Case Study of Urban Residential Remediation and Restoration in Port Hope, Canada – 13250

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ABSTRACT

The Canadian Municipality of Port Hope, Ontario, is located some 100 km east of Toronto and has been the location of radium and/or uranium refining since the 1930s. Historically, these activities involved materials containing radium-226, uranium, arsenic and other contaminants generated by the refining process. In years past, properties and sites in Port Hope became contaminated from spillage during transportation, unrecorded, unmonitored or unauthorized diversion of contaminated fill and materials, wind and water erosion and spread from residue storage areas.

Residential properties in Port Hope impacted by radioactive materials are being addressed by the Canadian federal government under programs administered by the Low-Level Radioactive Waste Management Office (LLRWMO) and the Port Hope Area Initiative Management Office (PHAIMO). Issues that currently arise at these properties are addressed by the LLRWMO's Interim Waste Management Program (IWM). In the future, these sites will be included in the PHAIMO's Small Scale Sites (SSS) remedial program. The LLRWMO has recently completed a remediation and restoration program at a residential property in Port Hope that has provided learnings that will be applicable to the PHAIMO's upcoming SSS remedial effort. The work scope at this property involved remediating contaminated refinery materials that had been re-used in the original construction of the residence. Following removal of the contaminated materials, the property was restored for continued residential use. This kind of property represents a relatively small, but potentially challenging subset of the portfolio of sites that will eventually be addressed by the SSS program.

INTRODUCTION

In 2010, the owner and resident of a property in Port Hope, Ontario (see Fig. 1), requested that the Low-Level Radioactive Waste Management Office (LLRWMO), part of Atomic Energy of Canada Limited's (AECL) Waste Management and Decommissioning Division, survey the property for indications of radiological activity. The initial LLRWMO surveys identified some building materials exhibiting anthropogenic contamination and determined that additional investigations would be required to fully characterize its extent and potential significance. AMEC Environment and Infrastructure (AMEC) was retained by the LLRWMO in February 2011 to undertake the next phase of investigation which identified additional impacted building materials and concluded that more detailed intrusive investigations involving the removal of surface finishes and fixtures would be required to fully characterize the residence[1].

