3 | — | — | — | — | — | 4,600 | — | 5 | |
| 4 | — | — | — | — | — | 4,900 | — | 5 | |
| 5 | — | — | — | — | — | 4,800 | — | 5 | |
| 6 | — | — | — | — | — | 5,300 | — | 6 | |
| 7 | — | — | — | — | — | 7,800 | — | 8 | |
| 8 | — | — | — | — | — | 6,200 | — | 4 | |
| 9 | — | — | — | — | — | 6,400 | — | 6 | |
| 10 | — | — | — | — | — | 6,600 | — | 6 | |
| 11 | — | — | — | — | — | 5,200 | — | 5 | |
| 12 | — | — | — | — | — | 4,800 | — | 5 | |
| 13 | — | — | — | — | — | 4,100 | — | 4 | |
| 14 | — | — | — | — | — | 9,400 | — | 6 | |
| 15 | — | — | — | — | — | 7,100 | — | 8 | |
| 16 | — | — | — | — | — | 9,700 | — | 9 | |
| 17 | — | — | — | — | — | 6,800 | — | 6 | |
| 18 | — | — | — | — | — | 8,400 | — | 7 | |
| 19 | — | — | — | — | — | 6,400 | — | 6 | |
| 20 | — | — | — | — | — | 6,500 | — | 5 | |
| 21 | — | — | — | — | — | 6,500 | — | 6 | |
| 22 | — | — | — | — | — | 8,800 | — | 8 | |
| 23 | — | — | — | — | — | 9,300 | — | 10 | |
| 24 | — | — | — | — | — | 12,000 | — | 12 | |
| 25 | — | — | — | — | — | 13,000 | — | 15 | |
| 26 | — | — | — | — | — | 13,000 | — | 15 | |
| 27 | — | — | — | — | — | 5,800 | — | 4 | |
| 28 | — | — | — | — | — | 4,600 | — | 4 | |
| 29 | — | — | — | — | — | 4,400 | — | 4 | |
| 30 | — | — | — | — | — | 5,400 | — | 4 | |
| 31 | — | — | — | — | — | 6,200 | — | 5 | |
| 32 | — | — | — | — | — | 13,800 | — | 8 | |
| 33 | — | — | — | — | — | 14,100 | — | 11 | |
| 34 | — | — | — | — | — | 12,500 | — | 12 | |
| 35 | — | — | — | — | — | 9,000 | — | 8 | |
| 36 | — | — | — | — | — | 9,000 | — | 8 | |
| 37 | — | — | — | — | — | 9,800 | — | 7 | |
| 38 | — | — | — | — | — | 8,000 | — | 7 | |
| 39 | — | — | — | — | — | 9,000 | — | 7 | |
| 40 | — | — | — | — | — | 9,000 | — | 9 | |
| 41 | — | — | — | — | — | 11,000 | — | 10 | |
| 42 | — | — | — | — | — | 10,000 | — | 8 | |
| 43 | — | — | — | — | — | 10,000 | — | 9 | |
| 44 | — | — | — | — | — | 10,000 | — | 9 | |
| 45 | — | — | — | — | — | 12,000 | — | 10 | |
| 46 | — | — | — | — | — | 11,000 | — | 9 | |
| 47 | — | — | — | — | — | — | — | 4 | |
| 48 | — | — | — | — | — | 4,300 | — | 4 | |
| 49 | — | — | — | — | — | 10,000 | — | 7 | |
| 50 | — | — | — | — | — | 9,300 | — | 8 | |
| 51 | — | — | — | — | — | 8,700 | — | 8 | |
| 52 | — | — | — | — | — | 8,300 | — | 8 | |
| 53 | — | — | — | — | — | 9,000 | — | 7 | |
| 54 | — | — | — | — | — | 9,000 | — | 7 | |
| 55 | — | — | — | — | — | 9,000 | — | 8 | |

a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter
b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI
— indicates measurement not collected at this location

