

Enclosure

**OAK RIDGE ASSOCIATED UNIVERSITIES:
SITE STATUS REPORT FOR THE DeLORENZO TOWERS
(FORMERLY INGRAHAM CLOCK COMPANY) AT
284 NORTH MAIN STREET, BRISTOL, CONNECTICUT**

November 9, 2018

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) requested that the Oak Ridge Associated Universities (ORAU) perform a scoping survey of the property at 284 North Main Street in Bristol, Connecticut as a follow up to the initial site visit performed on November 17, 2016. This property covers part of the footprint once occupied by the former Ingraham Clock Company, which used radium paint in the manufacturing of clocks and watches into the late 1950s. The original factory was torn down, and the land has been redeveloped. The area of interest for this scoping survey is the undeveloped embankment located on the eastern edge of the property. The November 2016, initial site visit identified one piece of slag-like material with elevated levels of radium. This was located on the undeveloped embankment that was not fully investigated during the initial site visit due to time and accessibility constraints. The objective of this second investigation was to thoroughly scan this area to determine if additional discrete sources of radium are present and if these sources could result in a dose above regulatory limits.

ORAU performed the scoping survey on November 14, 2017, and identified additional discrete sources of radium (slag-like material) in a 6-meter by 1-meter section of the embankment. Laboratory analysis, of materials collected during both the initial site visit and this scoping survey, determined that the slag-like material contains elevated concentrations of radium up to 290 pCi/g. In addition, several areas with elevated radiation levels were identified suggesting that more radium-containing materials may be present just below the soil surface. The area identified lies on a steep, overgrown embankment that leads to active railroad tracks at the top. It is unlikely any further development or significant occupancy of the area will occur for that reason. Based on the known conditions of the site, and analyses of reasonably foreseeable current and future land uses, expected site conditions make it unlikely that an average member of the critical group will receive a dose in excess of 100 mrem/yr under current conditions or exceed the NRC's dose criterion of 25 mrem/yr from unrestricted use in the future. Therefore, it is recommended that the NRC not pursue additional action at the 284 North Main Street property.

SITE STATUS REPORT

Property: Ingraham Clock Company-1
284 North Main Street
Bristol, CT 06010

Docket Number: 03038977

Current Property Name: DeLorenzo Towers

Current Property Owner: NCSC-UAW Region 9A Sch Dev Corp

Inspection Dates: November 14, 2017

Inspector: Orysia Masnyk Bailey/U.S. Nuclear Regulatory Commission (NRC), supported by Adam Kirthlink and Kaitlin Engel/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. As part of the NRC's program to identify radium sites, the NRC is evaluating properties where the former Ingraham Clock Factory was known to operate. An initial site visit was conducted on the 284 North Main Street property in November 2016, and a piece of slag-like material was found on the eastern embankment with Ra-226 concentrations of approximately 290 pCi/g. The area where the material was found was not thoroughly investigated due to time and access constraints, so a follow-up scoping survey was performed at the NRC's request. The objectives of the scoping survey were to determine if additional discrete sources of Ra-226 are present and, if so, evaluate whether these sources could result in a dose above regulatory limits.

Data from the November 14, 2017 scoping survey, which included gamma radiation scans, exposure rate measurements, and volumetric sampling, will be used to plan future actions and minimize, as appropriate, Ra-226 exposure to current and future site occupants. It is important to note that destructive testing is not generally performed, as described within the NRC's procedures, Temporary Instruction 2800/043 "Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources" (NRC 2017).

2.0 PROPERTY DESCRIPTION AND CONCEPTUAL MODEL

The site summary included in the Oak Ridge National Laboratory (ORNL) report, *Historical Non-Military Radium Sites Research Effort Addendum* (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. The information provided in the ORNL report is supplemented by the Agency for Toxic Substances and Disease Registry (ATSDR) report (ATSDR 1999) that addresses radium dial clock companies located in the state of Connecticut. The former Ingraham Clock Company was founded in 1884 and occupied several buildings on North Main Street in Bristol, Connecticut. In 1904, as a result of increased sales due to improvements in

manufacturing and machinery, Ingraham replaced the original wooden buildings with brick buildings. Clocks and watches with luminous radium paint were manufactured in these buildings until production ceased in 1942 due to World War II. Production resumed in 1946. In 1958, the company moved from North Main Street to Bristol's Redstone Hill Industrial Park at 210 Redstone Hill Road (ORNL 2015). A March 1921 street map of Bristol shows that 284 North Main Street lies on the southern portion of the former Ingraham Clock Company footprint (Sanborn Map Company 1921). The map of the former clock company is based on "Office Plans" and indicates that forges and soldering iron furnaces would be present, presumably for metalwork related to clock manufacturing.

During the 1960s, the abandoned buildings at the North Main Street location were torn down as part of a redevelopment project. Extensive testing took place at the site prior to 1980. The exact dates of testing, the types of tests performed, and the results are not known. Therefore, it is unknown if soil at the North Main Street location of the former Ingraham Clock Company was tested for radium (ORNL 2015). Test wells were drilled as part of this effort and still exist. Redevelopment activities included the removal of soil from the site for use as cover material at a Bristol landfill, a river running through the site was piped underground, and backfill was brought in to level the property for redevelopment. As part of the redevelopment, residential and commercial properties were constructed in the 1980s and early 1990s at the North Main Street locations.