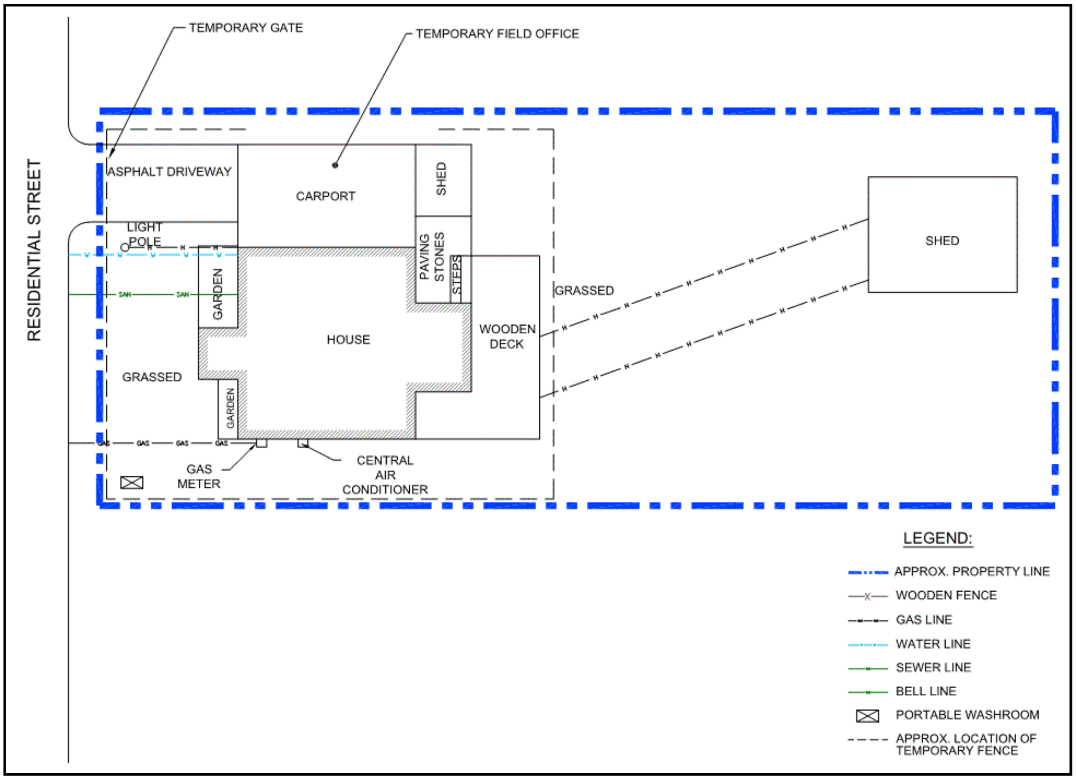

Fig. 1. General Arrangement of Subject Property

The intrusive investigation was completed in November and December of 2011[2]. Prior to the initiation of work, the residence was vacated and all contents removed, leaving only fixed chattels and fixtures. A Designated Substances Survey (DSS) was then completed by AMEC which identified the presence of chrysotile asbestos fibres in the wall and ceiling plaster (note: a DSS is required by the Province of Ontario's Occupational Health and Safety Act to identify biological, chemical and/or physical agents which have the potential to negatively impact on-site workers). Appropriate asbestos abatement processes and equipment were applied for the removal and handling of these materials. Upon removal of all chattels, fixtures, insulation and surface finishes, surface scanning identified an additional 40 impacted items on the main floor, attic area, and basement. In addition to the interior intrusive investigations, concurrent assessments of soils around and below the residence demonstrated that LLRW materials were not present.

PROJECT DEVELOPMENT

AMEC's final investigative report[2] included a comparative evaluation of various options for addressing the radioactive materials remaining in the property. The LLRWMO reviewed these options in consultation with Natural Resources Canada (NRCan), the funding agency for the project, and a decision was taken to remediate and restore the residence. AECL then developed and entered into a legal agreement with the owner stipulating the terms, conditions and specifications that would be applied to the work. The LLRWMO then contracted AMEC to execute the agreed upon work program in March of 2012.

Project Objective

The objective of the project was to remediate interior surfaces and materials within the residence to criteria established by the Port Hope Area Initiative (PHAI)[3] and to then restore the property to conditions consistent with those existing prior to the intrusive investigations.

Scope of Work

The scope of work was comprised of:

- remediation of contaminated materials within the building's interior perimeter; and
- restoration of the residence to agreed upon specifications.

An inventory of contaminated material was detailed in the project execution documents. This inventory was comprised of some 133 items, primarily contaminated wooden joists, studs, stringers and sub-floor planks. The restoration specifications that had been agreed between AECL and the property owner were also outlined in detail in the project execution documents.

Execution Planning

A survey of pre-remediation property conditions was completed prior to the initiation of that investigation and was an important element in the definition of restoration specifications for this phase of the work[4]. A comprehensive Project Execution Plan (PEP) was developed to describe the remediation and restoration scope and procedures proposed for the work. The PEP described the project scope; outlined major tasks and methods; detailed participant roles and responsibilities; provided health, safety, radiation protection and transportation plans; and outlined the agreed upon restoration specifications.

PROJECT EXECUTION

Project Management Organization

The project was executed by the LLRWMO using AMEC as the prime contractor. AMEC provided project management and controls services, health and safety planning and oversight, radiological assessment and monitoring services and project reporting. Building remediation and restoration services were provided by Dalren Limited, a local remediation and restoration contractor, working as a sub-contractor to AMEC. A project organization chart is provided on Fig. 2.

