NEW OPPORTUNITIES, INC.
Helping People. Changing Lives. ~ Community Action Partnership

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Mr. Richard Chang
Nuclear Regulatory Commission
11545 Rockville Pike
M.S. T8F5
Rockville, MD 20852-2738

June 27, 2018

RE: Remediation and Forgoing of Licensing of Waterbury Clock Company - 7

Dear Mr. Chang,

New Opportunities was able to work with DDES – ***Decontamination Decommissioning and Environmental Services LLC*** of Woburn MA to secure two reports:

- ***Clean-Up Plan for the Waterbury Clock Factory Site dated May 7, 2018***
- ***Former Waterbury Clock Factory Site Clean-Up Cost Estimate dated May 9, 2018***

Copies of the reports are attached.

Any feedback available after review would be appreciated.

If there are any questions, please do not hesitate to call me.

Sincerely,

Toni Hirst
Chief Administrative Officer

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FORMER WATERBURY CLOCK FACTORY SITE
CLEANUP COST ESTIMATE

Prepared for:

New Opportunities Inc.
232 North Elm Street
Waterbury, CT 06702

Prepared by:

DDES

Decontamination Decommissioning and Environmental Services, LLC
4 Arrow Drive
Woburn, MA 01801

May 9. 2018

1.0 Introduction

Decontamination Decommissioning and Environmental Services (DDES), LLC was retained by New Opportunities Inc., to assemble a cleanup cost estimate (CCE) for the remediation of interior surfaces that have been impacted with Radium-226 (^{226}Ra) at the Former Waterbury Clock Factory Site. Oak Ridge Institute for Science and Education (ORISE) performed a facility wide radiological characterization of the site to identify areas that were impacted by ^{226}Ra above the proposed site-specific Derived Concentration Guideline Level (DCGL) equaling 19 mrem per year to an exposed individual. A site-specific Cleanup Plan (CP) meeting the requirements NUREG-1757 Vol. 1, Rev. 2, *Consolidated Decommissioning Guidance* is required to define the cleanup criteria and establish the framework for the unrestricted release of the site.

This cost estimate is based on our team's experience performing cleanup, decontamination, and decommissioning projects for watch and clock manufacturing sites built at the turn of the 20th century. Many of these manufacturing sites have been updated or converted for multiple uses over the building history. This CCE is based on data obtained from the ORISE survey conducted November 29th and December 1nd, 2016. This report details the surficial contamination levels within the interior of the former manufacturing facility that is currently owned and operated by New Opportunities Inc. Table 1 shows the estimated area per floor that requires remediation.

Table 1: Proposed Remediation Areas (ft^2)

Floor	Wood Floors	Brick Walls	Total ft^2
4	200	50	250
5	240	0	240
Total Area	440	50	490

Various spot contamination was found on floors throughout the fourth and fifth floors. Also, windowsills were found to have contamination present. These surfaces will require remediation by aggressive means such as sanding, planning or complete removal. Contaminated materials removed from the building interior will be handled, packaged and disposed of as radioactive waste. Post-remediation final status surveys will be performed to verify all areas meet the remediation goals.

This DCE does not cover the cost for other hazardous materials (asbestos, PCB wastes, TCLP waste, mixed waste, etc.) that are also contaminated with radioactive material. These wastes must be segregated and profiled to determine proper handling, packaging, treatment and disposal options. This DCE is not inclusive of site soils or the building exterior.

2.0 Technical Approach

DDES has assembled this CCE based on our understanding of the production processes, operational history and similar cleanup projects. This site presents a number of challenges to cleanup activities. Foremost, sufficient electrical power will have to be provided to the areas designated for remediation. Site power will be used for powering the lights, HEPA air scrubbers, demolition equipment, and power tools. We have assembled the following generalized approach to preforming the remediation of impacted areas of the Site.

These remediation activities will be performed under a radioactive material license issued by the Nuclear Regulatory Commission (NRC) or under reciprocity from an Agreement State licensee capable of performing decommissioning work. Operation under a radioactive material license requires at a minimum, staff to be trained as radiological workers, biologically monitored, and participate in a comprehensive radiation protection program (RPP).

2.1 Decontamination and Demolition of Impacted Flooring

We believe this phase of work presents the highest level of hazard to site staff. Both engineering controls and personal protective equipment (PPE) will be required to assure proper protection for staff and to maintain control of the radioactive material. An operational work area will be established to limit the potential emissions of radioactive particulates. Immediate work areas will be fully enclosed and kept under negative pressure. The support areas around the work zones will be separated from the remaining areas of the building by plastic sheeting. High Efficiency Particulate Air (HEPA) filtered air scrubbers will be used to establish negative pressure within the work zone and a number of units will be used to clean the immediate work area. Additional HEPA vacuums and lockdown agents will be used to control radioactive emissions. It is anticipated that airborne radioactive concentrations may exceed Derived Air Concentration (DAC) limits, therefore respiratory protection will be used during higher risk remediation efforts. Disposable coveralls, nitrile gloves and shoe covers will be required during all invasive project activities. Both area sampling and personal air sampling will be performed daily to document the effectiveness of the engineering controls and support the selection of PPE.

During the site's operational years, extra layers of a fiber board sheet flooring were added to the operational floor. These fiber board layers can conceal low levels of ^{226}Ra contamination making them hard to identify. We have routinely found multiple layers of flooring present in original construction of manufacturing facilities. The structural flooring is composed of ¾" tongue and groove hardwood.

We believe a graded approach to the remediation of impacted flooring is necessary to reduce the total volume of radioactive waste generated under this scope of work. For waste estimation purposed, we have estimated that up to two layers of flooring will require removal in various locations to meet the site's remediation goals. It has been our experience that contamination is frequently found on the second layer of flooring when surface flooring levels that are greater than 10-times the remediation limit. Therefore, it is prudent to include the removal of the second layer of flooring in the radioactive waste estimate.

A structural engineer must assess if the floor/building structure will be compromised by the removal of both layers and determine if interior steel bracing is required to maintain the stability of the building after floor removal. As a waste reduction method, the second layer of flooring will be vacuumed after removal of the first. Then it will be surveyed by health physics personnel to confirm if removal is required.

Remediation efforts will begin with a gross decontamination of impacted areas using HEPA filtered vacuums and masslin dry mops. This will greatly reduce the presence of loose contamination, therefor reduce potential airborne particulates. DDES technicians will cut flooring into manageable lengths before removing them with high leverage bars.

Area air sampling will be required daily to demonstrate the engineering controls are effective. Waste will be palletized in packaged into cubic yard supersacks and lowered to the first floor via the elevator. It is assumed the elevator will be kept in working order throughout the remediation process. Any elevator maintenance required will be the responsibility of client

Each negative pressure area will be HEPA vacuumed to remove loose contamination from the remaining surfaces and followed by a comprehensive Final Status Survey of the operational area to document the area is acceptable for unrestricted release.

2.2 Remediation of Impacted Window Sills and Brick Surfaces

A number of brick window sills were identified as contaminated during site characterization surveys. It is believed that radium painted items were placed in the window to dry which originally contaminated the sill. Over time, rain is thought to have transported contamination from the sills, down the lower portion of the brick wall and floor.

Portable negative pressure containment will be setup at each remediation location. The contaminated brick surface will be scarified with a pneumatic needle gun to remove the contamination. The walls and window sills will be vacuumed after decontamination is complete. Confirmatory surveys will be performed to verify remediation goals have been met. The interior surfaces of the containment will be HEPA vacuumed and a remediation survey completed as previously described.

3.0 Waste Management

Radioactive Waste

It is estimated that approximately 3 cubic yards of radioactive waste will be generated from the removal of flooring and from the decontamination of building surfaces. An additional 1 cubic yard of radioactive waste will be generated from plastic sheeting, PPE, used HEPA air filters, etc. from materials that come into direct contact with contamination while performing the scope of work. Radioactive waste management is key to controlling the total cost for cleanup of the site. The majority of waste will be composed of wood flooring that will have a low density; therefore, packaging of the material to get the highest density per cubic foot will optimize the budget for waste disposal. Contaminated flooring will be uniformly cut prior to being placed into upersacks for disposal.

These waste conveyances will be staged on-site and loaded individually within the containment. Cubic yard containers will have a liner that can be tied off and sealed. When each container has met the best possible density, it will be sealed and covered in the methods mentioned above and staged in an area outside the containment for future transport. All waste will be measured for external removable contamination prior to shipping. It is our recommendation that no more than four containers be staged for a limited time outside the containment while work is being conducted. All packaged waste will be placed in locked storage at the end of every day. Coordination of waste pickup and transport on a timely basis will ensure security of staged waste containers.

4.0 Conclusion

This CCE was designed to provide comprehensive pricing for cleanup the Former Waterbury Clock Factory based on our experience as well as our knowledge performing small and large-scale decontamination projects. This information was incorporated into a comprehensive cleanup cost estimate presented in Appendix A. The table below presents individual cost categories items as required by NUREG-1757 Vol. 1, Rev. 2, *Consolidated Decommissioning Guidance*.

Note: The NRC requires a 25% contingency be added to the project costs to cover unknowns and assure adequate funding is available for cleanup.

Former Waterbury Clock Factory Site Total Cleanup Costs		
Task/Component	**Cost**	**Percentage**
Planning Preparation and Management	$4,664.00	16%
Decontamination and/or Dismantling of Radioactive Facility Components	$10,240.00	35%
Final Radiation Survey	$1312.00	4%
Site Stabilization and Long-Term Surveillance	NA	0%
Packing Material Costs	NA	0%
Radioactive Waste Disposal Costs	$3710.00	13%
Equipment/Supply Costs	$5791.00	19%
Travel Costs	$3,900.00	13%
Subtotal	**$29,617.00**	**100%**
25% Contingency	$7,405.00	
Total Cleanup Cost Estimate	**$37,022.00**	

REFERENCES

Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission (September 2003). *Consolidated NMSS* [Nuclear Material Safety and Safeguards] *Decommissioning Guidance*, NUREG-1757. Volume 1: *Decommissioning Process for Materials Licensees*. Volume 2: *Characterization, Survey, and Determination of Radiological Criteria*. Volume 3: *Financial Assurance, Recordkeeping, and Timeliness*. Washington D.C.: U.S. Nuclear Regulatory Commission.

U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, U.S. Department of Energy, and U.S. Department of Defense (August 2000). *Multi-Agency Radiation Survey and Site Investigation Manual* (***MARSSIM***), NUREG-1575, Rev. 1. Washington D.C. U.S. Nuclear Regulatory Commission.