During a November 2016, site visit, inspectors performed a cursory survey of the site, including the undeveloped embankment which lies along the eastern edge of the property. Though access was limited due to steep slopes and thick undergrowth, inspectors identified a piece of slag-like material that produced gamma radiation well above ambient background levels (ORAU 2017a). The material was collected and submitted for analysis at an analytical laboratory. Ra-226 was reported at approximately 290 pCi/g, with the noted absence of other possible contaminants. The NRC determined that the item is a discrete source of Ra-226, possibly from the forging and soldering operations at the former clock company (ORAU 2017a). However, it was unclear whether the material was simply an isolated instance or whether there may be a larger concern present. As a result, the area of interest for this scoping survey is the undeveloped eastern embankment.

The scoping survey continues the same type of surveys as were performed during the initial site visit but more thoroughly considers the eastern embankment of the property. As shown in Figure 1, the specific area of interest is the undeveloped embankment located on the eastern edge of the property. The area is characterized by steep slopes and heavy undergrowth. The survey design includes scanning safely accessible portions of the hillside for gamma radiation emanating from Ra-226-containing materials, documenting the location and magnitude of contamination, and sampling potential discrete sources of Ra-226.

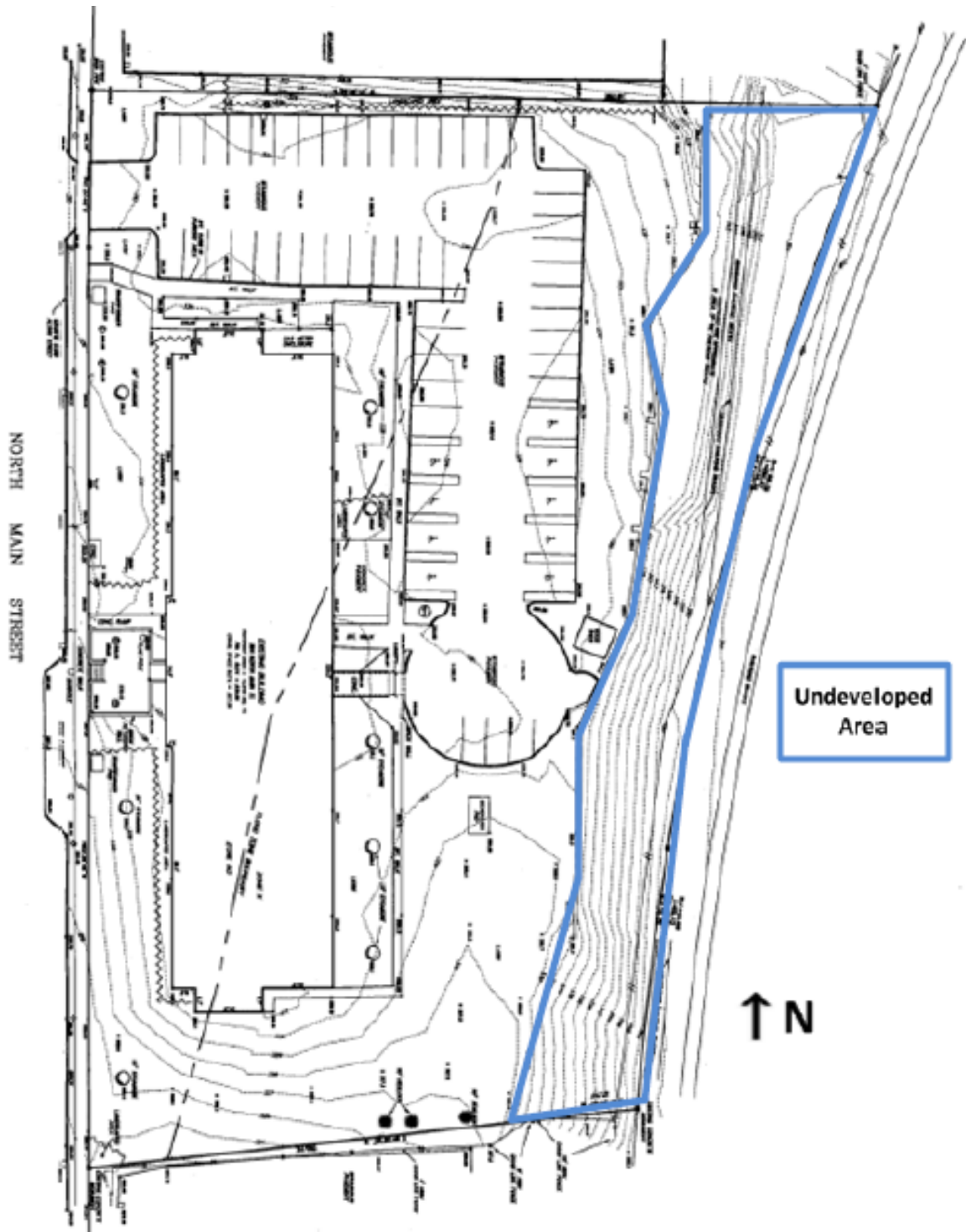


Figure 1. Undeveloped Embankment on the 284 North Main Street Property

3.0 SITE OBSERVATIONS AND FINDINGS

3.1 Summary of Activities

The inspection team conducted a scoping survey of the eastern embankment at the 284 North Main Street property on November 14, 2017. Inspectors met with the site contact prior to beginning the survey.