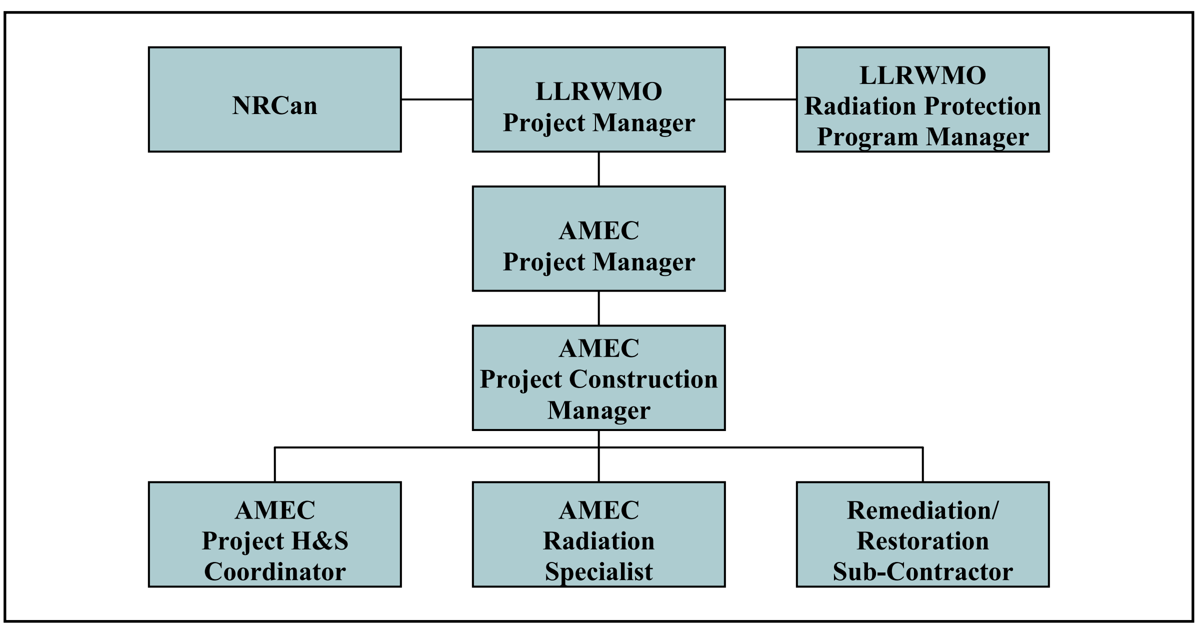

Fig. 2. Project Organization

Remediation

Radiation and Environmental Protection

Radiation and environmental protection were monitored and maintained during the work using a project-specific Radiation and Environmental Protection Plan (REPP). Potential hazards due to contamination were:

- external exposure to gamma radiation while working near impacted materials;
- accidental ingestion of contaminated materials; and
- inhalation of contaminated airborne dust.

Exposure Objectives

The Canadian Nuclear Safety Commission (CNSC) regulates the amount of dose that an individual can receive from activities within their jurisdiction. For members of the general public, the maximum allowed dose is 1,000 µSv over one (1) year above normal background. All personnel on LLRWMO projects are considered members of the general public and, therefore, may not receive more than 1,000 µSv per year above background.

Site Containment and Access Controls

As noted previously, a Designated Substances Survey completed during the investigative phase of the program identified the presence of asbestos in wall and ceiling plasters. Appropriate site containment and worker protection protocols (referred as "Type 3" protocols by the Province of Ontario's Ministry of Labour (the regulatory agency responsible for workplace health and safety)), were therefore applied as surface finishes were removed prior to the initiation of remedial activities. These Type 3 protocols conservatively addressed radiation protection protocols and were therefore also applied during the removal of LLRW contaminated building materials during the remediation phase.

A Controlled Area was established, marked and secured against casual access. This Controlled Area was restricted to authorized personnel, and was directly supervised by qualified radiation protection staff. Materials were monitored and characterized as they were exposed, removed, packaged and transported.