| Table B-3. Lux Clock Company Measurement Results - Second Floor | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 56 | — | — | — | — | — | 5,600 | — | 5 | |
| 57 | — | — | — | — | — | 5,100 | — | 4 | |
| 58 | — | — | — | — | — | 5,500 | — | 4 | |
| 59 | — | — | — | — | — | 7,100 | — | 4 | |
| 60 | — | — | — | — | — | 7,700 | — | 6 | |
| 61 | — | — | — | — | — | 9,500 | — | 8 | |
| 62 | — | — | — | — | — | 8,800 | — | 7 | |
| 63 | — | — | — | — | — | 9,300 | — | 8 | |
| 64 | — | — | — | — | — | 8,500 | — | 6 | |
| 65 | — | — | — | — | — | 9,600 | — | 7 | |
| 66 | — | — | — | — | — | 10,000 | — | 6 | |
| 67 | — | — | — | — | — | 10,000 | — | 9 | |
| 68 | — | — | — | — | — | 9,000 | — | 9 | |
| 69 | — | — | — | — | — | 12,200 | — | 13 | |
| 70 | — | — | — | — | — | 13,600 | — | 13 | |
| 71 | — | — | — | — | — | 8,500 | — | 5 | |
| 72 | — | — | — | — | — | 9,200 | — | 7 | |
| 73 | — | — | — | — | — | 8,000 | — | 8 | |
| 74 | — | — | — | — | — | 7,100 | — | 8 | |
| 75 | — | — | — | — | — | 8,500 | — | 7 | |
| 76 | — | — | — | — | — | 13,700 | — | 12 | |
| 77 | — | — | — | — | — | 13,800 | — | 12 | |
| 78 | — | — | — | — | — | 10,200 | — | 7 | |
| 79 | — | — | — | — | — | 10,500 | — | 10 | |
| 80 | — | — | — | — | — | 8,600 | — | 7 | |
| 81 | — | — | — | — | — | 10,000 | — | 9 | |
| 82 | — | — | — | — | — | 8,600 | — | 8 | |
| 83 | — | — | — | — | — | 9,800 | — | 9 | |
| 84 | — | — | — | — | — | 10,000 | — | 7 | |
| 85 | — | — | — | — | — | 9,200 | — | 12 | |
| 86 | — | — | — | — | — | 13,000 | — | 13 | |
| 87 | — | — | — | — | — | 8,200 | — | 7 | |
| 88 | — | — | — | — | — | 7,700 | — | 6 | |
| 89 | — | — | — | — | — | 7,900 | — | 4 | |
| 90 | — | — | — | — | — | 10,100 | — | 8 | |
| 91 | — | — | — | — | — | 9,200 | — | 8 | |
| a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | | |
| b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI | | | | | | | | | |
| — indicates measurement not collected at this location | | | | | | | | | |

| Site: Lux Clock Co | Area: First Floor (Basement) | Date(s): 6/28/2017 | Time: 1025 – 1130 |
|---|---|---|---|
| Surveyor(s): JDL / KME | | Purpose: Site Visit | |

| Radiation Type | Instrument | Detector | Background |
|---|---|---|---|
| Alpha-plus-beta | NA | NA | NA |
| Gamma | 2221 No.505, No.395 | 44-10 No.1151, No.639 | 6 - 14 kcpm[a] |
| Gamma | 192 No.1127, No.1129 | NA | 3 - 14 µR/h[a] |

[a]Background varied depending on naturally occurring radioactive material in the area.