Appendix A

Detailed Cost Estimate

Former Waterbury Clock Factory
Cleanup Cost Estimate

PROJECT STAFFING							
Personnel	**Quantity**	**Std. Rate**	**OT Rate**		**Item**	**Rate**	
Sr. Project Manager	1	$125.00	$125.00		Per Diem Rate	$195.00	
Sr. HP Technician	1	$92.00	$138.00		G&A	10%	Markup
Health Physics Technician	0	$85.00	$127.50				
Health and Safety Manager	1	$150.00	$150.00				
Waste Technician	2	$72.00	$108.00				
Administrative	0	$45.50	$68.25				

1.0 Project Management Decommissioning Planning, Final Status Survey Plan, Final Status Survey Report							
Service/ Activity	**Quantity**	**Std. Hours**	**Std. Rate**	**OT Hours**	**OT Rate**	**G&A**	**Totals**
Sr. Project Manager	1	32	$125.00	0	$125.00	NA	$4,000.00
Health and Safety Manager	1	2	$150.00	0	$150.00	NA	$300.00
Administrative	1	8	$45.50	0	$68.25	NA	$364.00
						Site Activities:	**$4,664.00**

2.0 Demolition of Contaminated Building Interior Surfaces							
Service/ Activity	**Quantity**	**Std. Hours**	**Std. Rate**	**OT Hours**	**OT Rate**	**G&A**	**Totals**
Sr. Project Manager	1	32	$125.00	0	$125.00	NA	$4,000.00
Sr. HP Technician	1	32	$92.00	0	$127.50	NA	$2,944.00
Waste Technician	2	32	$72.00	0	$108.00	NA	$4,608.00
						Site Activities:	**$11,552.00**

3.0 Equipment and Supplies						
Item	**Quantity**	**Weeks**	**Rate**	**Cost**	**G&A**	**Totals**
Plastic Sheeting	10		$98.00	$980.00	10%	$1,078.00
Fixative Agent	1		$150.00	$150.00	10%	$165.00
Cubic Yard Waste Containers	4		$96.00	$384.00	10%	$422.40
Saw Blades	2		$25.00	$50.00	10%	$55.00
Survey Instrumentation	4	1	$100.00			$400.00
Respiratory Protection (PAPRs, Filters, etc.)	4	1	$130.00			$520.00
PPE and Consumables (Tyvek, gloves, etc.)	4	1	$150.00			$600.00
Hand and Power Tool Rental	4	1	$30.00			$120.00
HEPA Vacuum Filter and Bags	2	1	$160.00			$320.00
HEPA Air Scrubber w/ filters	2	1	$45.00			$90.00
DFHV-1 Air Sampler	1	1	$35.00			$35.00
Gil Air Plus Personal Air Sampler	1	1	$20.00			$20.00
Lab Supplies	1	1	$50.00			$50.00
Fuel	2	1	$75.00	$150.00	10%	$165.00
Demolition Tools - Air Compressor/Needle Gun	1	1	$1,500.00	$1,500.00	10%	$1,650.00
Truck	1	1	$100.00			$100.00
					Equipment and Supplies Total:	**$5,791.00**

Former Waterbury Clock Factory
Cleanup Cost Estimate

4.0 Waste Disposal						
Item	**Quantity**	**Weeks**	**Rate**	**Cost**	**G&A**	**Totals**
Non-Hazardous Debris (cubic yard)	4		$455.00	$1,820.00	10%	$2,002.00
Transportation (cubic yard)	4		$388.00	$1,552.00	10%	$1,707.20
					Waste Total:	**$3,710.00**

5.0 Travel Expenses							
Personnel	**Quantity**	**Days**	**Per Diem Rate**			**G&A**	**Totals**
Project Manager	1	5	$195.00			N/A	$975.00
Health Physics Technician	1	5	$195.00			N/A	$975.00
Waste Technician	2	5	$195.00			N/A	$1,950.00
						Travel Expenses Total:	**$3,900.00**

Project Management	**$4,664.00**
Demolition of Contaminated Building Interior Surfaces	**$11,552.00**
Equipment and Supplies	**$5,791.00**
Radioactive Waste Disposal	**$3,710.00**
Travel Expenses	**$3,900.00**
Subtotal	**$29,617.00**
25% Contingency	**$7,405.00**
Total Decommissioning Cost Estimate	**$37,022.00**

Cleanup Plan
Former Waterbury Clock Factory Site
Waterbury, Connecticut

Prepared for:

New Opportunities Inc.
232 North Elm Street
Waterbury, CT 06702

Prepared by:

DDES

Decontamination Decommissioning and Environmental Services, LLC
4 Arrow Drive
Woburn, MA 01801

May 7, 2018
Revision 0

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TABLES

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ATTACHMENTS

DEFINITIONS

Action level - The numerical value that will cause the decision maker to choose one of the alternative actions. It may be a regulatory threshold standard (e.g., Maximum Contaminant Level for drinking water), a dose- or risk-based concentration level (e.g., DCGL), or a reference-based standard. See investigation level.

ALARA (acronym for As Low As Reasonably Achievable) - A basic concept of radiation protection which specifies that exposure to ionizing radiation and releases of radioactive materials should be managed to reduce collective doses as far below regulatory limits as is reasonably achievable considering economic, technological, and societal factors, among others. Reducing exposure at a site to ALARA strikes a balance between what is possible through additional planning and management, remediation, and the use of additional resources to achieve a lower collective dose level. A determination of ALARA is a site-specific analysis that is open to interpretation because it depends on approaches or circumstances that may differ between regulatory agencies. An ALARA recommendation should not be interpreted as a set limit or level.

Area factor - A factor used to adjust $DCGL_W$ to estimate $DCGL_{EMC}$ and the minimum detectable concentration for scanning surveys in Class 1 survey units—$DCGL_{EMC} = DCGL_W \bullet A_m$. Am is the magnitude by which the residual radioactivity in a small area of elevated activity can exceed the $DCGL_W$ while maintaining compliance with the release criteria.

Arithmetic standard deviation - A statistic used to quantify the variability of a set of data. It is calculated in the following manner: 1) subtracting the arithmetic mean from each data value individually, 2) squaring the differences, 3) summing the squares of the differences, 4) dividing the sum of the squared differences by the total number of data values less one, and 5) taking the square root of the quotient. The calculation process produces the Root Mean Square Deviation (RMSD).

Background radiation - Radiation from cosmic sources, naturally occurring radioactive material,

Calibration - Comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments.

Chain of custody - An unbroken trail of accountability that ensures the physical security of samples, data, and records.

Characterization survey - A type of survey that includes facility or site sampling, monitoring, and analysis activities to determine the extent and nature of contamination. Characterization surveys provide the basis for acquiring necessary technical information to develop, analyze, and select appropriate cleanup techniques.

CHP - Certified Health Physicist

CIH - Certified Industrial Hygienist

Class 1 survey - A type of final status survey that applies to areas with the highest potential for contamination, and meets the following criteria: (1) impacted; (2) potential for delivering a dose above the release criterion; (3) potential for small areas of elevated activity; and (4) insufficient evidence to support classification as Class 2 or Class 3.

Class 2 survey - A type of final status survey that applies to areas that meet the following criteria: (1) impacted; (2) low potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

Class 3 survey - A type of final status survey that applies to areas that meet the following criteria: (1) impacted; (2) little or no potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

Composite sample - A sample formed by collecting several samples and combining them (or selected portions of them) into a new sample which is then thoroughly mixed.

Confidence interval - A range of values for which there is a specified probability (e.g., 90%, 95%) that this set contains the true value of an estimated parameter.

Contamination - The presence of residual radioactivity in excess of levels which are acceptable for release of a site or facility for unrestricted use.

DAC - Derived Air Concentration

DCGL (derived concentration guideline level) - A derived, radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. The DCGL is based on the spatial distribution of the contaminant and hence is derived differently for the nonparametric statistical test ($DCGL_W$) and the Elevated Measurement Comparison ($DCGL_{EMC}$). DCGLs are derived from activity/dose relationships through various exposure pathway scenarios.

Decommissioning - The process of removing a facility or site from operation, followed by decontamination, and license termination (or termination of authorization for operation) if appropriate. The objective of decommissioning is to reduce the residual radioactivity in structures, materials, soils, ground water, and other media at the site so that the concentration of each radionuclide contaminant that contributes to residual radioactivity is indistinguishable from the background radiation concentration for that radionuclide.

Decontamination - The removal of radiological contaminants from a person, object or area to within levels established by governing regulatory agencies. Decontamination is sometimes used interchangeably with remediation, remedial action, and cleanup.

Derived concentration guideline level - See DCGL.

Detection limit - The net response level that can be expected to be seen with a detector with a fixed level of certainty.

Detection sensitivity - The minimum level of ability to identify the presence of radiation or radioactivity.

Exposure pathway - The route by which radioactivity travels through the environment to eventually cause a person or a group to be exposed to radiation.

Final status survey - Measurements and sampling to describe the radiological conditions of a site, following completion of decontamination activities (if any) in preparation for release.

FSS - Final status survey

Gamma radiation - Penetrating high-energy, short-wavelength electromagnetic radiation (similar to X-rays) emitted

Half-life ($t_{1/2}$) - The time required for one-half of the atoms of a particular radionuclide present to disintegrate.

HASP - Health and Safety Plan

Hypothesis - An assumption about a property or characteristic of a set of data under study. The goal of statistical inference is to decide which of two complementary hypotheses is likely to be true. The null hypothesis (H0) describes what is assumed to be the true state of nature and the alternative hypothesis (Ha) describes the opposite situation.

Impacted area - Any area that is not classified as non-impacted. Areas with a possibility of containing residual radioactivity in excess of natural background or fallout levels.

Infiltration rate - The rate at which a quantity of a substance moves from one environmental medium to another (e.g., the rate at which a quantity of rainwater moves into and through a volume of soil).

Investigation level - A derived media-specific, radionuclide-specific concentration or activity level of radioactivity that - 1) is based on the release criterion, and 2) triggers a response, such as further investigation or cleanup, if exceeded. See action level.

License - A license issued under the regulations in parts 30 through 35, 39, 40, 60, 61, 70 or part 72 of 10 CFR.

License termination - Discontinuation of a license, the eventual conclusion to decommissioning.

MARSSIM - Multi-Agency Radiation Survey and Site Investigation Manual

MDA - Minimum detectable activity

Minimum detectable concentration (MDC) - A priori activity level that a specific instrument and technique can be expected to detect 95% of the time. When stating the detection capability of an instrument, this value should be used. The MDC is the detection limit, LD, multiplied by an appropriate conversion factor to give units of activity.

Minimum detectable count rate (MDCR) - The minimum detectable count rate (MDCR) is the a priori count rate that a specific instrument and technique can be expected to detect.

Non-impacted area - Areas where there is no reasonable possibility (extremely low probability) of residual contamination. NRC - United States Nuclear Regulatory Commission

NVLAP - National Voluntary Laboratory Accreditation Program

OSHA - Occupational Safety and Health Administration

QAPP - Quality Assurance Project Plan

QA/QC - Quality Assurance/Quality Control

Quality assurance (QA) - An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

Quality control (QC) - The overall system of technical activities that measure the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer, operational techniques and activities that are used to fulfill requirements for quality.

Radioactivity - The mean number of nuclear transformations occurring in a given quantity of radioactive material per unit time. The International System (SI) unit of radioactivity is the Becquerel (Bq). The standard unit is the Curie (Ci).

Radiological survey - Measurements of radiation levels and radioactivity associated with a site together with appropriate documentation and data evaluation.

Radionuclide - An unstable nuclide that undergoes radioactive decay.

Release criterion - A regulatory limit expressed in terms of dose or risk.

Remedial action - Those actions that are consistent with a permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment.

Representative measurement - A measurement that is selected using a procedure in such a way that it, in combination with other representative measurements, will give an accurate representation of the isotope being studied.

RESRAD - A computer code used to determine residual radioactivity in the environment by analysis of various exposure pathways.

Sample - A part or selection from a medium located in a survey unit or reference area that represents the quality or quantity of a given parameter or nature of the whole area or unit; a portion serving as a specimen.

Site - Any installation, facility, or discrete, physically separate parcel of land, or any building or structure or portion thereof, that is being considered for survey and investigation.

Soil activity (soil concentration) - The level of radioactivity present in soil and expressed in units of activity per soil mass (typically Bq/kg or pCi/g).

Survey - A systematic evaluation and documentation of radiological measurements with a correctly calibrated instrument or instruments that meet the sensitivity required by the objective of the evaluation.

Survey plan - A plan for determining the radiological characteristics of a site.

Survey unit - A geographical area of specified size and shape defined for the purpose of survey design and compliance testing.

TEDE (total effective dose equivalent) - The sum of the effective dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposure). TEDE is expressed in units of Sv or rem. See CEDE.

1.0 INTRODUCTION

Decontamination Decommissioning and Environmental Services (DDES), LLC was retained by New Opportunities, Inc. to assemble a Cleanup Plan (CP) for the Former Waterbury Clock Factory Site at 232 North Elm Street in Waterbury, Connecticut. The former clock factory structure encompasses approximately 500,000 square feet. A scoping survey was performed by Oak Ridge Institute for Science and Education (ORISE) from November 29th – December 1st, 2016. The isotope of concern for the site has been limited to Radium-226 (^{226}Ra) based on the available historical information and clock manufacturing practices.

This scoping survey was designed to identify and quantify the current contamination levels present throughout the complex. The survey was designed to identify contamination levels that would exceed a total effective dose equivalent (TEDE) of nineteen (19) mrem/year to an individual member of the public. The goal of the scoping survey was to identify and quantify radiological contamination that persists on site and use this data to assemble a comprehensive cost estimate and cleanup plan for unconditional release of the site.