The Controlled Area was assigned radiological safety zones were based on both external ("radiation") and potential internal ("contamination") radiological hazards. The appropriate Radiological Safety Zone sign was posted at all points of entry to the Controlled Area. On at least a daily basis, the Radiation Specialist confirmed that levels did not exceed limits set for the defined zone. When required, the sign was updated by the Radiation Specialist to reflect changing conditions.

Worker Training

Site workers were given a half day of project-specific training to augment earlier Class 1 training provided during the second phase of investigative work[2]. In addition, training specific to working in a Type 3 enclosure was given by an AMEC asbestos awareness instructor. A third training session was given by an AMEC Health and Safety Plan (HASP) specialist in the use of full-faced respiratory protection and routine PPE doffing and donning procedures. All workers on site were also provided with refresher Workplace Hazardous Materials Information System (WHMIS) training.

Removal Methods

The remediation involved removing lumber and associated building materials, and replacement with new materials to maintain the structural integrity of the building. All load bearing members scheduled for removal were reviewed by a licensed structural engineer and individual removal protocols developed to maintain a structurally safe environment during the removal and replacement stage of the work. The contaminated material inventory included floor board members that had been characterized from the bottom only. All floor boards were removed during remediation to access the impacted members.

Before any impacted material was remediated or removed, all accessible surfaces of the materials were cleaned of loose material with a HEPA vacuum and then painted with an encapsulant to prevent inadvertent transfer of contamination to workers or other surfaces. Cutting of materials to dislodge them or facilitate removal was completed by three workers. One worker did the removal while the second applied the HEPA vacuum at the dust generating points. A third worker encapsulated the recovered pieces at the newly exposed surfaces and packaged each for disposal (see Fig. 3). At the points of contact, a worker vacuumed the newly exposed surface and the area was monitored by a Radiation Protection (RP) technician with a pancake Geiger. Any residual activity above background was then scraped, cleaned and vacuumed as required until near background values were achieved (60-80 cpm) (note that ~200 cpm is approximately equivalent to 1 Bq/cm^2 total alpha/beta/gamma).

Fig. 3. Removing impacted stud (note HEPA vacuuming at cut)

A representative swipe was then taken over an area of 300 cm^2 at the points where the impacted materials had been in contact. The date, time, location, object identification, comments, and results of a field measurement on the swipe in cpm were recorded on each swipe.

Fig. 4. Main floor with all walls removed (note HEPA depressurization unit)

The Type 3 enclosure (see Fig. 4) was maintained until all impacted materials had been removed and disposed of off-site and verification monitoring completed. All filters, tarps, and other enclosure materials were scanned for possible contamination in addition to all personnel PPE.

Worker Protection and Environmental Monitoring

Monitoring and ACLs

Monitoring of workers, the environment and equipment was carried out to:

- ensure safe working conditions;
- evaluate work practices so that doses were kept as low as reasonably achievable; and
- avoid the uncontrolled spread of contamination.

Monitoring locations were determined on-site and documented. Monitoring methods, locations and the ACLs used are described in Table I.

Table I: Monitoring Methods and ACLs

	External Gamma Radiation Dose Rate	**External Gamma Radiation Dose**	**Surface Contamination (Total)**	**Long-Lived Alpha Activity in Air**
Monitoring Method	Gamma radiation dose rate monitoring carried out with scintillation detectors.	Personnel dose monitoring carried out using direct reading personal dosimeters.	Open-faced "pancake" Geiger counters used to measure gross alpha, beta and gamma radiation.	Samples collected by drawing air through glass fibre filters and counted after the decay of short-lived progeny.
Frequency and Locations	Active work areas monitored on an ongoing basis as determined by the Radiation Specialist.	All personnel monitored individually while within the Controlled Area. Accumulated doses checked and recorded.	All materials, personnel, and equipment monitored before exiting the Controlled Area.	Work areas monitored and the results recorded at least daily.
Administrative Control Level (ACL)	0.5 µSv/h (83 µR/h) at 1 m from the work face.	0.5 µSv/h averaged over one day (e.g., 4 µSv for an 8 hour day).	Any level above the range of local background readings.	0.04 Bq/m^3.
ACL Justification	Dose rates below the ACL ensured that a dose of 1,000 µSv not exceeded for an exposure time of one working year (2,000 h).	ACL equivalent to that for External Gamma Radiation Dose Rate.	Any level above the range of local background indicates the possible spread of contamination.	A conservative estimate of a derived air concentration for a member of the general public for either thorium or uranium series radionuclides.