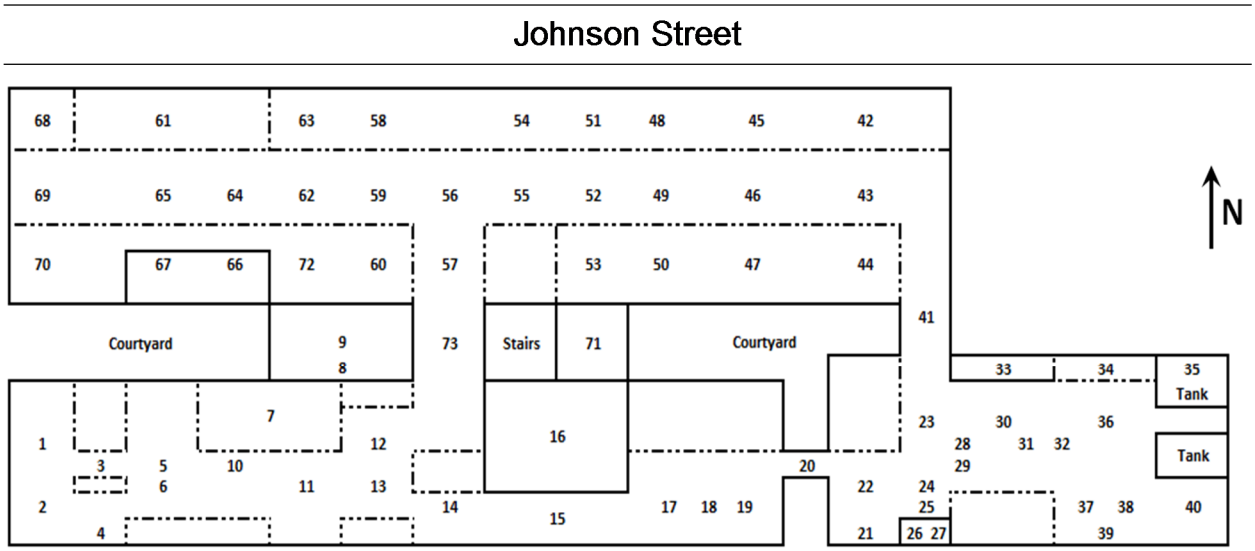



**Figure B-4. Survey Results First Floor (Basement)**

| Table B-4. Lux Clock Company Measurement Results - First Floor | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 1 | — | — | — | — | — | 10,000 | — | 10 | |
| 2 | — | — | — | — | — | 7,500 | — | 8 | |
| 3 | — | — | — | — | — | 12,000 | — | 12 | |
| 4 | — | — | — | — | — | 9,600 | — | 9 | |
| 5 | — | — | — | — | — | 9,700 | — | 9 | |
| 6 | — | — | — | — | — | 10,000 | — | 10 | |
| 7 | — | — | — | — | — | 12,000 | — | 12 | |
| 8 | — | — | — | — | — | 10,000 | — | 10 | |
| 9 | — | — | — | — | — | 10,000 | — | 10 | |
| 10 | — | — | — | — | — | 12,000 | — | 12 | |
| 11 | — | — | — | — | — | 9,100 | — | 9 | |
| 12 | — | — | — | — | — | 10,000 | — | 10 | |
| 13 | — | — | — | — | — | 9,700 | — | 9 | |
| 14 | — | — | — | — | — | 11,000 | — | 11 | |
| 15 | — | — | — | — | — | 13,000 | — | 13 | |
| 16 | — | — | — | — | — | 12,000 | — | 12 | |
| 17 | — | — | — | — | — | 9,700 | — | 10 | |
| 18 | — | — | — | — | — | 10,400 | — | 11 | |
| 19 | — | — | — | — | — | 9,700 | — | 10 | |
| 20 | — | — | — | — | — | 10,500 | — | 10 | |
| 21 | — | — | — | — | — | 10,400 | — | 10 | |
| 22 | — | — | — | — | — | 9,800 | — | 9 | |
| 23 | — | — | — | — | — | 10,300 | — | 10 | |
| 24 | — | — | — | — | — | 10,000 | — | 10 | |
| 25 | — | — | — | — | — | 10,800 | — | 10 | |
| 26 | — | — | — | — | — | 10,800 | — | 6 | |
| 27 | — | — | — | — | — | 10,400 | — | 6 | |
| 28 | — | — | — | — | — | 11,200 | — | 10 | |
| 29 | — | — | — | — | — | 10,600 | — | 9 | |
| 30 | — | — | — | — | — | 10,200 | — | 6 | |
| 31 | — | — | — | — | — | 10,600 | — | 6 | |
| 32 | — | — | — | — | — | 10,600 | — | 10 | |
| 33 | — | — | — | — | — | 12,600 | — | 11 | |
| 34 | — | — | — | — | — | 12,200 | — | 11 | |
| 35 | — | — | — | — | — | 12,300 | — | 11 | |
| 36 | — | — | — | — | — | 10,000 | — | 10 | |
| 37 | — | — | — | — | — | 9,900 | — | 10 | |
| 38 | — | — | — | — | — | 9,200 | — | 9 | |
| 39 | — | — | — | — | — | 9,100 | — | 8 | |
| 40 | — | — | — | — | — | 9,200 | — | 10 | |
| 41 | — | — | — | — | — | 12,900 | — | 13 | |
| 42 | — | — | — | — | — | 8,000 | — | 6 | |
| 43 | — | — | — | — | — | 8,400 | — | 8 | |
| 44 | — | — | — | — | — | 9,200 | — | 9 | |
| 45 | — | — | — | — | — | 8,100 | — | 7 | |
| 46 | — | — | — | — | — | 7,800 | — | 6 | |
| 47 | — | — | — | — | — | 9,200 | — | 7 | |
| 48 | — | — | — | — | — | 8,600 | — | 6 | |
| 49 | — | — | — | — | — | 8,200 | — | 7 | |
| 50 | — | — | — | — | — | 8,400 | — | 7 | |
| 51 | — | — | — | — | — | 9,100 | — | 8 | |
| 52 | — | — | — | — | — | 6,800 | — | 6 | |
| 53 | — | — | — | — | — | 8,600 | — | 7 | |
| 54 | — | — | — | — | — | 7,700 | — | 6 | |
| 55 | — | — | — | — | — | 6,400 | — | 3 | |