Radiological surveys consisted of gamma radiation scans using a Ludlum model 44-10 2-inch by 2-inch (2×2) sodium iodide detector connected to a Ludlum model 2221 ratemeter/scaler and exposure rate measurements using a Ludlum model 192 sodium iodide-based μR ratemeter¹. The 2×2 sodium iodide detector gamma radiation measurements were collected near the ground surface and the exposure rate readings were collected at approximately 1 meter (3 feet) above the ground surface. As a rule-of-thumb, the 2×2 sodium iodide detector can respond to gamma-emitting radionuclides located in the top 15 to 30 centimeters of soil.

A SAM-940 spectrum analyzer was also available in case elevated gamma radiation levels were identified. Table 1 presents the specific instruments used during the site visit.

Radiation Type (units)	Detector Type	Detector (Number)	Ratemeter (Number)
Gross gamma (cpm)	Sodium Iodide	44-10 (1151) Calibrated 11/03/17	2221 (1140) Calibrated 11/03/17
Gross gamma ($\mu\text{R}/\text{h}$)	Gamma Exposure Ratemeter	192 (1129) Calibrated 06/02/17	N/A
Gamma Spectrum Analyzer (SAM-940)	Lanthanum Bromide	940 (40272) Daily check source response	N/A

N/A = not applicable; ratemeter is not required.
cpm = counts per minute
 $\mu\text{R}/\text{h}$ = micro roentgen per hour

Heavy vegetative undergrowth, branches, and steep inclines with loose soil prevented surveyors from accessing the entire area—approximately 70 percent of the embankment was surveyed. An approximately 6-meter by 1-meter area with several small areas of elevated radiation was identified. This area is located near the building's centerline, approximately 9 meters west of the (apparently) active railroad tracks and in the same general area identified during the initial site visit (ORAU 2017a). When identified, slag-like materials were found in shallow soils anywhere from 0.1 to 0.5 meters below the ground surface. Two samples were collected for laboratory analysis.

¹Roentgen 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).

3.2 Summary of Results

Appendix A presents photos from the scoping survey. Figures A-1 through A-10 present the eastern embankment from various angles. Figure A-11 shows what appear to be old chain-link fence posts located approximately 1 meter north of the current southern, physical boundary, suggesting the current property boundary is different from the historical property boundary. Figures A-12 through A-15 depict the inspectors performing surveys and the heavy undergrowth and steep slope of the area. Figure A-16 shows a rock with elevated radiation levels (up to 18,000 cpm) that is due to naturally occurring radioactive material (NORM) and is not associated with former Ra-226-related operations. Figures A-17 and A-18 show the approximate location in relation to the building where the slag-like materials were found during the initial site visit and the scoping survey. Figure A-19 shows the location of small areas of elevated radiation marked by blue flags. Note that not all identified pieces of slag-like material produced elevated radiation levels.

Appendix B presents survey data collected during the scoping survey. Figure B-1 outlines the eastern embankment targeted during the scoping survey (blue lines), and the area with elevated radiation levels (green lines). Figure B-2 provides a summary of the survey data with the area with elevated radiation levels outlined in green. Due to the large number of data points collected, the results have been summarized into ranges of 2×2 sodium iodide and exposure ratemeter responses. Table B-1 provides the tabularized survey data (excluding the elevated radiation levels).

In general, the 2×2 sodium iodide detector background responses ranged from approximately 5,000 to 13,500 cpm. A rock in a wall was found to have 18,000 cpm and is due to NORM (Figure A-16), so the associated cpm result is not considered to be part of the ambient background distribution. The gamma exposure ratemeter background responses ranged from approximately 5 to 12 µR/h. Table B-2 presents summary statistics of the background survey data collected during the initial site visit (excluding the elevated radiation levels). For the 2×2 sodium iodide detector measurements, the mean is close to the median and 99+ percent of the data points fall within three standard deviations of the mean. The one anomaly is the above mentioned NORM rock. Likewise, exposure rate measurement data demonstrated similar statistical characteristics with 100 percent of the data points falling within three standard deviations with no anomalies. In the approximately 6-meter by 1-meter section with small areas of elevated radiation, the 2×2 sodium iodide detector responses ranged from 15,000 to 53,000 cpm on the surface. After some of the slag-like material was uncovered and samples were collected, the detector responses increased up to 280,000 cpm, 44 µR/h at 1 meter. This indicates that additional contaminated materials are likely present below the ground surface, which shielded radiation emanating from the slag-like material in its original configuration. The samples collected exhibited a maximum exposure rate of 34 µR/h,² on contact. Table B-3 provides a summary of the samples collected for analysis, and Figures B-3 and B-4 provide the SAM-940 output for the two samples submitted for analysis.