1.1 Introduction and Objective of the Cleanup Plan

This CP describes the remedial actions that will be implemented and defines the site specific radiological release criteria that will be used to show the site has been remediated to meet the 19 mrem/year criteria. Once decontamination activities have been completed in accordance with this CP, A Final Status Survey Report will be assembled to support the release of the areas for unrestricted use, as governed by the U.S. Nuclear Regulatory Commission (NRC) License Termination Rule (LTR), Subpart E of Title 10 of the Code of Federal Regulations (CFR) Part 20.1402 "Radiological Criteria for Unrestricted Use."

This plan was developed using the guidance provided in NUREG 1757, “Consolidated NMSS Decommissioning Guidance” and NUREG 1575, “Multi-Agency Radiation Survey and Site Investigation Manual” (MARSSIM). It provides the approach, methods, and techniques for the radiological decontamination and decommissioning of impacted building surfaces. DandD 2.4 was used to establish derived concentration guideline levels (DCGL) for ^{226}Ra.

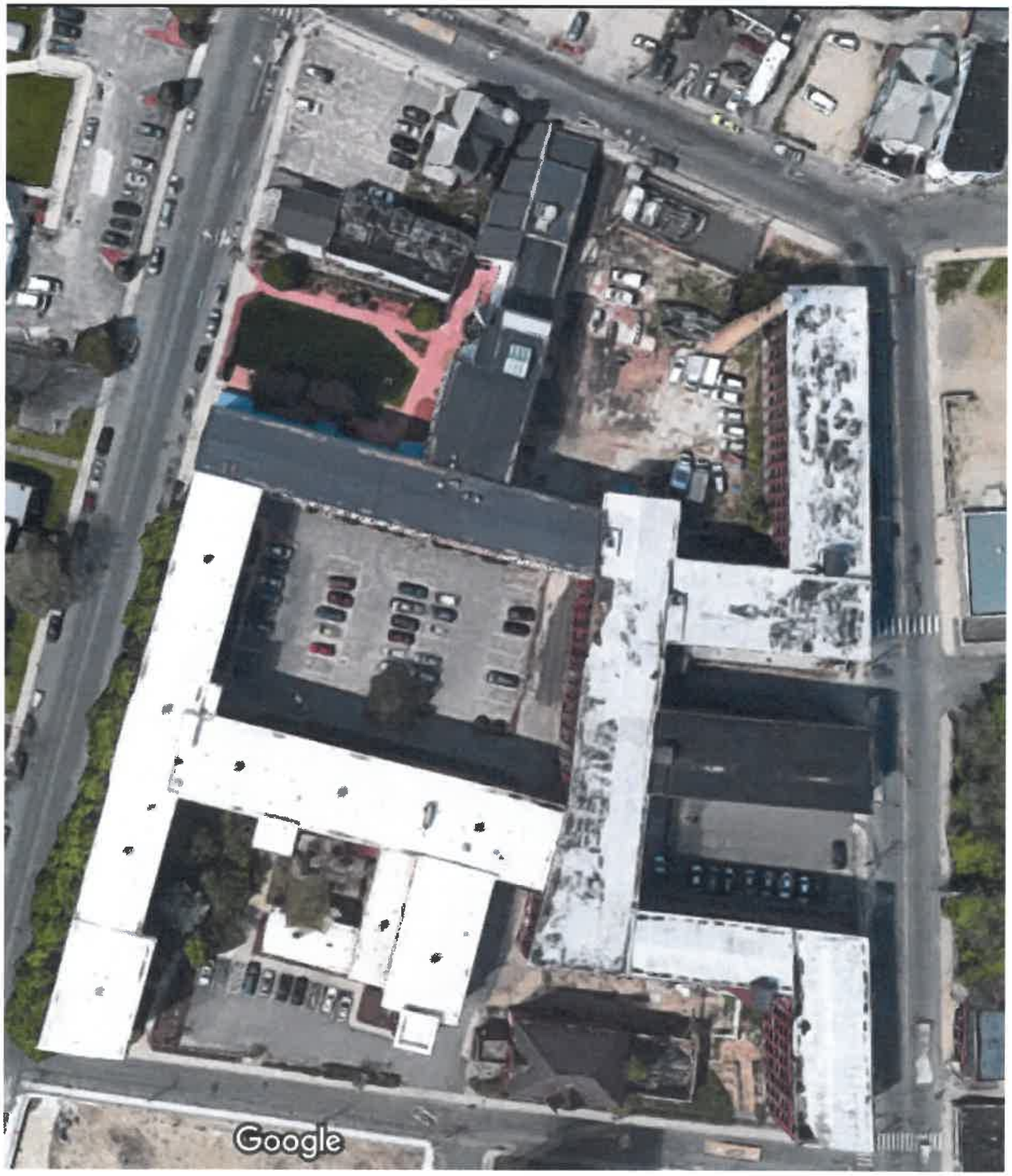
1.2 Site Description

The former Waterbury Clock Company Site is a 500,000-square foot structure located at 232 North Elm Street in Waterbury, Connecticut. This five-story building is made up of brick and wood structure. The original building is currently owned and occupied by New Opportunities, Inc. The site had a survey performed at the Waterbury Clock Factory which found elevated levels of radioactivity. According an Agency for Toxic Substances and Disease Registry (ATSDR) issued in 1998 titled "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." This report is included as Attachment A.

A Site Plan depicting the current Site layout and pertinent Site features is provided as Figure 1-1.

Figure 1-1

Former Waterbury Clock Factory Site



1.3 Planned Cleanup Activities

The proposed decontamination methods have the potential to disturb interior surfaces and structures with in the building envelope. Impacted areas will be removed or decontaminated using aggressive techniques. The majority of areas to be remediated are floor surfaces. Floor surfaces that found to have average concentrations above the DGCL will be torn up, planned or sanded until levels are reduced sufficiently. Contaminated brick/concrete will be scarified or needle gunned to remove the upper surfaces to reduce contamination levels.

We believe this phase of work presents the highest level of hazard to site staff. Both engineering controls and personal protective equipment (PPE) will be required to assure proper protection for staff and to maintain control of the radioactive material. An operational work area will be established to limit the potential emissions of radioactive particulate. Immediate work areas will be separated from the remaining areas of the building by plastic sheeting. High Efficiency Particulate Air (HEPA) filtered air scrubbers will be used to establish negative pressure within the work area. A number of these units will be used to clean the air in the immediate work area. HEPA vacuums and lockdown agent will be used to control radioactive emissions during remediation activities. Elevated levels of respiratory protection, disposable coveralls, nitrile gloves and shoe covers will be required during invasive project activities. Area sampling and personal air sampling will be performed to document the effectiveness of the engineering controls and support the selection of PPE.

A second containment area will be built around the first to completely separate the donning and doffing, staging, and support areas from the occupied spaces of the building. This second containment will also be at negative pressure. The inner containment will be kept at slightly more negative pressure than the outer. This will effectively maintain an engineering control over airborne particulates. The flow will be verified using a manometer.

We believe a graded approach to the remediation of impacted flooring is necessary to reduce the total volume of radioactive waste generated under this decommissioning. We will remove the flooring in layers, with a detailed scan of each layer until the site's remediation goals are met.

If additional floor layers require removal a structural engineer will be retained to assess if the floor/building structure will be compromised by the removal actions to maintain the stability of the building after floor removal.

Waste will be packaged into cubic yard waste containers and lowered moved to the ground floor by elevator.

Each area where remediation is required will be HEPA vacuumed to remove loose contamination from the remaining surfaces and followed by a comprehensive Final Status Survey of the survey unit to document the area is acceptable for unrestricted release.

The Final Status Survey of the Former Waterbury Clock Factory Site is intended to demonstrate the requirements in 10 CFR 20.1402 for unrestricted release have be met.

2.0 FACILITY OPERATING HISTORY

The Waterbury Clock Company was founded in Waterbury in 1857. The Waterbury Clock Company in Waterbury, CT historically produced under various trademarks and pseudo names, watches with radium-luminous dials.

One Public Health Assessment Survey from 1999 issued by ATSDR was located which provided limited dose rate survey data. Readings in excess of 1000 μR/hr. were noted on the 3rd, 4th and 5th floors of the facility.

A scoping survey was performed on all floors of the facility by ORISE in 2016 which confirmed elevated levels of radioactivity were still present in each of these areas. These areas of elevated readings needed further quantification and areas of contamination bound to determine the level of remediation necessary to release the Site.

2.1 Recent Site History

New Opportunities, Inc. currently operates various social programs and community outreach at the Former Waterbury Clock Factory Site. The locations identified as impacted are currently used as office and storage space.

2.2 Radioactive Material

Radioactive materials onsite are in the form of residual contamination from historic clock making operations in various locations throughout the facility. The building is currently occupied.

2.3 Potential Contaminants

Table 2-1 lists the potential radioactive contaminants. The site would have used radium luminescent paints while these radioactive materials were exempt from regulation. These legacy ^{226}Ra sites are now regulated under the NRC. No records relating to the use or storage of radium paint onsite could be located.

Nuclides were evaluated by utilizing Default Screening Values (DSV's) generated from a screening analysis using the default parameters contained in the DandD Code v.2.4. Table 2-1 presents the contaminant of concern.

Table 2-1
Contaminant of Concern

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

2.4 Radiological Surveys

To our knowledge, the Former Waterbury Clock Factory did not perform radioactive surveys when ^{226}Ra paints were used during the facilities use. There are no known areas of removable contamination identified during the Scoping Survey.

2.5 Spills and Uncontrolled Release of Radioactivity

Since no radiological records were required to be kept, no radiological spills have been reported over the history of the site.

2.6 Potentially Impacted Facilities

Table 2-2 lists the areas that have been impacted by the use of radioactive material and require remediation to meet the cleanup criteria. The majority of areas identified were flooring, brick surfaces and window sills. Table 2-2 presents the list of impacted areas at the site.

Table 2-2

Potentially Impacted Areas (ft^2)

Floor	Wood Floors	Brick Walls	Total
4	200	50	250
5	240	0	240
Total Area	440	50	490

2.7 Non-Impacted Areas

The following areas are considered non-impacted based on the scoping survey results:

- Exterior Areas
- Floors 1,2, and 3
- Basement

2.8 Previous Decommissioning Activities

No previous radiological decommissioning activities have been performed at the site to this date.

3.0 FACILITY DESCRIPTION

The building that formerly housed the Waterbury Clock Factory is now a multi-use building with residential, commercial, and office space. New Opportunities Inc. is one of a handful of tenants. The exterior of the building appears mostly original but the inside has been refinished and updated in many areas.

3.1 Current/Future Land Use

Currently there are occupants of the building envelope. New Opportunities Inc. is using the space as its headquarters for social and economic wellness endeavors. This includes both office and residential spaces. However, the impacted areas are currently used as office and storage spaces.

4.0 RADIOLOGICAL STATUS OF THE FACILITY

Total contamination measurements were obtained from a scoping survey performed by ORISE on November 29th, 2016 and December 1st 2016. Additionally, measurement data was reviewed and compared with the DCGLs and annual TEDE limits to confirm the correct classification of the affected areas. A summation of the findings are presented in Table 4-1.

Table 4-1

Scoping Survey Summary

Floor	Total Survey Locations	β Max	γ Max	Exposure Rate Max	Locations Exceeding Twice Background
		(CPM)		μR/hr.	
4th	14	13,082	228,975	200	6
5th	19	356,369	2,900,000	4,000	5

A total of 11 locations on the 4th and 5th floors had total contamination results exceeding the 19 mrem/year criteria.

4.1 Removable Contamination Results

Additionally, smears were taken in the survey locations to determine if there was loose radiological contamination. There was no loose contamination found above the administrative limit of 20 dpm/ 100cm^2 during the scoping survey. However, it is important to note that the original building surfaces have been covered in all of the areas designated for remediation. Additional smears will be taken during the remediation process to assess the potential for loose contamination behind the newer constructed building surfaces.