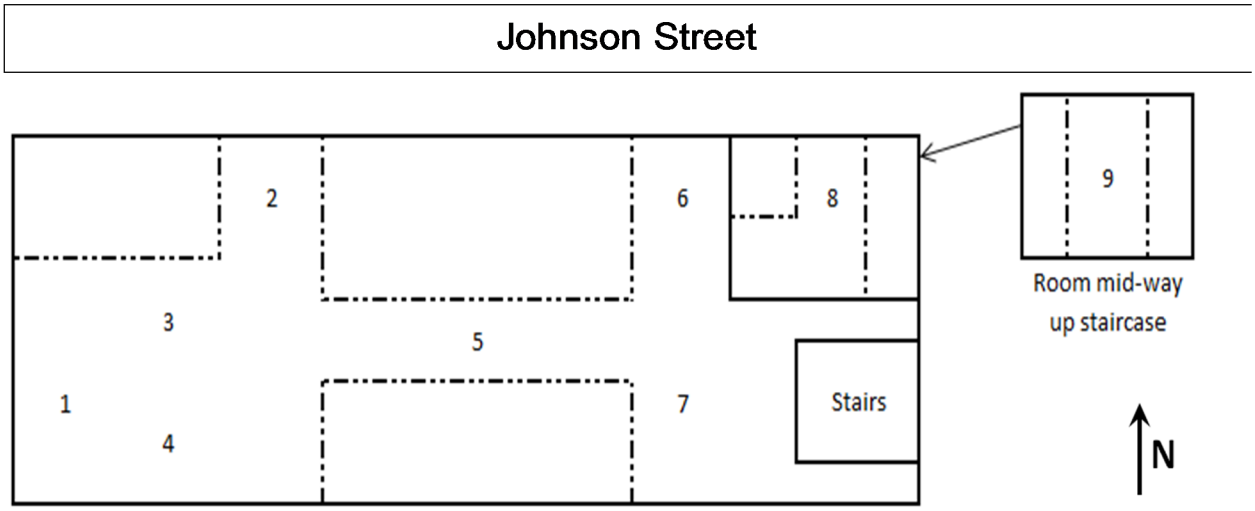
a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter
b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI
— indicates measurement not collected at this location

| Table B-4. Lux Clock Company Measurement Results - First Floor | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 56 | — | — | — | — | — | 8,600 | — | 7 | |
| 57 | — | — | — | — | — | 7,700 | — | 6 | |
| 58 | — | — | — | — | — | 13,500 | — | 14 | |
| 59 | — | — | — | — | — | 8,900 | — | 7 | |
| 60 | — | — | — | — | — | 6,400 | — | 5 | |
| 61 | — | — | — | — | — | 9,700 | — | 7 | |
| 62 | — | — | — | — | — | 8,800 | — | 7 | |
| 63 | — | — | — | — | — | 13,800 | — | 12 | |
| 64 | — | — | — | — | — | 7,700 | — | 7 | |
| 65 | — | — | — | — | — | 8,600 | — | 7 | |
| 66 | — | — | — | — | — | 9,300 | — | 7 | |
| 67 | — | — | — | — | — | 8,700 | — | 8 | |
| 68 | — | — | — | — | — | 10,200 | — | 10 | |
| 69 | — | — | — | — | — | 8,200 | — | 7 | |
| 70 | — | — | — | — | — | 8,200 | — | 6 | |
| 71 | — | — | — | — | — | 13,200 | — | 12 | |
| 72 | — | — | — | — | — | 8,500 | — | 8 | |
| 73 | — | — | — | — | — | 12,000 | — | 12 | |
| a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | | |
| b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI | | | | | | | | | |
| — indicates measurement not collected at this location | | | | | | | | | |

| Site: Lux Clock Co | Area: Sub-Basement | Date(s): 6/28/2017 | Time: 1300 – 1320 |
|---|---|---|---|
| Surveyor(s): JDL / KME | | Purpose: Site Visit | |

| Radiation Type | Instrument | Detector | Background |
|---|---|---|---|
| Alpha-plus-beta | NA | NA | NA |
| Gamma | 2221 No.505 | 44-10 No.1151 | 10 - 15 kcpm[a] |
| Gamma | 192 No.1129 | NA | 10 - 14 µR/h[a] |

[a]Background varied depending on naturally occurring radioactive material in the area.