The analytical laboratory reported a Ra-226 concentration of up to 140 pCi/g from the two scoping survey samples (see Appendix C). The Ra-226 concentration in the sample obtained during the initial site visit was 290 pCi/g. Other gamma-emitting constituents were not identified

² As indicated in figures B-3 and B-4 the SAM-940 reported exposure rates of almost 150 µrem/h for each of the sample collection locations on contact with the slag-like material. The SAM-940 measurements were performed prior to the collection of the samples and the higher exposure rate is attributed to additional buried sources in the locality.

in elevated concentrations, thus the data demonstrate that the slag-like materials are process-related and are discrete sources of Ra-226. Though the specific origin of the slag-like material remains unknown, the physical characteristics suggest that these discrete sources of Ra-226 resulted from the forging or soldering operations at the former Ingraham Clock Company.

3.3 Summary of Dose Assessment Results

During the initial site visit and scoping survey, three samples of slag-like material were collected from the eastern embankment surface soil (defined here as 0 to 30 cm) in a 6-meter by 1-meter (6-m²) area. Occupancy in the area is currently limited, if not precluded, due to the steep slope and heavy vegetative undergrowth, and there is no obvious reason to believe these conditions will change in the foreseeable future, primarily due to the presence of nearby railroad tracks. Therefore, it is concluded that a radiological exposure above the 100 mrem/yr public dose limit for current receptors (i.e., members of the public) is unlikely even though localized exposure rates of almost 0.15 mrem/h (on sample contact) were recorded. At these exposure rates, it would take more than 500 hours of exposure at the location of highest recorded exposure rate to approach the 100 mrem/yr public exposure limit. The inspection team considers this to be unrealistic given the current condition and utilization of the site.

The “*Dose Assessment Technical Basis Document for Potential Exposures to Discrete Sources of Radium-226 and Associated Contamination*” (ORAU 2017b) presents a conservative 42 pCi/g not-to-exceed concentration for soil or soil-like material. The conceptual model used to derive the 42-pCi/g value is based on a dose of 25 mrem/yr to a subsistence farmer, which includes contaminated meat and produce consumption and the use of contaminated water resources. The Technical Basis Document describes methods for refining dose calculation when, as is the case here, certain pathways are unrealistic. The agricultural, drinking water, surface water, and irrigation pathways are assumed to be incomplete for small pieces of slag-like material. This leaves external gamma, inhalation, and secondary ingestion as potentially completed pathways that could reasonably lead to a receptor dose. Similarly, it is unrealistic to assume that an individual would spend significant time within the identified 6-m² area, on the steep embankment whether or not heavy undergrowth is present. It is conceivable, however, that a recreational walker may pass through the area. Considering a contaminated 6-m² area, a radium concentration of 290 pCi/g, and modifications to default parameters related to the time spent in the area and the possible ingestion and inhalation of radium, RESRAD, Version 6.5, was used to calculate a dose of 2.1 mrem/yr to a recreational walker. Additional scenarios that could involve longer exposure times to the material, such as a rock collector who relocates a piece of the material to a residential dwelling, were also found to result in doses less than 25 mrem/yr (the NRC unrestricted use criterion in Title 10 of the *Code of Federal Regulations* [10 CFR] Section 20.1402, *Radiological criteria for unrestricted use*). Therefore, concentrations in samples collected to date support the conclusion that exposure to Ra-226 on the eastern embankment of the 284 North Main Street will not produce a dose of 100 mrem/yr to a current receptor or 25 mrem/yr to a reasonably conceivable future receptor. While it is possible materials are present above the not-to-exceed value, such were not identified during either the initial site visit or scoping survey. Higher Ra-226 concentrations may be present in areas that are currently inaccessible or in deeper soils. Given the proximity of identified discrete sources of Ra-226 to the railroad tracks, railroad companies would likely be stakeholders if intrusive characterization or remediation is required.

4.0 OBSERVATIONS AND RECOMMENDATIONS

Based on the data collected during the initial site visit and scoping survey, the eastern embankment at 284 North Main Street, occupying a portion of the former Ingraham Clock Company property, was found to contain discrete sources of Ra-226. Laboratory measurements of samples collected on the site identified radium concentrations up to 290 pCi/g in slag-like material. Measurements of other gamma-emitting radionuclides were reported at concentrations consistent with background—therefore the slag-like materials are considered discrete sources of Ra-226. Other observations indicative of possible radium contamination include:

- Gamma radiation levels across the property's eastern embankment are consistent with background with the exception of an approximately 6-meter by 1-meter area which contained several small areas of elevated radiation.
- The elevated radiation levels appear to be due to slag-like pieces of material found on the site, which may be associated with forging and soldering operations at the former clock company.
- After samples of the slag-like material were collected (i.e., removed), radiation detector responses up to 280,000 cpm and 44 μ R/h at 1 meter (gross) were measured, suggesting that additional or more concentrated sources of Ra-226 may be present below the surface.