Locations where scanning and total contamination measurements did not identify contamination above twice background meet the 19 mrem/year criteria and would not require further remediation. However, a number of survey locations had surface scans and total contamination measurements that exceeded the DCGL of 819 dpm/100cm^2 for Radium-226 that would require remediation if the suggested limit was accepted by the NRC. The majority of areas identified were small floor areas and window ledges.

4.2 Determining Compliance for Building Surfaces and Structures

Total count rate and exposure rate measurements were compared with known Radium-226 response and then calculated to compare against the applicable DCGL to determine compliance with the 19 mrem/year TEDE requirement for Connecticut DEEP. Surface scans were performed on horizontal surfaces to identify areas of elevated activity that exceeded the DCGL. Additionally, removable contamination measurements were taken to compare against the applicable limit. The removable activity measurements collected during the characterization surveys were less than the applicable limit. A total of 38 locations were found to be in compliance with the 19 mrem/year TEDE limit for unrestricted release and no further radiological evaluation is recommended.

4.3 Building Systems

The designated remediation areas do not contain ventilation systems or drainage systems that would have been used during clock manufacturing. In the event building systems are uncovered during cleanup operations, they will be evaluated for radiological content and removed if contamination levels exceed release criteria.

5.0 DOSE MODELING

An important aspect of the Cleanup Plan is to assess what potential radiation dose could result to a potential receptor from the remaining residual radioactivity after decommissioning activities have been completed. The Derived Concentration Guideline Level (DCGL) development analyses simulate the behavior of residual radioactivity over one year, a period during which peak annual doses from the radionuclides of primary interest would be expected to occur. DCGLs were developed for residual radioactivity that will result in 19 mrem per year dose to the average member of the critical group.

The NRC has published default screening values in NUREG 1757 for commonly used radionuclides that is based on 25 mrem/year. DandD v.2.4 software was used to calculate the site DCGL based on 25 mrem/year. Surface contamination limits were derived using the Building Occupancy scenario together with default parameter values. Screening values were selected such that the 0.9 quantile of projected doses was less than or equal to 25 mrem/year (i.e., when probabilistic dose assessment calculations were performed, there was a 90% probability the calculated dose would be less than 25 mrem/year).

The nuclide of concern (NOC) has been limited to ^{226}Ra. The NOC screening values for surfaces under default conditions (generic screening levels) from the NRC DandD code v.2.4 are provided in Table 5-1, while DCGLs equating to 19mrem are provided in Table 5-2.

Table 5-1
Established $DCGL_W$ for Survey 25 mrem/year

Isotope	Total (DPM/100 cm2)	Removable (DPM/100 cm2)
^{226}Ra	1,116	111

Table 5-2

Calculated $DCGL_W$ for Survey 19 mrem/year

Isotope	Total Average (DPM/100 cm2)	Removable (DPM/100 cm2)
^{226}Ra	819	20

The term DCGLs will be generically used to describe the proposed levels specified in Table 5-1 and Table 5-2. These criteria are the basis for developing the DCGLs to compare with the survey results. $DCGL_W$ is the concentration limit if the residual activity is essentially evenly distributed over a large area of the survey unit.

In the case of non-uniform contamination, higher levels of activity are permissible over small defined areas. The $DCGL_{EMC}$ is derived separately for these small areas. The $DCGL_{EMC}$ is the $DCGL_W$ increased by an area factor depending on the size of the elevated area. The default area factors for ^{226}Ra listed in MARSSIM will be used.

5.1 ALARA Goals

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

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

6.0 ALARA ANALYSIS

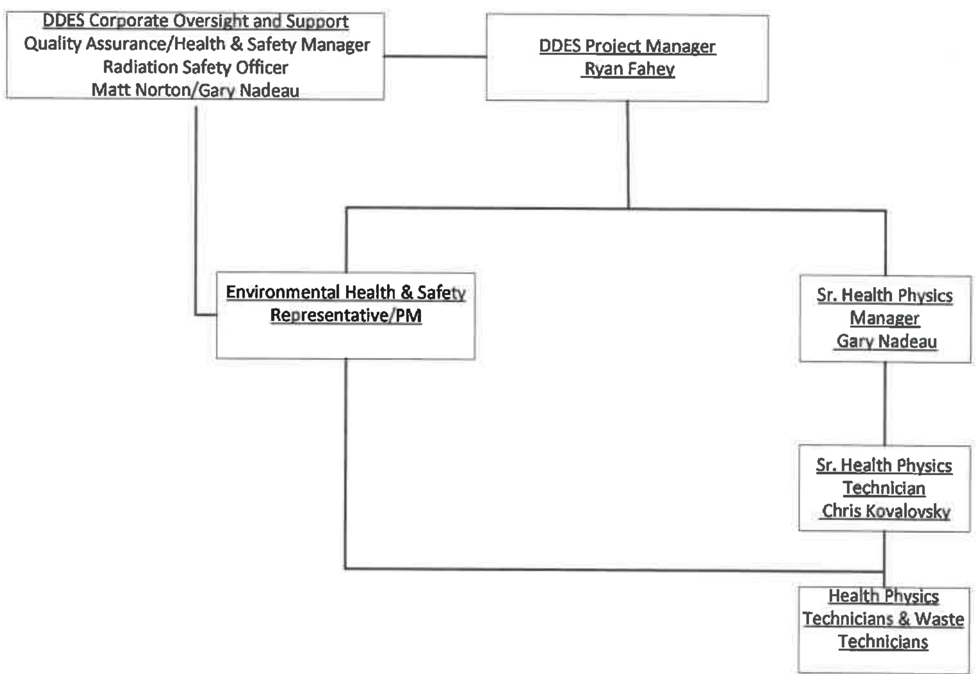
The proposed decommissioning of the Former Waterbury Clock Factory includes the removal and/or decontamination of impacted building surfaces that exceed the established administrative levels for total contamination based on 19 mrem/year (819 dpm/100cm^2) to comply with the Connecticut Department of Energy and Environmental Program (DEEP) requirements. The NRC has published default screening values in NUREG 1757 for commonly used radionuclides based on 25 mrem/year (1,116 dpm/100cm^2) to show compliance with the license termination rule. Further the site will use 20 dpm/100cm^2 as a removable limit which is substantially less than the default value of 111 dpm/100cm^2. This approach is consistent with the ALARA (As Low As Reasonably Achievable) principle. Removal of loose residual radioactivity from buildings is almost always cost-effective except when very small quantities of radioactivity are involved. Therefore, loose residual radioactivity normally should be removed, and if it is removed, the analysis would not be needed, per NUREG-1757, Vol. 2, APPENDIX N

7.0 PROJECT MANAGEMENT AND ORGANIZATION

Decontamination Decommissioning and Environmental Services (DDES) LLC will maintain primary responsibility for all activities conducted under the requirements of the CP with Massachusetts Radioactive Material License No. 56-0623 under reciprocity with the NRC. The point of contact between applicable regulatory authorities and DDES will be the DDES Principal. Figure 7-1 shows the organizational structure for the implementation of the CP.

Figure 7-1

Project Organization



7.1 Decommissioning Task Management

Radiation Work Permits (RWPs) will be used for the administrative control of personnel entering or working in areas that have radiological hazards present. Work techniques will be specified in such a manner that the exposures for all personnel, individually and collectively, are maintained ALARA. RWPs will not replace work procedures, but will act as a supplement to such procedures. Radiation work practices will be considered when procedures are developed for work which will take place in a radiologically controlled area.

Project RWPs will describe the job to be performed, define protective clothing and equipment to be used, and personnel monitoring requirements. RWPs will also specify any special instructions or precautions pertinent to radiation hazards in the area to be entered including listing the radiological hazards present, and the presence and intensity of hot spots, loose surface radioactivity, and other hazards as appropriate. The radiation safety program will ensure that radiation, surface radioactivity, and equipment surveys are performed as required to define and document the radiological conditions for each job.

RWPs for jobs with low dose commitments (less than 25 millirem total effective dose equivalent or TEDE) will be approved at the health physics (HP) technician or HP supervisor while RWPs for jobs with potentially significant radiological hazards will be approved by the RSO. Examples of topics covered by implementing procedures for the RWPs are:

- Requirements, classifications and scope for RWPs;
- Initiating, preparing and using RWPs; and
- Terminating RWPs.

Work procedures and practices associated with radioactive materials, such as RWPs, will be developed, reviewed, implemented and managed pursuant to DDES health physics procedures.

7.2 Decommissioning Management Positions and Qualifications

7.2.1 Radiation Safety Officer

The RSO will be an employee of DDES and will have a Bachelors' degree in the physical sciences, health physics, industrial hygiene or engineering from an accredited college or university, with at least one (1) year of work experience in applied health physics, industrial hygiene or similar work relevant to radiological hazards, and a thorough knowledge of the proper application and use of all radiation safety equipment used in connection with the radioactivity present at the site, the chemical and analytical procedures used for radiological sampling and monitoring, and methodologies used to calculate personnel exposure to the radionuclides present at the site. The name and qualifications of the individual serving as RSO for this work, who will be available full-time for the decommissioning, will be provided to the NRC prior to the start of the on-site efforts.

7.2.2 Other Management Positions

7.2.2.1 Decommissioning Contractor

DDES will prepare the final work plans, perform decontamination activities, perform and document Final Status Surveys, facilitate communications with federal and state regulatory authorities, and provide on-site project management and site-specific health and safety support (radiological, industrial hygiene, and industrial safety support) during the implementation phase.

7.2.2.2 Project Manager

The DDES will designate an individual to serve as the Project Manager. The Project Manager, who will have training and education in applicable radiological, engineering and environmental aspects of decommissioning, as well as expertise in managing projects of this magnitude, will be responsible for the following:

- Verifying that the personnel are provided with the proper radiation protection, industrial safety training and possess the requisite knowledge for the job assignment;
- Observing work in progress to verify adherence to the radiological and industrial safety rules and procedures;
- Recommending changes to operational and radiological protection practices;
- Enforcing compliance with DDES facility rules and license requirements;
- Reviewing reports and results; and
- Establishing and maintaining a records management system to verify that project documents, such as correspondence, procedures, drawings, specifications, contract documents, changes to documents, and inspection records are controlled.

The Project Manager has the responsibility and authority to stop or terminate any work activities that do or may violate regulatory or contract requirements.

7.2.2.3 Site Health and Safety Officer

Reporting to the Project Manager will be the Site Health and Safety Officer (Site HSO). This individual will be present at the Former Waterbury Clock Factory Site for the duration of all on-site decommissioning work, and is to have a combination of education and experience in the following radiation protection and industrial safety subjects:

- Principles and practices of radiation protection;

- Radioactivity measurements, monitoring techniques, and the use of instruments;
- Mathematics and calculations basic to the use and measurement of radioactivity;
- Biological effects of radiation;
- Safety practices applicable to protection from radiation, chemical toxicity, and other properties of the materials that may be encountered during the decommissioning;
- Conducting radiological surveys and evaluating results;
- Evaluating and implementing the final work plans for proper operations from a radiological safety standpoint;
- Applicable NRC, EPA, and OSHA regulations, as well as the terms and conditions of any licenses and permits issued by regulatory agencies; and the requirements contained in License No. 56-0623
- Establishing the health and safety program requirements for field activities;
- Verifying that the requirements of the industrial safety and radiation protection program are implemented adequately;
- Reviewing the results of surveys, sampling, and environmental monitoring to identify trends and potential for personnel exposure;
- Evaluating the effectiveness of engineering and administrative control including the requirements for personnel protective equipment;
- Developing new safety protocols and procedures necessary for new field activities;
- Providing internal review and approval for work related documents;
- Auditing key aspects of the safety and health program; and
- Making recommendations to the Project Manager regarding the control of existing and potential industrial, chemical and radiological hazards.

The Site HSO has the responsibility and authority to terminate any work activities if conditions indicate the potential for unnecessary radiation exposure to site personnel or members of the public, or for unsafe working conditions.

7.2.2.4 Quality Assurance Officer

An individual, with a reporting line directly to the RSO, will be assigned to serve as the Quality Assurance Officer (QAO) for the project." The QAO, who will have training in the implementation of quality programs, will perform the following:

- Technical assistance and peer review of all deliverables;
- Prepare and review the Quality Assurance Project Plan (QAPP);
- Coordinate with analytical laboratories, as necessary;
- Oversee subcontractor QA activities to ensure compliance with the QAPPs;
- Track laboratory submittals and sample analyses and verify delivery of data, as necessary;
- Coordinate validation of analytical data;
- Monitor the on-site activities; and
- Prepare and submit QA reports, as required.