**- Heavy concentration of stored materials**

**# = General area measurement ranges provided in table**

**Figure B-5. Survey Results Sub-Basement**

| Table B-5. Lux Clock Company Measurement Results - Sub-Basement | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | µR/hr | µR/hr | |
| 1 | — | — | — | — | — | 10,500 | — | 11 | |
| 2 | — | — | — | — | — | 10,900 | — | 11 | |
| 3 | — | — | — | — | — | 11,500 | — | 10 | |
| 4 | — | — | — | — | — | 10,500 | — | 10 | |
| 5 | — | — | — | — | — | 11,500 | — | 11 | |
| 6 | — | — | — | — | — | 12,500 | — | 13 | |
| 7 | — | — | — | — | — | 11,600 | — | 11 | |
| 8 | — | — | — | — | — | 13,000 | — | 14 | |
| 9 | — | — | — | — | — | 14,500 | — | 14 | |
| a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | | |
| b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI | | | | | | | | | |
| — indicates measurement not collected at this location | | | | | | | | | |

| Site: Lux Clock Co | Area: Land Area | Date(s): 6/28/2017 | Time: 1320 – 1415 |
|---|---|---|---|
| Surveyor(s): JDL / KME | | Purpose: Site Visit | |

| Radiation Type | Instrument | Detector | Background |
|---|---|---|---|
| Alpha-plus-beta | NA | NA | NA |
| Gamma | 2221 No.505 | 44-10 No.1151 | 7 - 13 kcpm[a] |
| Gamma | 192 No.1129 | NA | 6 - 12 µR/h[a] |

[a]Background varied depending on naturally occurring radioactive material in the area.