Despite the presence of discrete sources of Ra-226 and elevated exposure rates in a localized area of the eastern embankment, the NRC does not currently consider it realistic that an individual would receive an exposure approaching the public dose limit given the localized site conditions. Due to site conditions, surveyors evaluating the area could not access all areas or evaluate subsurface materials and therefore could not make a definitive conclusion that the entire area meets the unrestricted use requirements. Regardless, the site area is generally uninhabitable, which limits exposure as discussed above, and is unlikely to be further developed due to the nearby railroad tracks. Based on consideration of reasonably foreseeable future uses, site conditions make it unlikely that an average member of the critical group will receive a dose in excess of the NRC's dose criterion of 25 mrem/yr for unrestricted use as detailed in 10 CFR 20.1402. Therefore, it is recommended that the NRC not pursue additional action at the 284 North Main Street property.

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*. U.S. Department of Health and Human Services. January 29. (Agencywide Documents Access and Management System [ADAMS] Accession No. ML17038A052).

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).

ORAU 2017a. *Site Status Report for Former Ingraham Clock Company Property at 284 North Main Street in Bristol, Connecticut*. DCN 5307-SR-20-1, Oak Ridge Associated Universities, September 11. (ADAMS Accession No. ML17034A506).

ORAU 2017b. *Dose Assessment Technical Basis Document for Potential Exposures to Discrete Sources of Radium-226 and Associated Contamination*. Oak Ridge Associated Universities, Oak Ridge, Tennessee, May 30. (ADAMS Accession No. ML17072A414).

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*. Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488).

Sanborn Map Company 1921. "Mar. 1921 Bristol Conn." Stack 766, B77, Sheets 12 and 13.

APPENDIX A
PHOTOS FROM THE INGRAHAM-1 SCOPING SURVEY



**Figure A-1. Eastern Embankment
West Side North End**



**Figure A-2. Eastern Embankment
East Side North End**



Figure A-3. Eastern Embankment East Side North End



Figure A-4. Abandoned Railroad (left) in Eastern Embankment



**Figure A-5. Eastern Embankment
East Side South End**



**Figure. A-6. Eastern Embankment
South End Looking Up (East)**



Figure A-7. Eastern Embankment West Side South End



Figure A-8. Eastern Embankment West Side Midway



Figure A-9. Eastern Embankment Under Abandoned Railroad



Figure A-10. Eastern Embankment Under Abandoned Railroad



Figure A-11. Eastern Embankment South End



Figure A-12. Inspectors Performing Survey



Figure 13. Inspectors Performing Survey



Figure A-14. Example of Heavy Undergrowth



Figure A-15. Example of Heavy Undergrowth



**Figure A-16. Rock with Elevated Radiation Levels
(due to NORM)**



Figure A-17. Location of Slag-Like Material in Reference to the Building Found During the Initial Site Visit in November 2016



Figure A-18. Location of Elevated Area in Reference to the Building Found During the Scoping Survey in November 2017



Figure A-19. Location of Elevated Areas (note blue flags)



Figure A-20. Slag-Like Material (Sample 5307M0001)