The QAO has the responsibility and authority to stop or terminate any work activities that may lead to conditions adverse to the quality requirements of the CP.

7.3 Training

All employees, contractors, and visitors with unescorted access to the restricted area of the facility will be trained on the types and magnitudes of the radiological hazards they might face. All personnel performing the on-site work described in this CP will be current in the training required in 29 CFR 1910.120. The following subsections briefly describe the various training programs that will be implemented as part of the CP.

7.3.1 Visitor Training

Visitors to the work zone will be trained by a combination of reading, oral briefing, and signing a briefing form. The briefing form will contain information about the hazards present in the work zone, and the requirement that all visitors be escorted while in the work zone.

7.3.2 Radiation Worker Training

Radiation Worker Training (RWT) will be administered to all employees performing invasive activities with radioactive materials. RWT will address the following topics:

- Radioactivity and radioactive decay;
- Characteristics of ionizing radiation;
- Man-made radiation sources;
- Acute effects of exposure to radiation;
- Risks associated with occupational radiation exposures;
- Special considerations in the exposure of women of reproductive age;
- Dose-equivalent limits;
- Modes of exposure - internal and external;
- Dose-equivalent determinations;
- Basic protective measures - time, distance, shielding;
- Specific procedures for maintaining exposures as low as reasonably achievable (ALARA);
- Radiation survey instrumentation, calibration, use and limitations;
- Radiation monitoring programs and procedures;
- Contamination control, including protective clothing, equipment and work place design;
- Personnel decontamination;
- RWP issue, modification, termination and use;
- Emergency procedures;
- Warning signs, labels, and alarms;
- Responsibilities of employees and management; and

- How to contact project radiation safety staff.

RWT will consist of a classroom lecture and procedure review, a half-hour practical and demonstration. The duration of training will be approximately three (3) hours. An exam to test employee proficiency in the class topics shall be administered and a passing score of 80% is required. Refresher training will be provided annually thereafter.

7.3.3 Tailgate Safety Training

Tailgate safety meetings will be conducted at the beginning of each work shift, whenever significant changes are made in job scope, or whenever new personnel arrive at the job site. The meetings will present radiation safety as well as health and safety procedures and issues for the day, any unique hazards associated with an activity and review any significant topics from previous activities. The information discussed will be recorded, which will serve as confirmation that the information was presented to those persons whose signatures are on the form.

7.3.4 Training Records

A form will be developed to demonstrate that training commitments are being met. The form will capture the following information: the facility, date, time, type of work, hazardous/radioactive materials used, protective clothing/equipment, chemical hazards, radiological hazards, physical hazards, emergency procedures, special equipment, and any other safety topics that may be relevant.

8.0 HEALTH AND SAFETY PROGRAM

DDES is committed to implementing this Cleanup Plan in a manner that ensures the health and safety of workers, the surrounding environment and the public. Consequently, comprehensive health and safety requirements and access controls will be specified in the final work plans. These requirements will remain in effect during all decommissioning activities. DDES will also verify there is sufficient documentation to demonstrate the effectiveness of the health and safety program.

This chapter of the CP describes those measures that will be used to control and monitor the impacts of ionizing radiation on workers. The Radiation Protection Program described herein is designed to be compliant with U. S. Nuclear Regulatory Commission (NRC) regulations in 10 CFR Parts 19 and 20 and provisions in License No. 56-0623 and is implemented through a set of approved radiation safety procedures.

At a minimum, DDES will maintain a copy of DDES radiation safety procedures for regulatory inspection.

Each member of the decommissioning project team will assume certain health and safety responsibilities. These will include, but are not limited to, the following:

- The RSO is responsible for providing oversight for implementation of the Cleanup Plan and making changes to reflect field situations that were not anticipated during the plan's initial development. Changes in the radiation protection program can only be made with the concurrence of the RSO.
- The designated health and safety contact for each subcontractor is responsible for verifying field implementation of the radiation protection program provisions. This verification includes communicating site requirements to all personnel on the job, field supervision, and consultation with the RSO regarding appropriate changes to this Cleanup Plan.
- All on-site project personnel are responsible for understanding and complying with all site health and safety requirements, including proper maintenance of health and safety

equipment and facilities. This understanding will be documented by signature prior to any team member being authorized to work on decommissioning operations.

DDES will provide a work-place environment in which employees, visitors and contractors are adequately protected from hazards, including the hazards associated with exposure to radiation and radioactive material. While the exposures associated with the planned decommissioning operations are low, all exposures are assumed to entail some risk to the employee.

The ALARA requirement will be communicated to all personnel at the outset of this project. All individuals must understand their responsibilities to reduce their radiation exposure. Methods to be used to achieve exposure reduction will be reviewed during General Employee Training and Tailgate Safety Training. Monitoring and surveillance information will be summarized and reviewed by the work force on a planned and periodic basis.

8.1 Radiation Safety Controls and Monitoring for Workers

Radiation, airborne radioactivity and contamination surveys during decommissioning will be conducted in accordance with approved procedure(s) (HP-MA-06, HP-MA-07, HP-MA-12). The purposes of these surveys will be to:

- Protect the health and safety of workers,
- Protect the health and safety of the general public, and
- Demonstrate compliance with applicable license, federal and state requirements, as well as Cleanup Plan commitments.

Radiation safety personnel assigned to the project will verify the presence and adequacy of posted radiological warning signs during the conduct of these surveys. Surveys will be conducted in accordance with procedures utilizing survey instrumentation and equipment suitable for the nature and range of hazards anticipated. Equipment and instrumentation will be calibrated and, where applicable, operationally tested prior to use in accordance with procedural requirements. Routine surveys will be conducted at a specified frequency to ensure that contamination and radiation levels in unrestricted areas do not exceed license, federal, state or site limits. Radiation protection staff will also perform surveys during decommissioning whenever work activities create a potential to impact radiological conditions.

Control levels have been established for the decommissioning actions. Based upon knowledge of the radiological constituents present at the site and existing exposure rates, it is expected that maximum individual personnel exposures will not exceed 100 millirem TEDE over the life of the project. Surveillances will be performed to verify that exposures are minimized and within applicable limits.

Because the exposure potential is expected to be less than 500 millirem TEDE, individual monitoring for on-site personnel is not required, however DDES will require both internal and external dose monitoring for the decommissioning project as a conservative measure.

8.1.1 Work Area Air Sampling Program

The air sampling program during decommissioning will be implemented to assure that workers are adequately protected from inhalation of radioactive material. Air sampling will be performed for decommissioning activities involving disturbance or handling of contaminated material where employee exposures could be expected to receive an internal exposure of more than ten (10%) percent of an Annual Limit on Intake (ALI, as specified in 10 CFR 20, Appendix B, Table 1) for Ra-226. DDES will collect both personal and area sampling using approved procedures for collecting representative air samples.

Following collection of air samples, a screening analysis for gross alpha air activity will be performed. Samples will be analyzed on a Ludlum 3030 (or instrument of similar sensitivity). In order to account for Radon-222/220 interference during this initial analysis and determine if airborne radioactivity concentrations are at acceptable levels, alpha to beta ratios will be determined and used. Final air sampling results will not be available for three days following collection to allow for decay of Radon-222/220 short-lived daughters. Once the final results are available, airborne radioactivity concentrations will be documented in accordance with approved procedures.

8.1.2 Respiratory Protection Program

In controlling the concentrations of radioactive materials in air, the use of process controls, engineering controls or administrative procedures will be used. Examples may include the use of exhaust ventilation, diversion of air flow, dust suppression, fixative coatings, etc. The use of respiratory protection will be implemented to reduce the projected work dose in compliance with the ALARA principal.

The program will require use of National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) certified equipment, and procedures that comply with 10 CFR 20, Subpart H. At a minimum, respiratory protection procedures will address the following elements:

- Monitoring, including air sampling and bioassays;
- Supervision of the program, including program audits;
- Training and minimum qualifications of respirator program supervisors and implementing personnel;
- Training of respirator users, including the requirement for each user to inspect and perform a user seal check (for face-sealing devices) or an operational check (non-face-sealing devices) on a respirator each time it is donned;
- Fit-testing requirements;
- Selecting respirators;
- Maintaining breathing air quality;
- Inventory and control of respiratory protection equipment;

- Storage and issuance of respiratory protection equipment;
- Maintenance, repair, testing, and quality assurance of respiratory protection equipment;
- Recordkeeping; and
- Limitations on periods of respirator use and relief from respirator use.

The Project Manager and the RSO will jointly determine the need for and on the procedural requirements prior to implementing a respiratory protection program.

NIOSH approved loose fitting positive pressure air purifying respirators will be used (i.e., full face piece assemblies with air purifying elements to provide respiratory protection against particulate matter and/or hazardous vapors and gases.

Respiratory protective equipment will be kept in proper working order. When any respirator shows evidence of excessive wear or has failed inspection, it will be repaired or replaced. Respiratory protective equipment that is not in use will be stored in a clean dry location.

8.1.3 Internal Exposure Determination

A combination of bioassay and breathing zone air sampling will be used to determine internal exposures incurred by decommissioning workers while on site. Workers will submit a bioassay at the end of the project due to the short project timeframe. In addition, special bioassays may be required in the event air sample data and/or process knowledge warrants stricter monitoring. All samples will be analyzed by a laboratory that meets the performance criteria in ANSI N13.30.

The RSO (or designee) will determine the validity of bioassay and air monitoring results prior to their inclusion in the internal dose assessment process. The RSO will typically evaluate the following items to ascertain the validity of monitoring results:

- sample collection errors;
- radiation background interference during counting;
- calibration errors;
- computer software errors;
- errors due to counting geometry; and
- statistical errors.

Only valid bioassay or air monitoring results, as determined by the RSO, will be used for assessment of internal radiation dose. If the data is not valid, the RSO will document the basis for that conclusion and include the documentation in the individual's dosimetry record. The RSO will also estimate the internal dose to the individual via other means and include the estimate in the individual's exposure history. The RSO will identify the route of entry (i.e., inhalation, ingestion, etc.), as the most likely route based upon current knowledge of exposure conditions. The lung clearance class for intake by inhalation will be selected based upon current knowledge of the chemical form and/or particle size.

The CEDE (stochastic) incurred by workers will be estimated by:

$$CEDE\ (millirem) = \frac{Intake}{ALI_S} \times 5{,}000$$

where Intake = the activity taken into the body as determined from bioassay measurements, and ALIS = the stochastic Annual Limit on Intake for the radionuclide of interest. Committed dose equivalents to particular organs or tissues of interest (CDE) will be estimated by:

$$CDE_T\ (millirem) = \frac{Intake}{ALI_{NS}} \times 50{,}000$$

where Intake = the activity taken into the body as determined from bioassay measurements or air monitoring results, and the ALINS = the non-stochastic

Annual Limit on Intake for the radionuclide of interest. To determine the contribution of CDE to the CEDE, the CDE is multiplied by the appropriate organ dose weighting factor specified in 10 CFR 20.1003.

In general, minors will be excluded from work with the potential for intakes of radioactive material. Internal exposure determinations for declared pregnant workers will be based on air monitoring results unless the RSO (or designee) determines that special bioassay sampling is warranted. These intakes will be converted into a dose to the embryo/fetus based on methodologies discussed in Regulatory Guide 8.36.

8.1.4 External Exposure Determination

Individual monitoring devices, at a minimum, will consist of a whole body thermoluminescent dosimeter (TLD) or equivalent (e.g., optical dosimeter, etc.). The TLDs will be ordered from a vendor that has been approved in advance by the Decommissioning Contractor, and whose program has met the requirements of ANSI N13.11. In addition, the vendor must demonstrate accreditation by National Voluntary Laboratory Accreditation Program (NVLAP), which includes range, sensitivity and accuracy performance criteria. TLDs will be processed at the end of the quarter and individual doses will be tracked.