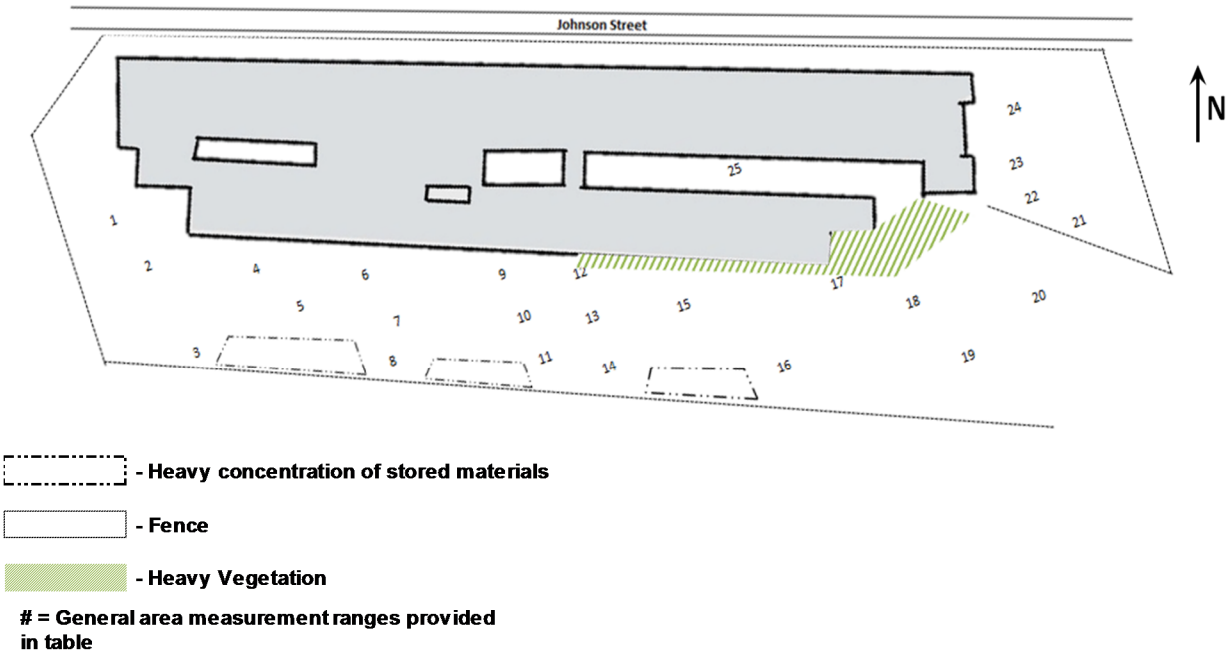
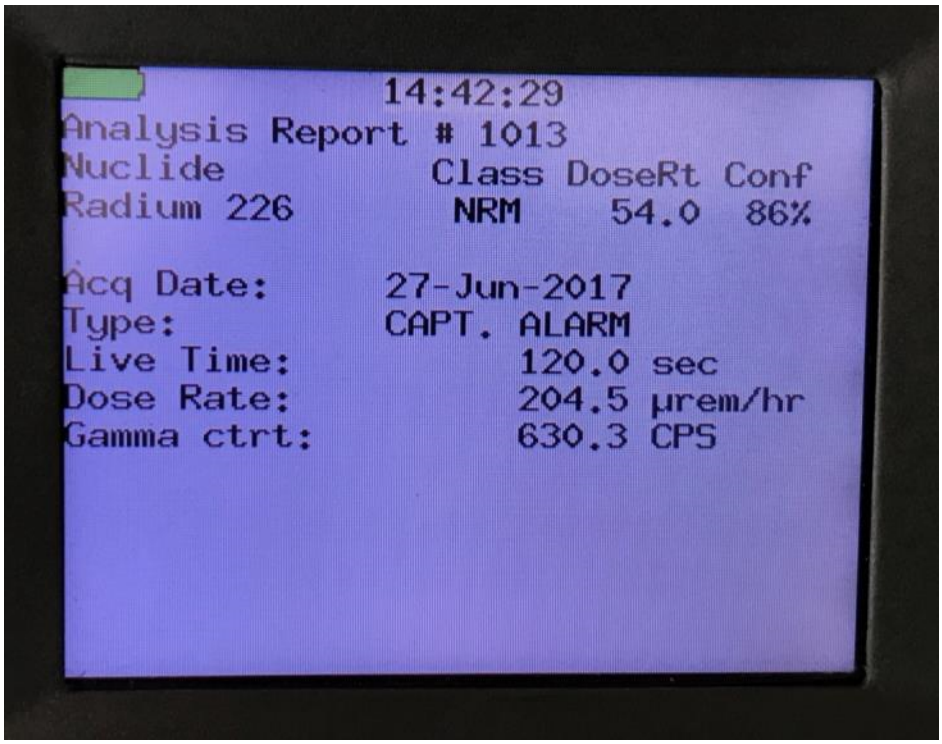
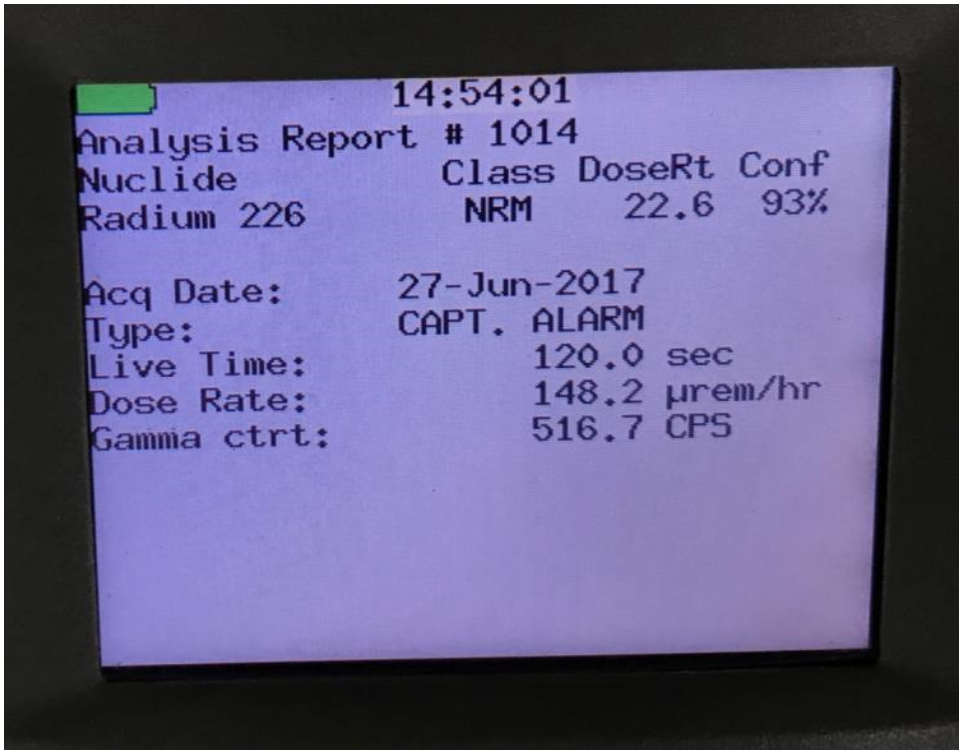