Worker Protection Monitoring Results

A preliminary dose assessment for this work, completed as part of the Project REPP estimated a potential external incremental dose to workers during the remedial works period (approximately 120 hours) of 2.4 µSv (against a CNSC annual limit for the general public of 1,000 µSv). Direct-reading dosimetry measurements found that two workers received an incremental dose of 2.5 µSv during this period. Other workers received much lower incremental doses that were more or less indistinguishable from background. Daily gamma radiation measurements at monitoring stations within the building were substantially unchanged throughout the work, supporting the preliminary dose assessment.

The preliminary dose assessment also estimated a potential internal dose of 41.5 µSv, primarily from the inhalation pathway. In the event, most measured concentrations were below the method detection limit, and in the case of those that were measurable, did not exceed ACLs. This indicated that the dose mitigation methods, including high-volume Type 3 negative-pressure air exchange, full-faced respirators, contaminated surface encapsulation and HEPA vacuuming at cutting sites, effectively kept airborne contaminants as low as reasonably achievable.

Environmental Monitoring Results

On a daily basis, gamma radiation measurements were made at eight perimeter monitoring stations around the wire fencing used to delineate the construction zone outside of the residence. All readings ranged from 0.03 to 0.04 μSv/h, consistent with background radiation levels. At no time was a change in these background values observed.

On six days, during the most active impacted materials removals, long-lived alpha emitters in air were measured at the exhaust of the HEPA negative-pressure air handling system. Make-up air from this system came from openings in the building envelope (i.e., no other potentially dust-containing air could escape from the building). Each of these measurements indicated that alpha emitters in this stream were below the detection limit of this method.

Material Handling, Transport and Disposal

The handling, transport and disposition of contaminated materials following their removal from the structure were conducted in accordance with a Project Transportation Plan (PTP) and the federal Transportation of Dangerous Goods Act and Regulations. The PTP outlined measures for packaging and tagging of shipments, compiling activity measurements, accessing the disposition site, and specified a transport route and spill/emergency response procedures. Contaminated materials recovered from the residence were double-wrapped in plastic film and taped securely for transport to a storage site operated by the LLRWMO (i.e., the Pine Street Temporary Storage Site (TSS)) (see Fig. 5). All recovered and packaged contaminated materials were removed from the work site at the end of each working day. The permanent disposition of materials from this site is included within the scope of the Port Hope Area Initiative (PHAI) remediation program.

Fig. 5. Reducing the size of materials prior to packaging (note HEPA vacuuming at cut)

In total, 117 packages in 14 shipments were delivered to the Port Hope TSS. The mass of materials was about 1,700 kg, the volume approximately 16 m^3 and the estimated activity 60 kBq. No emergencies or incidents occurred during transportation.

Verification

Criteria and Protocols

This program was undertaken to remediate interior surfaces and materials within the structure to the Port Hope Area Initiative (PHAI) criteria[3]. The PHAI criteria relevant to the scope were interpreted and applied as follows:

- *Surface Contamination* – if total alpha, beta and gamma levels exceed 1 Bq/cm^2 averaged over 100 cm^2 or gamma radiation levels at 0.5 m from the surface exceed 0.5 μSv/h (~83 μR/h), the materials should be removed; and
- *Removable Surface Contamination* – beta emitters must not exceed 0.4 Bq/cm^2 averaged over 300 cm^2 and alpha emitters (in practice, assumed to be from ^{226}Ra and ^{210}Po) must not exceed 0.04 Bq/cm^2 averaged over 300 cm^2.