8.1.5 Summation of Internal and External Exposures

Internal and external radiation exposures will be assessed for the project. The total organ dose equivalent (TODE) is computed by summing the deep dose equivalent (DDE) from external sources, as determined from external radiation monitoring, and the CDE, as determined from internal radiation monitoring. The TEDE is determined by summing the CEDE from sources internal to the body and the DDE.

8.2 Contamination Control Program

The procedures for accessing contaminated areas will address the responsibilities of all personnel permitted access, contamination limits, posting, labeling and tagging requirements, protective clothing requirements of each level of contamination encountered, entry and exit requirements, measurement methodologies, decontamination of personnel and training requirements, as described in DDES's HP Procedures. Routine surveys will be performed throughout the decommissioning activities to assess contamination control methodologies.

The initial level of protection for the intrusive tasks of the decommissioning operations (i.e., where residual radioactivity may be encountered) will be hard hats, respirators, Tyvek coveralls, safety glasses with side shields, steel-toed boots, and gloves. Upgrading or downgrading of the level of protection will be specified by the RWP.

To assure radioactive materials remain under the control, each person performing invasive activities frisk using calibrated, handheld instrument prior to leaving the contaminated work area. Equipment, people and materials will be frisked and decontaminated prior to exiting the controlled area. Records of release surveys will be maintained on standardized forms and maps. Release criteria will be consistent with those shown in the Final Status Survey Plan.

8.3 Instrumentation Program

Radiation survey equipment and instrumentation suitable for detecting and quantifying the radiological hazards to workers and the public will be used. The selection of equipment and instrumentation to be utilized will be based upon knowledge of the radiological contaminants and concentrations that were identified during the scoping survey.

All instruments will be calibrated and maintained according to applicable HP Procedures. Instruments will be calibrated using radiation sources which are National Institute of Standards and Technology (NIST) traceable. The methods used to estimate uncertainty bounds for each type of instrumental measurement will be as specified in ANSI N323.

Each instrument will be response-checked using a reference source and have pre-operational checks performed daily. Pre-operational checks will include battery function, response to reference source, reset button function, audible response function if applicable, physical condition, current calibration and response to background radiation. These results will be documented and any instruments failing any of the pre-operational checks will be tagged and taken out of service.

8.4 Health Physics Audits, Inspections and Recordkeeping

Informal assessments and inspections will be completed by the RSO (or designee) on a daily basis, with unexpected, non-conforming, or unusual items and situations documented, along with their resolution. These assessments and inspections will include performance and documentation of radiological surveys, radiological work practices, posting and labeling, contamination control, and internal and external dosimetry. Due to the frequency of these informal assessments and inspections, they serve as routine, unannounced inspections by the RSO (or designee).

Any findings identified during formal assessments or informal assessments and inspections will be evaluated by the RSO for compliance with license commitments or NRC requirements. Documentation of such evaluations will be maintained and available for inspection, including corrective actions taken to prevent recurrence and any follow-up to verify effectiveness of corrective actions. Records of RSO audits will include the dates of the audit, the name of the auditor, persons contacted by the auditor, areas audited, audit findings, corrective actions, and any follow-up required.

9.0 ENVIRONMENTAL MONITORING AND CONTROL PROGRAM

We are committed to reducing exposures to radioactive materials to levels that are ALARA. Exposures should be reduced to ALARA to employees and members of the public living near the site. Potential pathways for exposure exist during the removal of contaminated building surfaces. Engineering and administrative controls will be implemented when performing invasive activities which could generate radioactive particulate inside the buildings. No invasive activities are planed exterior of the building.

Sealed enclosures fitted with High-Efficiency Air Particulate (HEPA) filtered negative pressure air scrubbers will be used in the general work area. These will be combined with the use of HEPA filtered vacuums at the point of operation to control fugitive emissions. Fixative agents will be used to further reduce the levels of removable contamination on surfaces designated for removal.

10.0 RADIOACTIVE WASTE MANAGEMENT PROGRAM

It is estimated that approximately 3 cubic yards of radioactive waste will be generated from the removal of flooring from the decontamination of building surfaces. An additional 1 cubic yard of radioactive waste will be generated from plastic sheeting, PPE, used HEPA filters, etc. from materials that come into direct contact with contamination while performing the scope of work. Radioactive waste management is key to controlling the total cost for the cleanup of this site. The majority of waste will be composed of wood flooring that will have a low density; therefore, packaging of the material to get the highest density per cubic foot will optimize budget for waste disposal. Waste Packages will be secured in an unoccupied and locked area at the site.

The radioactive waste will be shipped to Veolia Alaron ES LLC in Wampum, PA. This processor is permitted to accept the remediation waste generated under this scope.

There is the potential to generate radioactive waste that contains lead based paint from remediation activities at the site. These wastes will be separated from non-lead containing wastes. They will be tested by an offsite laboratory using the Toxicity Characteristic Leaching procedure (TCLP) to determine if they area hazardous for lead. These wastes are acceptable for disposal at the US Ecology facilities previous listed. A separate waste acceptance profile will be completed and waste stabilization will occur at the designated facility prior to disposal.

11.0 QUALITY ASSURANCE PROGRAM

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

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

12.0 Release Surveys

Release surveys for materials and equipment that may become surface-contaminated during decommissioning will be performed using portable radiation survey instruments. Table 12-1 describes the criteria for materials and equipment release as they are taken from Table 1 of U. S. Nuclear Regulatory Commission (NRC) Regulatory Guide No. 8.23 Revision 1("Radiation Safety Surveys at Medical Institutions", January, 1961), which is consistent with the guidance found in NUREG-1757, Vol. 1, Section 15.11.1.1:

Table 12-1

Material and Equipment Release Criteria

Radionuclide(a)	Acceptable Surface Contamination Limits (dpm/100 cm^2)		
	Average[b, c]	Maximum [b, d]	Removable [b, c]
U-Natural, U-235, U-238, and associated decay products	5,000	15,000	1,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U- 232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneours fission) except Sr-90 and others noted above.	5,000	15,000	1,000

Notes	
a)	Where surface contamination by both alpha- and beta-gamma emitting nuclides exists, the limits established for alpha-and beta-gamma emitting nuclides are to be applied separately.
b)	As used in this table, disintegrations per minute (dpm) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
c)	Measurements of average contaminant will not be averaged over more than one (1) square meter. For objects of less surface area, an average will be derived for each object.
d)	The maximum contamination level applies to an area not more than 100 square centimeters (cm^2).
e)	The amount of removable radioactive material per 100 cm^2 of surface area will be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels will be reduced proportionately and the entire surface will be wiped

12.1 Remedial Action Support Surveys

DDES will conduct remedial action surveys to guide clean-up actions and provide updated estimates of site-specific parameters used for final status survey planning. These surveys may consist of surface scans, volumetric screening, composite sampling and offsite analysis.

12.2 Final Status Survey Design

At the conclusion of decommissioning activities, DDES will submit to the NRC a Final Status Survey Report that is compliant with the content requirements specified in the Plan.

13.0 FINANCIAL ASSURANCE

The cost estimates for the decommissioning actions described in this CP were developed using a variety of cost-estimating data, including vendor-provided information, conventional cost-estimating guides, prior experience, and prior similar estimates as modified by site-specific information. Site-cost experience and good engineering judgments were also used to identify those items that will control the estimates. In addition, the following were also assumed:

- The estimated inventories of radioactive materials are representative of the quantities that are present at the time decommissioning activities begin.
- The decommissioning effort will begin upon NRC approval of this CP.
- Unit costs presented in the cost estimates represent materials, labor, equipment, and overhead and profit (O&P) costs. For cost data sources that did not include O&P, a value equal to 25% of the combined materials, labor and equipment cost was used to represent O&P.
- In accordance with NRC guidance, a 25 percent contingency has been added to both the capital costs and the long-term surveillance and monitoring costs of all alternatives.

The estimated present cost for the cleanup of the former Waterbury Clock Factory Building is $37,022 and would be completed in one week.

13.1 Certification Statement

New Opportunities, Inc. will be responsible for funding the Cleanup Plan and Final Status Survey of the Former Waterbury Clock Factory Site.

ATTACHMENT A

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

ATSDR Agency for Toxic Substances & Disease Registry Public Health Assessments & Health Consultations

PUBLIC HEALTH ASSESSMENT

PUBLIC HEALTH IMPLICATIONS OF RADIATION CONTAMINATION AT FORMER CLOCK FACTORIES LOCATED IN
BRISTOL (HARTFORD COUNTY), NEW HAVEN (NEW HAVEN COUNTY), THOMASTON (LITCHFIELDCOUNTY), AND WATERBURY (NEW HAVEN COUNTY)
CONNECTICUT

DISCUSSION

Radiation Surveys

Radiation surveys included gamma, alpha, beta radiation, and radon gas sampling. The gammaradiation measurements included direct contact, and waist level or general area readings. The waistlevel readings are measured at three feet from the suspected source.

The alpha and beta radiation measurements were reported as either fixed or smearable. Thesmearable results indicate that radioactive contamination is present. The units of radiation aredependent on the radiation type and measurement techniques. Gamma radiation is generally reportedin uR/hr (micro Roentgen per hour). Alpha and beta radiation units are either reported as counts perminute (cpm) or disintegrations per minute (dpm). The value of dpm will always be greater than thevalue for counts per minute, since the efficiency for the alpha detector is approximately 30 percentand the beta/gamma detector is approximately 10 percent. Radon is a radioactive gas that is a decayproduct of radium. The units of measurement are pCi/L (pico Curie per liter).

The CT DEP requested radiological assistance from the US Department of Energy (DOE) on April1, 1998. Surveying was conducted from April 2, 1998, to April 7, 1998.

On April 2, 1998, the DOE/CT DEP team conducted sampling at the Waterbury Clock Companyincluding, the Ville Swiss Automatics and Belco.

On April 3, 1998, the investigation proceeded to the former Lux Clock Company in Waterbury.

On April 6, 1998, the radiation survey investigated the former Seth Thomas Clock company inThomaston, as well as the former Benrus Clock Company in Waterbury.

On April 7, 1998, the Thomaston radiation survey was completed, and a separate survey wasconducted in New Haven.

The results of the radiation surveys are presented below in Tables 2 through 14. Each table identifiesthe town name, former clock company name, current occupant, location of sample, maximumradiation levels detected, background levels, and the relevant comparison value. In 1997, EPA issuedOSWER Directive 9200.4-18, Establishment of cleanup levels for Superfund sites with radioactivecontamination. This directive provides guidance for establishing protective cleanup levels forradioactive contamination at Superfund sites. Using this directive, an effective dose of 15 mRem/yrequates to an increased lifetime risk of 3 in 10,000 of cancer, serving as the upper bounds of EPAacceptable risk. This would include exposures from all pathways, and through all media (*e.g.*, soil,ground water, surface water, sediment, air, structures, biota).

Results of Radiation Surveys

Occupant(s): DABKO CO.

Table 2.

Town: Bristol Clock Company Name: Sessions Clock Company Current

Radiological Parameter (units)	Location	Floor	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	Building A	2nd floor	not applicable	0	NR	15
		3rd floor	not applicable	0		
		4th floor	not specified	120		
	Building D	2nd floor	not applicable	0	NR	NR
		3rd floor	not specified	40		

CL = EPA Cleanup Level
NR = not reported
uR/hr = Micro Roentgen per hour

Table 3.

Town: Bristol Clock Company Name: Sessions Clock Company Current Occupant(s): Bristol Instrument Gears

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	15	5	15
		Measured at Waist level	12		
Alpha, Beta gamma activity		not measured			

CL = EPA Cleanup Level
uR/hr = Micro Roentgen per hour

Table 4.

Town: New Haven Clock Company Name: New Haven Clock Company Current Occupant(s): Goodies Repairs

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	35	10	15
		Measured at Waist level	13		
Alpha, Beta gamma activity		not measured			

CL = EPA Cleanup Level
uR/hr = Micro Roentgen per hour

Table 5.