**Figure B-6. Survey Results Land Area**

| Table B-6. Lux Clock Company Measurement Results - Land Area | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location No. | Removable | | | Alpha-plus-Beta[a] | | Gamma[b] | | | Comments |
| | Smear No. | (dpm/100 cm$^2$) | | Gross | Total | Contact | | 1 m | |
| | | Alpha | Beta | cpm | dpm/100 cm$^2$ | cpm | μR/hr | μR/hr | |
| 1 | — | — | — | — | — | 10,500 | — | 11 | |
| 2 | — | — | — | — | — | 10,500 | — | 11 | |
| 3 | — | — | — | — | — | 9,800 | — | 10 | |
| 4 | — | — | — | — | — | 11,500 | — | 12 | |
| 5 | — | — | — | — | — | 12,000 | — | 12 | |
| 6 | — | — | — | — | — | 13,000 | — | 11 | |
| 7 | — | — | — | — | — | 11,000 | — | 10 | |
| 8 | — | — | — | — | — | 10,500 | — | 9 | |
| 9 | — | — | — | — | — | 11,200 | — | 10 | |
| 10 | — | — | — | — | — | 12,000 | — | 10 | |
| 11 | — | — | — | — | — | 10,500 | — | 10 | |
| 12 | — | — | — | — | — | 11,200 | — | 10 | |
| 13 | — | — | — | — | — | 10,200 | — | 9 | |
| 14 | — | — | — | — | — | 10,000 | — | 9 | |
| 15 | — | — | — | — | — | 10,700 | — | 9 | |
| 16 | — | — | — | — | — | 10,500 | — | 9 | |
| 17 | — | — | — | — | — | 9,800 | — | 10 | |
| 18 | — | — | — | — | — | 9,500 | — | 9 | |
| 19 | — | — | — | — | — | 9,500 | — | 8 | |
| 20 | — | — | — | — | — | 9,900 | — | 8 | |
| 21 | — | — | — | — | — | 7,200 | — | 6 | |
| 22 | — | — | — | — | — | 7,800 | — | 7 | |
| 23 | — | — | — | — | — | 10,100 | — | 10 | |
| 24 | — | — | — | — | — | 9,400 | — | 8 | |
| 25 | — | — | — | — | — | 13,000 | — | 11 | |
| a) Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter | | | | | | | | | |
| b) Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI | | | | | | | | | |
| — indicates measurement not collected at this location | | | | | | | | | |




**B-7. SAM-940 Gamma Spectroscopy Analysis Report for 5307R0001**




**B-8. SAM-940 Gamma Spectroscopy Analysis Report for 5307R0002**

**APPENDIX C**
**DOSE ASSESSMENT FOR THE FORMER LUX CLOCK COMPANY SITE VISIT**

| Table C-1. Estimated Industrial Dose from the External Pathway Only | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Measured μr/hr at 1 m | | | | Gamma-only Dose (mrem/yr) | | Locations used in max area calcultions[a] |
| | Survey Unit Avg | | Max Area Avg | | | | |
| Area Description | All Data | Bkg | All Data | Bkg | Survey Unit | Max Area | |
| Outdoor Land Area | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Sub-Basement | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| First Floors (Basement) | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Second Floor | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Third Floor | 7.2 | 7.1 | 6.3 | 4.5 | 0.1 | 4.1 | Locations 1-13; max at 7 |
| Fourth Floor | 6.3 | 6.3 | 5.5 | 5.4 | <0.1 | 0.2 | Locations 28 - 49; max at 38 |

Survey Unit Avg = the average value considering all data collected in the survey unit (floor of building or outdoor area)
Max Area Avg = the average value for the area around the highest measured radioactivity
All Date = results from across the entire apartment or room, as applicable
Bkg = all results excluding results from hot spots

[a]See Appendix B for gross measurement data by location.

| Table C-2. Estimated Industrial Dose from the Internal Pathways Only | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Measured dpm/100 $cm^2$ | | | | Internal Dose (mrem/yr) | | Locations used in max area calcultions[a] |
| | Survey Unit Avg | | Max Area Avg | | | | |
| Area Description | All Data | Bkg | All Data | Bkg | Survey Unit | Max Area | |
| Outdoor Land Area | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Sub-Basement | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| First Floors (Basement) | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Second Floor | N/A | N/A | N/A | N/A | N/A | N/A | No data available |
| Third Floor | 76 | 0 | 500 | 0 | <0.1 | <0.1 | Locations 1-13; max at 2[b] |
| Fourth Floor | N/A | N/A | N/A | N/A | N/A | N/A | No data available |

Survey Unit Avg = the average value considering all data collected in the survey unit (floor of building or outdoor area)
Max Area Avg = the average value for the area around the highest measured radioactivity
All Date = results from across the entire apartment or room, as applicable
Bkg = all results excluding results from hot spots

[a]See Appendix B for gross measurement data by location.