Standard operating procedures developed by the PHAI were applied to verify compliance of remedial activity with these cleanup criteria[5]).

Contaminated Surfaces and Objects

Fig. 6. Monitoring contact areas after removal of cross ties

After the removal of the impacted materials, gamma radiation measurements were made throughout the house, focusing on the remediated locations (see Fig. 6), and all observed levels were consistent with the ambient background levels within the house (i.e., there were no gamma radiation measurements indicative of levels approaching the interpreted PHAI criterion of 0.5 µSv/h at 0.5 m from the surface). A pre-restoration gamma radiation survey was conducted for comparison to pre-remedial conditions. The survey showed that pre-restoration gamma radiation levels were consistent with background levels for residences in Port Hope and not noticeably different from the pre-remediation surveys.

This and the data compiled for the verification program demonstrated that all materials remaining in the residence are below the prescribed PHAI cleanup criteria.

Restoration

Following completion of all remediation and verification activity, restoration of the residence was initiated. This work involved more traditional house renovation activities such as electrical wiring, framing, window and trim work, flooring, plumbing, painting and some minor duct work (Fig. 7).

Fig. 7: Plaster work

Assessments of structural integrity and plans for structural modifications to the residence were provided by Holmes Engineering of Port Hope, operating as a subcontractor to AMEC. Holmes Engineering worked with the AMEC team to identify these structural members that were impacted by the work and to identify and plan for appropriate mitigative measures and modifications.

General Project Health and Safety

A Site Specific HASP was created to provide hazard identification and procedures for the purpose of accident prevention, health protection and other safety precautions. The HASP also outlined training requirements, emergency response information, exposure monitoring and personal protective equipment requirements. Over the period of radiological remediation works and subsequent restoration of the home, there were no Recordable Incidents (medical aid, restricted work, fatality).

Stakeholder Interactions

Property Owner

The homeowner's access to the property during remediation was limited to escorted tours at agreed upon intervals given the health and safety risks and contamination control protocols that applied during this phase. During restoration, the owner was allowed regular access to the works (typically two or three times per week). However, all owner visits were escorted and completed observing the standard project health and safety protocols. At no time prior to handover, did the owner have uncontrolled access to the property.

Other Stakeholders

The LLRWMO contacted all neighbouring residents prior to the initiation of work and provided information on the planned activity. There were no inquiries or complaints directed to AMEC or Dalren from the neighbours, or any other public stakeholders, during the work. Similarly, there were no inquiries, directives and/or complaints received from any municipal or provincial authorities (other than the prescribed building and/or MOL inspections) received during the work.

PROGRESSIVE LEARNING

The work scope for the remediation and restoration program combined requirements for radiological assessment and risk mitigation with conventional residential home renovation in ways that are likely to be required in future as the PHAI fulfills its mandate in the Port Hope area. It is useful then to consider and compile the learnings derived from this work program so that they may be usefully applied to upcoming requirements. The following discussion captures and categorizes the project team's learnings from the program.

Project Organization and Management

- Full-time on-site supervision was provided by the Project Construction Manager and the Radiation Specialist during the remediation phase and this was necessary and appropriate given the nature of the work. On-site supervision was reduced by about two-thirds for the restoration phase as the work reverted to a more conventional home renovation project. This level of restoration oversight was still relatively comprehensive, but justified given the level of homeowner interest and involvement in the restoration scope. In future, the level of management oversight for the restoration phase should be tailored to both the complexity of the physical work scope and the dynamics of the LLRWMO's relationship with the property owner.

Contracting Strategy

- Utilizing a local prime sub-contractor (Dalren Limited) provided the benefits of access to the local trade resource pool and established relationships with local regulatory structures (e.g., building inspectors). This helped preserve schedule because Dalren had ready access to local trades in responding to unexpected conditions or task durations (i.e., it was relatively easy for them to mobilize additional resources) and because established inspector relationships facilitated timely code inspections and compliance.