Town: Thomaston Clock Company Name: Seth Thomas Clock Company Current Occupant(s): Various Companies

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	100	12	15
		General Area	40		
	2nd floor	Direct contact	80		
		General Area	25		
	3rd floor	Direct contact	650		
		General Area	80		
	4th floor	Direct contact	45		
		General Area	12		
Alpha activity (net cpm) DP (cpm/100 cm²) DP (cpm/100 cm²) DP (cpm/100 cm²) DP (cpm/100 cm²)	1st floor	Fixed	0	0	300 20*
		Measurement of Loose Material (Smear)	0	0	
	2nd floor	Fixed	not measured	NR	300 20
		Measurement of Loose Material (Smear)	0	0	
	3rd floor	Fixed	100	0	300 20
		Measurement of Loose Material (Smear)	10	0	
	4th floor	Fixed	550	0	300

		Measurement of Loose Material (Smear)	50	0	20
Beta Gamma activity (net cpm) DP (cpm/100 cm²) DP (cpm/100 cm²) DP (cpm/100 cm²) DP (cpm/100 cm²)	1st floor	Fixed	6,000	50	300 20
		Measurement of Loose Material (Smear)	0	50	
	2nd floor	Fixed	500	50	300 20
		Measurement of Loose Material (Smear)	0	0	
	3rd floor	Fixed	3,000	50	300 20
		Measurement of Loose Material (Smear)	30	50	
	4th floor	Fixed	1,300	50	300 20
		Measurement of Loose Material (Smear)	30	50	

CL = EPA Cleanup Level
cpm = counts per minute
dpm = disintegrations per minute
NR = not reported, background counting rates ranged from 0.2-0.3 cpm for alpha, and 30-50 cpm for beta/gamma.
uR/hr = Micro Roentgen per hour
*The cpm units can be converted into dpm units, however the calibration isotope is required for this. In general, if an unconverted cpm value exceeds the dpm cleanup level, then the converted value will also be greater.

Table 6.

Town: Waterbury Clock Company Name: Benrus Clock Company Current Occupant(s): Bender Plumbing

Radiological Parameters (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	0	10	15
		Measured at Waist level	0		
	2nd floor	Direct contact	0		
		Measured at Waist level	0		
	3rd floor	Direct contact	0		
		Measured at Waist level	0		

	4th floor	Direct contact	120		
		Measured at Waist level	26		
	5th floor	Direct contact	40		
		Measured at Waist level	15		
	6th floor	Direct contact	0		
		Measured at Waist level	0		
	7th floor	Direct contact	600		
		Measured at Waist level	100		
Radon-222 (pCi/L)	4th floor	Not applicable	1.0	NR	4

CL = EPA Cleanup Level
NR = not reported
pCi/L = Pico Curries per Liter
uR/hr = Micro Roentgen per hour

Table 7.

Town: Waterbury Clock Company Name: Lux Clock Company Current Occupant(s): Anchor Advanced Products

Radiological Parameters (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	20	10	15
	2nd floor	Direct contact	20		
	3rd floor	Direct contact	30		
	4th floor	Direct contact	140		
Alpha Beta activity(dpm)	1st floor	Measurement of Loose Material (Smear)	not measured	NR	20
	2nd floor	Measurement of Loose Material (Smear)	not measured	NR	
	3rd floor	Measurement of Loose Material (Smear)	not measured	NR	
	4th floor	Measurement of Loose Material (Smear)	150	NR	

CL = EPA Cleanup Level
dpm = disintegrations per minute
NR= not reported, background counting rates ranged from 0.2-0.3 cpm for alpha, and 30-50 cpm for beta/gamma.

uR/hr = Micro Roentgen per hour

Table 8.

Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): Belco 2nd floor

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	Cutting Room	Direct contact	55	10	15
		Measured at Waist level	55		
	Machine Room	Direct contact	140		
		Measured at Waist level	140		
Alpha activity(dpm/100 cm²)	Cutting Room	Measurement of Loose Material (Smear)	<MDA	NR	20
	Machine Room	Measurement of Loose Material (Smear)	150	NR	
Beta Gamma activity(dpm/100 cm²)	Cutting Room	Measurement of Loose Material (Smear)	<MDA	NR	20
	Machine Room	Measurement of Loose Material (Smear)	232	NR	

<MDA = less than minimum detected activity
CL = EPA Cleanup Level
dpm = disintegrations per minute
NR = not reported, background counting rates ranged from 0.2-0.3 cpm for alpha, and 30-50 cpm for beta/gamma.
uR/hr = Micro Roentgen per hour

Table 9.

Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): Belco 3rd floor Highest radiation level detected

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	Hallway	Direct contact	5,000	10	15
		Measured at Waist level	1,500		
	Store room	Direct contact	3,200		
		Measured at Waist level	250		

	Liba room	Direct contact	300		
		Measured at Waist level	52		
Alpha activity (dpm/100 cm²)	Hallway	Measurement of Loose Material (Smear)	7,985	NR	20
	Store room	Measurement of Loose Material (Smear)	4,438	NR	
	Liba room	Measurement of Loose Material (Smear)	328	NR	
Beta Gamma activity (dpm/100 cm²)	Hallway	Measurement of Loose Material (Smear)	16,636	NR	20
	Store room	Measurement of Loose Material (Smear)	9,242	NR	
	Liba room	Measurement of Loose Material (Smear)	695	NR	

CL = EPA Cleanup Level
dpm = disintegrations per minute
NR = not reported, background counting rates ranged from 0.2-0.3 cpm for alpha, and 30-50 cpm for beta/gamma.
uR/hr = Micro Roentgen per hour

Table 10.

Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): Belco 4th floor

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	Store room	Direct contact	120	10	15
		Measured at Waist level	70		
Radon-222 (pCi/L)	4th floor	not applicable	6.5	NR	4
Alpha activity (dpm/100 cm²)	Store room	Measurement of Loose Material (Smear)	19	NR	20
Beta Gamma activity (dpm/100cm²)	Store room	Measurement of Loose Material (Smear)	<MDA	NR	20

CL = EPA Cleanup Level
dpm = disintegrations per minute
NR = not reported, background counting rates ranged from 0.2-0.3 cpm for alpha, and 30-50 cpm for beta/gamma.
pCi/L = Pico Curries per Liter

uR/hr = Micro Roentgen per hour

Table 11.

Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): Belco 5th floor

Radiological Parameter (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	Rental area	Direct contact	800	10	15
		Measured at Waist level	800		
Alpha activity (dpm/100 cm²)	Rental area	Measurement of Loose Material (Smear)	247	NR	20
Beta Gamma activity(dpm/100 cm²)	Rental area	Measurement of Loose Material (Smear)	516	NR	20

CL = EPA Cleanup Level
dpm = disintegrations per minute
NR = not reported, background counting rates ranged from 0.2-0.3 cpm for alpha, and 30-50 cpm for beta/gamma.
uR/hr = Micro Roentgen per hour

Table 12.

Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): Enterprise Apartments

Radiological Parameters (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	0	10	15
		Measured at Waist level	0		
	2nd floor	Direct contact	0		
		Measured at Waist level	0		
	3rd floor	Direct contact	0		
		Measured at Waist level	0		
	4th floor Apt 417	Direct contact	240		
		Measured at Waist level	15		
	5th floor Apt 505	Direct contact	30	7	
		Measured at Waist level	12		

	5th floor Apt 507	Direct contact	90	10	
		Measured at Waist level	30		
	5th floor Apt 508	Direct contact	28	8	
		Measured at Waist level	12		
	5th floor Apt 512	Direct contact	30	7	
		Measured at Waist level	15		
	5th floor Apt 513	Direct contact	45	8	
		Measured at Waist level	15		
	5th floor Apt 514	Direct contact	100	10	
		Measured at Waist level	30		
	5th floor Apt 515	Direct contact	110	8	
		Measured at Waist level	20		
	5th floor Apt 516	Direct contact	25	12	
		Measured at Waist level	15		
	5th floor Apt 517	Direct contact	120	10	
		Measured at Waist level	18		
	5th floor Apt 520	Direct contact	30	10	
		Measured at Waist level	15		
	5th floor Apt 525	Direct contact	70	8	
		Measured at Waist level	12		
	5th floor Hall	Direct contact	800	8	
		Measured at Waist level	80		
Radon-222 (pCi/L)	4th floor	Not applicable	1.5	NR	4

CL = EPA Cleanup Level
NR = not reported
pCi/L = Pico Curries per Liter
uR/hr = Micro Roentgen per hour

Table 13.
Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): NOW 3rd through 5th Floors

Radiological Parameters (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	3rd floor	Direct contact	60	10	15
		Measured at Waist level	18		
	4th floor	Direct contact	180	12	
		Measured at Waist level	35		
	5th floor	Direct contact	4,000	12	
		Measured at Waist level	125		
Radon-222 (pCi/L)	3rd floor	Not applicable	0.8	NR	4
	4th floor	Not applicable	8.5		

CL = EPA Cleanup Level
NR = not reported
pCi/L = Pico Curries per Liter
uR/hr = Micro Roentgen per hour

Table 14.
Town: Waterbury Clock Company Name: Waterbury Clock Company Current Occupant(s): Ville Swiss Automatics Automotive 3rd through 5th Floors

Radiological Parameters (units)	Location	Measurement Description	Maximum Level	Background	CL
Gamma radiation (uR/hr)	1st floor	Direct contact	Nd		15
		Measured at Waist level	Nd		
	2nd floor	Direct contact	Nd		
		Measured at Waist level	Nd		
	3rd floor	Direct contact	100	20	
		Measured at Waist level	20		
	4th floor	Direct contact	40	20	
		Measured at Waist level	20		
	5th floor	Direct contact	40	13	
		Measured at Waist level	13		

Radon-222 (pCi/L)	4th floor	Not applicable	0.3		4

CL = EPA Cleanup Level
Nd = none detected
pCi/L = Pico Curries per Liter
uR/hr = Micro Roentgen per hour

Radium Toxicity

Studies have shown that internal deposition of ^{226}Ra results in the induction of skeletal tumors andparanasal sinus carcinomas (cancer of the sinus cavities) (3, 4). Argonne National Laboratory andits' Center for Human Radiobiology have studied the human health effects of radium deposition forover 20 years. Stebbings, *et al.* (5) reported that in U.S. white females employed as dial painters, therates of liver, pancreatic, cervical, and uterine cancers were not related to radium exposure. Somecancers of the digestive system, however, may have been indirectly related to radium exposure. Theyreported that although, there was an increase in multiple myeloma (a form of leukemia), indicationswere that this increase was related more to the length of employment as a dial painter than the amountof radium in the body. This indirectly suggests the myeloma may be due to the external exposure tothe gamma radiation emitted during the radioactive decay of ^{226}Ra.

The major health effects resulting from internally deposited ^{226}Ra are noted in cases dealing withoccupational exposure, the majority being radium dial painters. The alpha particle is the major typeof damaging radiation from internalized (inhaled or ingested) ^{226}Ra. This decay particle travels veryshort distances within the body and the majority, if not all its energy is absorbed within the body partwhere the ^{226}Ra is deposited. ^{226}Ra has chemical characteristics similar to calcium therefore, most ofthe ingested ^{226}Ra deposits in bones where the greatest exposure and dose is delivered to bonesurfaces and perhaps the blood-forming bone marrow. Additionally, more specific informationregarding ^{226}Ra is given in Appendix A.

As of 1984, almost 6,000 individuals with all types of exposure to radium had been locatedthroughout the United States (6). Of the 6,000 identified, 1,907 dial painters were located and hadtheir radium body burden measured. In this group, there were 44 cases of bone tumors and 19 casesof sinus or mastoid (associated with the head) carcinomas. These totals include three individuals withboth types of illnesses. The study concluded that these illnesses and skeletal tissue deterioration werenevertheless unquestionably related to the presence of internal radium.

Radiation doses and related information: International and National

The National Council on Radiation Protection and Measurements (NCRP) is a non-governmentalbody that makes recommendations to the radiation protection community within the United States. In 1987, the NCRP recommended that in the case of continuous or frequent exposure to radiation,a population should not exceed 1 milliSieverts (mSv; 100

milliRem per year [mRem/yr]) abovebackground. For a population infrequently exposed, a limit of 5 mSv (500 mRem/yr) wasrecommended (7). In 1994, the NCRP reaffirmed and refined these exposure limits (8).