APPENDIX B
SURVEY DATA FROM THE INGRAHAM-1 SCOPING SURVEY



Figure B-1. Map of Eastern Embankment and Elevated Radiation Area

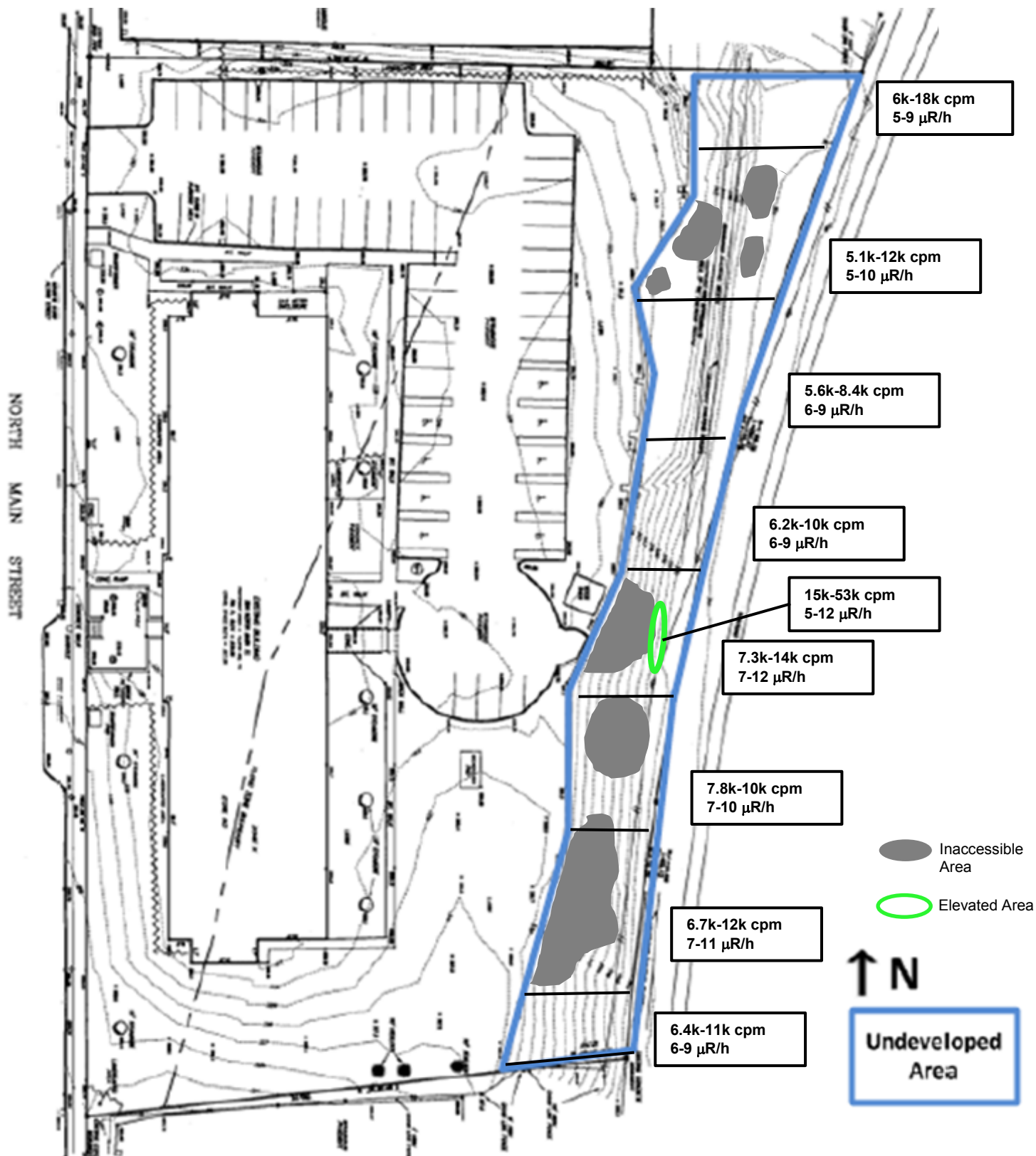


Figure B-2. Summary of Survey Data

Table B-1. Ingraham-1 Scoping Survey Results^a

Nal (cpm)	Exposure Rate (μR/h at 1 m)		Nal (cpm)	Exposure Rate (μR/h at 1 m)		Nal (cpm)	Exposure Rate (μR/h at 1 m)
8,500	6		6,800	7		7,600	8
6,700	7		5,800	6		10,000	9
8,500	7		7,300	7		9,300	9
9,600	8.5		6,000	5		7,300	8
11,000	10		7,100	7		9,100	8
8,600	8		6,800	7		7,500	8
11,000	10		8,900	8		8,500	9
18,000 ^b	8		8,400	7		11,000	10
7,500	7		5,600	6		12,000	12
13,000	9		6,600	6		12,000	9
6,000	5		5,800	6		8,500	8
8,500	7		7,900	7		8,500	7
7,000	7		6,700	5		9,300	9
7,200	7		6,900	6		14,000	10
9,400	9		6,000	6		10,000	9
9,300	10		7,900	7		11,000	12
8,500	8		7,700	6		10,000	10
8,000	7		9,200	8		9,400	8
7,500	7		7,200	6		7,800	7
6,800	6		6,800	6		8,400	8
9,100	9		7,600	7		8,100	9
9,200	8		7,600	7		9,400	10
8,000	7		5,700	6		10,000	9
6,600	6		7,300	6		9,800	9
5,800	6.5		8,200	9		10,000	10
12,000	10		7,400	7		9,500	8
8,100	8		7,100	7		11,000	10
7,400	7		7,900	7		7,400	8
6,100	5		6,700	6		8,800	7
6,100	6.5		6,200	6		12,000	11
6,800	6		6,400	5		6,700	8
9,500	9		7,000	6		12,000	8
8,000	8		6,600	5		10,000	10
8,500	9		6,200	6		9,400	8
9,100	7		5,800	6		9,500	9
7,900	8		6,500	6		9,800	9
6,500	6		6,200	5		11,000	9
7,200	7		6,500	5		8,900	9
9,100	9		6,800	7		8,500	7
8,100	7		6,500	6		8,200	8
5,600	5		6,200	6		8,700	9
7,500	8		6,600	6		8,300	7
5,100	5		8,000	7		8,900	8
7,400	7		10,000	9		7,800	8
6,500	6		7,400	7		7,400	7
7,300	8		9,600	8		6,400	6

^a Excluding the elevated radiation levels.

^b Rock in wall. Appears to be NORM. See Figure A-16.