- There were benefits to using the same labour pool for both the remediation and restoration phases; in this case, Dalren's usual restoration team was trained as needed to safely execute the remediation phase. Having the removal works undertaken by staff who could anticipate impacts on the restoration scope was useful (i.e., removal works were done in ways that were as consistent as possible with the subsequent restoration requirements). Having a dedicated removals team (e.g., a firm specializing in Type 3 enclosures work) would likely have reduced the training obligation (which proved to be modest and quite manageable) but would likely have left the restoration team with more work to do.
- Combining future work programs over continuous time frames will allow local contracting resources to maintain trained and integrated remediation/restoration teams. This would ultimately allow the contracting authority to reap the schedule and cost benefits provided by economies of scale.

Remediation

- For future programs, the default planning assumption should be that Type 3 enclosures with full PPE will be required. A program of monitoring should be then agreed upon with the Ontario Ministry of Labour (MOL) beforehand to identify any opportunities that might be available to reduce PPE requirements based on site-specific monitoring outcomes. Reducing the PPE requirement will tend to improve worker productivity and, therefore, preserve schedule, in Type 3 enclosure working environments.
- The investigative and subsequent remedial programs demonstrated that typical surface finishes (e.g. plaster and/or drywall) quickly attenuate the gamma radiation signature generated by underlying materials exhibiting mild (but above cleanup criteria) surface contamination. A conservative (i.e. more aggressive) approach to establishing the scope of surface finish removal requirements is necessary for areas where contamination is suspected.

Health & Safety

- The contractors and subcontractors engaged for this kind of work, particularly the restoration components, will typically be relatively small and from the residential construction/renovation sector. These companies are often less familiar with the nature and rigor of the H&S regimes required for this work and execution plans should be set-up recognizing that there will likely be a need for relatively comprehensive contractor training and oversight.

Stakeholder Interactions

- Any ambiguity in agreed upon restoration specifications adds schedule and budget risk because it generates the need to respond to homeowner requests for either changes, or interpretations of ambiguous specifications that favour the homeowner. Because these projects will almost always be schedule driven (at least when a homeowner is involved), this creates pressure to accede to homeowner requests in order to preserve schedule. Restoration specifications in the agreement completed prior to contact initiation should therefore be as specific, and as comprehensive as possible.
- The homeowner for this project had regular escorted access to the property during restoration and this facilitated accommodation of the changes and adjustments (most were minor and did not involve a material change in scope) that are the norm in residential renovation projects. Restricting owner access during restoration would likely be counterproductive because it would generate requests for re-work at project completion.

CONCLUSIONS

The following general conclusions were derived from the LLRWMO's recent residential remediation and restoration program in Port Hope, Ontario.

- Projects involving individual homeowners require extraordinary efforts with stakeholder consultation. Homeowners are typically deeply invested in properties both financially and emotionally, and are therefore particularly interested in and sensitive to, the various components of project development and execution (e.g., restoration specifications, schedules, relocation requirements). Executing agencies need to incorporate the resources and timelines into project development and execution plans that are needed to engage with homeowners and to achieve alignment on key project objectives, elements and outcomes.
- The local regulatory authorities responsible for worker health and safety should be engaged early in the execution planning effort to ensure they have adequate time to understand the worker hazards involved (recognizing they may have limited experience with LLRW remediation programs) and to participate in the definition of site containment and PPE protocols that are reasonably aligned with the hazards. Inadequate and/or late consultation is likely to result in highly conservative protocol specifications.
- Remediation and restoration programs like this require relatively intensive management and oversight before and during execution. This, combined with the physical complexities of removing multiple, discrete building elements, means that program costs will often exceed the market value of the property involved. Executing agencies need to consider this fact early in the development of general policy and strategy decisions for community based LLRW assessment, remediation and restoration programs.

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