[b]Measured removable fraction < 1 percent though the model assumes 10 percent

| Table C-3. Total Estimated Industrial Dose All Pathways | | | | |
|---|---|---|---|---|
| | Current Dose[a] (mrem/yr) | | Future Dose[b] (mrem/yr) | |
| Area Description | Survey Unit | Max Area | Survey Unit | Max Area |
| Outdoor Land Area | N/A | N/A | N/A | N/A |
| Sub-Basement | N/A | N/A | N/A | N/A |
| First Floors (Basement) | N/A | N/A | N/A | N/A |
| Second Floor | N/A | N/A | N/A | N/A |
| Third Floor | 0.1 | 4.1 | 0.2 | 4.2 |
| Fourth Floor | <0.1 | 0.2 | <0.1 | 0.2 |

[a]Current dose is due to the external pathway only (values from Table C-1)

[b]Future dose is comprised of all pathways and is a summation of the values from Tables C-1 and C-2

| Table C-4. Estimated Residential Dose from the External Pathway Only | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Measured µr/hr at 1 m | | | | Gamma-only Dose (mrem/yr) | | Locations used in max area calcultions[a] |
| | Survey Unit Avg | | Max Area Avg | | | | |
| Area Description | All Data | Bkg | All Data | Bkg | Survey Unit | Max Area | |
| Outdoor Land Area | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Sub-Basement | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| First Floors (Basement) | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Second Floor | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Third Floor | 7.2 | 7.1 | 6.3 | 4.5 | 0.4 | 10.1 | Locations 1-13; max at 7 |
| Fourth Floor | 6.3 | 6.3 | 5.5 | 5.4 | 0.1 | 0.4 | Locations 28 - 49; max at 38 |

Survey Unit Avg = the average value considering all data collected in the survey unit (floor of building or outdoor area)

Max Area Avg = the average value for the area around the highest measured radioactivity

All Date = results from across the entire apartment or room, as applicable

Bkg = all results excluding results from hot spots

[a]See Appendix B for gross measurement data by location.

| Table C-5. Estimated Residential Dose from the Internal Pathways Only | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Measured dpm/100 cm$^2$ | | | | Internal Dose (mrem/yr) | | Locations used in max area calcultions[a] |
| | Survey Unit Avg | | Max Area Avg | | | | |
| Area Description | All Data | Bkg | All Data | Bkg | Survey Unit | Max Area | |
| Outdoor Land Area | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Sub-Basement | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| First Floors (Basement) | N/A | N/A | N/A | N/A | N/A | N/A | No elevated activity identified |
| Second Floor | N/A | N/A | N/A | N/A | N/A | N/A | No data available |
| Third Floor | 76 | 0 | 500 | 0 | 0.0 | 0.2 | Locations 1-13; max at 2[b] |
| Fourth Floor | N/A | N/A | N/A | N/A | N/A | N/A | No data available |

Survey Unit Avg = the average value considering all data collected in the survey unit (floor of building or outdoor area)
Max Area Avg = the average value for the area around the highest measured radioactivity
All Date = results from across the entire apartment or room, as applicable
Bkg = all results excluding results from hot spots

[a]See Appendix B for gross measurement data by location.

[b]Measured removable fraction < 1 percent though the model assumes 10 percent

| Table C-6. Total Estimated Residential Dose All Pathways | | | | |
|---|---|---|---|---|
| | Current Dose[a] (mrem/yr) | | Future Dose[b] (mrem/yr) | |
| Area Description | Survey Unit | Max Area | Survey Unit | Max Area |
| Outdoor Land Area | N/A | N/A | N/A | N/A |
| Sub-Basement | N/A | N/A | N/A | N/A |
| First Floors (Basement) | N/A | N/A | N/A | N/A |
| Second Floor | N/A | N/A | N/A | N/A |
| Third Floor | 0.4 | 10.1 | 0.4 | 10.3 |
| Fourth Floor | 0.1 | 0.4 | 0.1 | 0.4 |

[a]Current dose is due to the external pathway only (values from Table C-4)

[b]Future dose is comprised of all pathways and is a summation of the values from Tables C-4 and C-5