Nal = sodium iodide

Measurement	Minimum Value	Maximum Value	Mean	Median	St. Deviation	Number of Measurements
Nal (cpm)	5,100	18,000	8,198	7,900	1,850	138
Exposure Rate (μ R/h at 1 m)	5.0	12	7.5	7.0	1.5	138

Nal = Sodium Iodide

Sample ID	Location (m)		Nal (cpm)	Exposure Rate (μ R/h)		Picture Figure
	Easting	Northing	Contact	Contact	1 m	
5307M0001	288457.3	246262.3	43,000	34	10	A-20
5307M0002	288457.5	246265.3	20,000	27	8.5	N/A

Nal = Sodium Iodide

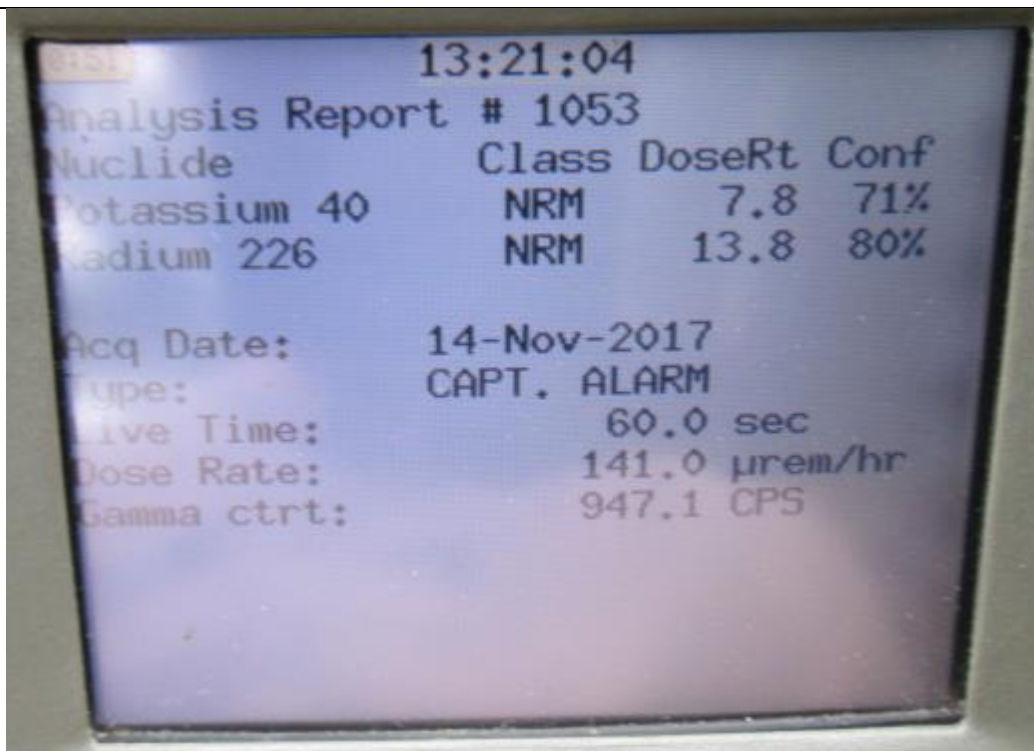


Figure B-3. SAM Report for Sample 5307M0001

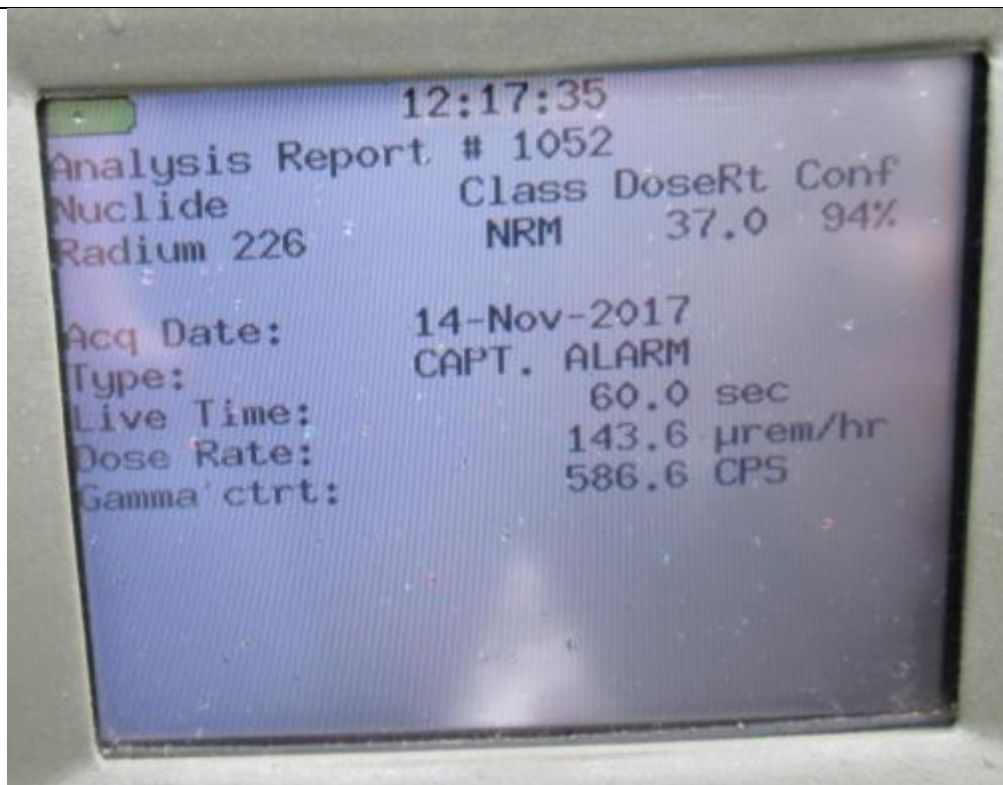


Figure B-4. SAM Report for Sample 5307M0002

APPENDIX C
ANALYTICAL RESULTS FOR THE INGRAHAM-1 SCOPING SURVEY

Client Sample Results

Client: Oak Ridge Associated Universities
Project/Site: Radium Program

TestAmerica Job ID: 160-25626-2
SDG: No In-growth

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

Client Sample ID: 5307M0001

Date Collected: 11/14/17 12:45
Date Received: 11/16/17 09:25

Lab Sample ID: 160-25626-1

Matrix: Solid

Method: 901.1 - Radium-226 & Other Gamma Emitters (GS)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Actinium-227	0.992	U	2.69	2.69		4.43	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Actinium-228	1.70		0.819	0.837		0.845	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Bismuth-212	2.29		1.91	1.92		2.27	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Bismuth-214	118		1.19	12.4		0.543	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Cesium-137	0.000	U	0.0744	0.0744		0.445	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Lead-210	48.7		4.24	7.12		4.79	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Lead-212	1.05		0.256	0.290		0.411	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Lead-214	126		1.02	13.1		0.669	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Potassium-40	8.19		3.03	3.14		2.79	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Protactinium-231	-3.23	U	15.7	15.7		25.9	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Radium-226	141		6.82	25.6	5.00	6.72	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Radium-228	1.70		0.819	0.837		0.845	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Thallium-208	-0.0129	U	0.230	0.230		0.291	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Thorium-232	1.70		0.819	0.837		0.845	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Thorium-234	4.19	U	4.64	4.66		7.64	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Uranium-235	-0.315	U	1.04	1.04		3.45	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Uranium-238	4.19	U	4.64	4.66		7.64	pCi/g	11/17/17 14:47	11/17/17 15:24	1
Other Detected Radionuclides			Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Other Detected			None				pCi/g	11/17/17 14:47	11/17/17 15:24	1