Smear Samples

The radiation protection industry has adopted stringent, acceptable levels of surface contaminationthat is fixed in place (non-removable) or that which can be removed from the contaminated surface. In the case of removable contamination, these levels are determined by taking a surface smear froma square meter area and averaging the results per 100 square centimeters (cm^2). The radioactivematerial collected by this procedure is analyzed for the specific radionuclide. For non-removable^{226}Ra, the average allowable limit is 100 dpm per 100 cm^2, and the maximum allowable limit in any100 cm^2 area is 300 dpm. If more than 20 dpm can be removed, then the contaminated surfaceexceeds these federal standards (9).

The US Environmental Protection Agency (EPA) uses Applicable or Relevant and AppropriateRequirements (ARAR) which, in many cases, serve as the determining factor for site cleanup. Because the contamination in these non-Superfund facilities are not specifically addressed by ARARvalues, the EPA can set site specific cleanup levels. In 1997 EPA issued OSWER Directive 9200.4-18. Establishment of cleanup levels for Superfund sites with radioactive contamination (10). Thisdirective provides guidance for establishing protective cleanup levels for radioactive contaminationat superfund sites. Using this directive, an effective dose of 0.15 milliSieverts (mSv; 15 mRem/yr)equates to an increased lifetime cancer risk of 3 in 10,000, serving as the upper bounds of EPAacceptable risk.

Discussion of removable contamination

Removable contamination indicates how easily radiologic contamination might be transferred tohumans or other surfaces. This is performed by using a standard size paper swab and gently butfirmly rubbing the paper over an area of 100 square centimeters. The paper is then checked for typeof radioactivity removed and the results are expressed as disintegrations per minute (dpm) per 100square centimeters (cm^2) of surface. Surface contamination limits have been established for ^{226}Ra (9);the limit for removable ^{226}Ra contamination is 20 dpm/100 cm^2.

Discussion of Results

The following section summarizes the results presented in the tables above. This section describesthe results stratified by town and presents an overview of the radiation surveys conducted thus far. Locations that have not been fully characterized (identified previously pending data) are alsodiscussed.

Bristol:

All facilities in the Sessions Clock Company were examined. Radiation was detected in two locations above the EPA risk-based cleanup level in two buildings. The locations included: a storage area on the 4th floor of building A, the other was located in an area designated as an old storage area on the 3rd floor of building D. These areas are not currently occupied. One area of the first floor of the Bristol Instrument Gears building was affected with radiation levels at the EPA risk-based cleanup level.

New Haven:

Club International is the current occupant of the four story building associated with the former New Haven Clock Company buildings. The first two floors are not affected, the third and fourth floors are pending further investigations.

Goodies Repairs is the current occupant of the two story building associated with the former New Haven Clock Company buildings. The first floor has one small spot identified as containing radiation levels above the EPA risk-based cleanup level. The second floor is pending further investigations.

St. John's Restaurant is the current occupant of the second four story building associated with the former New Haven Clock Company buildings. The first floor is not affected. The second through fourth floors are pending further investigations. There are several abandoned building also associated with the former New Haven Clock Company. These structures range in size from four to six floors. These have not been fully characterized and are pending further investigations.

Thomaston:

The Former Seth Thomas Clock Company was affected with radiation in isolated areas on the first through the fourth floors. Two companies located in the basement and a social club on the fourth floor are pending further investigations. The basement of this structure contains two areas not characterized and one identified as unaffected. The first floor was only affected in one facility, the Verka Enterprise. The second floor was affected in two locations which include the Gaynor Electric facility and WTM. The affected locations on the third floor included the Power Trans facility, the Global Spice Company, and J. McGowan facility. The fourth floor location identified as containing radiation levels above the EPA risk-based cleanup level is the storage area.

Waterbury-Benrus Clock Company:

Radiation levels were above the EPA risk-based cleanup level in isolated areas of the fourth, fifth, and seventh floors of the former Benrus Clock Company building. The current occupant is Bender Plumbing.

Waterbury-Lux Clock Company:

Radiation levels were above the EPA risk-based cleanup level in isolated areas of the first through the fourth floors of the former Lux Clock Company building. The current occupant is Anchor Advanced Products, which is also known as Lakewood Metals.

Waterbury-Waterbury Clock Company:

The affected areas of the former Waterbury Clock facility currently occupied by the Belco company include the cutting room and machine shop in the second floor; the store room, hallway, and Liba section of the third floor, the store room on the fourth floor, and the rental area of the fifth floor. The highest detected levels of radiation above the EPA risk-based cleanup level were located on the third floor hallway. This section is not frequently used. The radiation source has been covered with tape. The tape was used to prevent loose material from being relocated by accidental contact. This procedure will not, however, reduce gamma radiation levels emitted from that location.

Many of the areas within the Belco facility were checked for removable contamination using the procedure discussed in the previous section. The results indicated that in all areas checked, the removable contamination was positively identified as ^{226}Ra, and exceeded the regulations. These areas included: 1) the second floor machine shop 2) the third floor store room, hallway, and Liba 3) the fourth floor store room and 4) the fifth floor rental areas. In these areas, the removable alpha contamination ranged from approximately 20 dpm/100 cm^2 to over 7,900 dpm/100 cm^2. These areas contained beta/gamma removable contamination at levels ranging from approximately 200 dpm/100 cm^2 to over 16,600 dpm/100 cm^2. Because there is insufficient information as to the amount of dust loading in these areas, additional dose assessment is not possible at this time

The occupant of a second Former Waterbury Clock facility is the New Opportunities for Waterbury (NOW). This structure has thirteen offices identified as containing radiation levels above the EPA risk-based cleanup level. The third floor contains one of these offices, the fourth floor houses eight, and the fifth floor has four of these offices.

The five story building associated with the former Waterbury Clock Company which houses Ville Swiss Automatics Automotive is affected on isolated areas of the third through fifth floors.

Enterprise Apartments is located in another structure also associated with the former Waterbury Clock Company. This complex has radiation levels above the EPA risk-based cleanup level in isolated areas of one fourth floor apartment and in isolated areas of nine 5th floor apartments. Additionally a section of the fifth floor hallway is affected. Two additional apartments on the fifth floor contained radiation levels slightly below the EPA risk-based clean up levels at waist level, but exceeded this value with direct contact readings.

Pathway Analysis

To determine whether occupants, workers, or visitors have been or are being exposed to radiation,the CT DPH and the ATSDR evaluate the environmental and human exposure and an exposedpopulation. There are three types of exposures when radium is present:
- gamma ray exposure occurs when people are near the radium;
- radon exposure, occurs when radium decays into radon and is inhaled (breathed); and
- radium dust exposure occurs through inhalation, dermal contact (direct contact with the skin), andingestion (through the mouth) of dust.

The pathways analysis consist of: the source of contamination, a point of exposure, a route ofexposure, and an exposed population. The ATSDR categorizes exposure pathways as eithercompleted or potential pathways. For an exposure pathway to be completed all elements of thepathway must be present. Potential pathways are those where there is not sufficient evidence to showthat all the elements are present now, could be present in the future, or were present in the past.

Completed exposures have occurred to gamma ray and radon exposure to radium and radon. Thereis insufficient information to determine whether dust containing radium is present in the air of theaffected buildings. In addition, there is insufficient information regarding current or past exposuresto dust on any surface in the affected buildings. Consequently, the exposure pathway involving dustis considered potential.

Public Health Implications

Occupants of buildings identified with radium radiation levels above 15 mRem/yr may be at a lowincreased risk of developing bone cancer. This risk may be characterized as higher at locations wherethe radiation source has been identified as moveable (smearable). These locations may be exposingoccupants to an additional health risk due to inhalation and incidental ingestion of radium-contaminated dust particles. Additionally, elevated levels of radon gas were detected in the 4th floorof the Waterbury Clock Company building which now houses Belco. This concentration of radongas may increase the risk of developing lung cancer among occupants of that facility. The source ofthe radon gas is from the radiation decay products of ^{226}Ra.

Conclusions

1. The former Waterbury Clock factory buildings are contaminated in isolated areas with radioactive material emitting radiation at levels (as measured at waist level) that may pose a public health hazard to occupants of the buildings.
2. The former Sessions Clock Company in Bristol (in isolated areas of the fourth floor of building A and in isolated areas of the third floor of building D) are contaminated with elevated levels of radiation. The CT DPH understands that the locations where the radiation was detected is not currently occupied. However, if the use of these locations changes, occupants may be exposed to radiation at levels of a public health hazard. The Bristol Instrument Gears Company has radiation levels at the EPA risk-based cleanup level.
3. The former Seth Thomas Clock Company in Thomaston (in isolated areas of the first through the fourth floors) are contaminated with elevated levels of radioactive material. The occupants may be exposed to radiation at levels considered a public health hazard.
4. Many of the areas within the Belco facility were checked for removable contamination, and the results indicated that sections of each floor were contaminated with removable ^{226}Ra which exceeded the regulations. These areas included: 1) the second floor machine shop 2) the third floor store room, hallway, and Liba 3) the fourth floor store room and 4) the fifth floor rental areas.
5. Two sites, included as part of these radiation scoping surveys, have data gaps in New Haven and Thomaston. Specifically, the data gaps for the New Haven site include the third and fourth floors of the building which houses Club International, as well as the second through fourth floors of the building which currently houses St. John's Restaurant. The data gaps for the Thomaston site include two areas located in the basement, and a social club located on the fourth floor.

6. Locations that have been adequately characterized and do not contain radiation levels abovebackground, represent no public health hazard to the occupants.

Recommendations

1. Dissociate people from areas contaminated with radiation at levels exceeding the EPA directivefor establishing protective cleanup levels for radioactive contamination (15 mRem/yr). Thefollowing table lists the locations of elevated radiation levels:

Recommendations (continued)

Town	Clock Company	Current Occupant	Floor Location	
Bristol	Sessions Clock Company	DABKO CO	4th floor*	Building A
			3rd floor*	Building D
		Bristol Instrument Gears	1st floor*	
New Haven	New Haven Clock Company	Goodies Repair	1st floor*	
Thomaston	Seth Thomas Clock Company	Various Companies	1st floor*	
			2nd floor*	
			3rd floor*	
			4th floor*	
Waterbury	Lux Clock Company	Anchor Advanced Products	1st floor*	
			2nd floor*	
			3rd floor*	
			4th floor*	
	Benrus Clock Company	Bender Plumbing	4th floor*	
			5th floor*	
			7th floor*	
	Waterbury Clock Company	Belco	2nd floor*	Cutting Room
				Machine Room
			3rd floor*	Hallway
				Store room
				Liba room
			4th floor*	Store room
			5th floor*	Rental area

	Enterprise Apartments	4th floor*	Apt 417
		5th floor*	Apt 505 **
			Apt 507
			Apt 508
			Apt 512
			Apt 513
			Apt 514
			Apt 515
			Apt 516
			Apt 517
			Apt 520
			Apt 525 **
			Hall
	New Opportunities for Waterbury	3rd floor*	
		4th floor*	
		5th floor*	
	Ville Swiss Automatics Automotive	3rd floor*	
		4th floor*	
		5th floor*	

* Only isolated areas of the floors listed were affected.
** These apartments were slightly below the EPA risk-based cleanup levels at waist level, but exceeded this value on direct contact.

2. Mark all areas identified as containing radioactive contamination exceeding the EPA cleanup level of 15 mRem/yr.
3. Complete full radiation characterization surveys of all sites. Specifically, the following locations are pending further investigations in the New Haven Clock Company buildings: the third and fourth floors of the Club International Building, the second floor of the Goodies Repairs building, the second through the fourth floors of the building which houses St. John's Restaurant, and the multiple abandoned buildings. Additionally, the former Seth Thomas Clock Company in Thomaston has areas in the basement, and on the fourth floor that are pending further investigations.
4. ATSDR and the Connecticut Department of Public Health recommend that the amount of radioactive dust on the floors and in the air be determined in order to assess the radiologic inhalation and ingestion doses from ^{226}Ra.
5. Inform occupants of all buildings of the findings of this Public Health Assessment.

6. Radon sampling should be conducted to further characterize sites.

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