Radionuclide										

Client Sample ID: 5307M0002

Date Collected: 11/14/17 13:00
Date Received: 11/16/17 09:25

Lab Sample ID: 160-25626-2

Matrix: Solid

Method: 901.1 - Radium-226 & Other Gamma Emitters (GS)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Actinium-227	0.340	U	0.855	0.856		1.41	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Actinium-228	0.797		0.303	0.314		0.375	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Bismuth-212	-0.758	U	1.27	1.27		2.10	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Bismuth-214	49.9		0.509	5.21		0.231	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Cesium-137	-0.000503	U	0.0394	0.0394		0.189	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Lead-210	16.3		1.45	2.40		1.76	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Lead-212	0.678		0.104	0.136		0.162	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Lead-214	53.5		0.462	5.58		0.243	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Potassium-40	7.22		1.52	1.69		1.27	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Protactinium-231	1.41	U	4.99	5.00		10.9	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Radium-226	60.6		2.88	11.0	5.00	2.97	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Radium-228	0.797		0.303	0.314		0.375	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Thallium-208	0.168		0.0595	0.0620		0.0944	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Thorium-232	0.797		0.303	0.314		0.375	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Thorium-234	0.742	U	0.575	0.580		3.57	pCi/g	11/17/17 13:39	11/17/17 15:25	1
Uranium-235	-0.283	U	0.338	0.339		1.11	pCi/g	11/17/17 13:39	11/17/17 15:25	1

TestAmerica St. Louis

Client Sample Results

Client: Oak Ridge Associated Universities
 Project/Site: Radium Program

TestAmerica Job ID: 160-25626-2
 SDG: No In-growth

Client Sample ID: 5307M0002

Lab Sample ID: 160-25626-2

Date Collected: 11/14/17 13:00

Matrix: Solid

Date Received: 11/16/17 09:25

Method: 901.1 - Radium-226 & Other Gamma Emitters (GS) (Continued)

Analyte	Result	Qualifier	Count	Total	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
			Uncert. (2σ+/-)	Uncert. (2σ+/-)						
Uranium-238	0.742	U	0.575	0.580		3.57	pCi/g	11/17/17 13:39	11/17/17 15:25	1
<i>Other Detected Radionuclides</i>			<i>Count</i>	<i>Total</i>						
	<i>Result</i>	<i>Qualifier</i>	<i>Uncert.</i> (2σ+/-)	<i>Uncert.</i> (2σ+/-)	<i>RL</i>	<i>MDC</i>	<i>Unit</i>	<i>Prepared</i>	<i>Analyzed</i>	<i>Dil Fac</i>
<i>Other Detected Radionuclide</i>	<i>None</i>						pCi/g	11/17/17 13:39	11/17/17 15:25	1

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

TestAmerica St. Louis