Conducting Gamma Radiation Surveys on Municipal Roadways in Support of the Port Hope Area Initiative - 16602

J. Stuart Bailey*, David A. Raymond*, Jeffrey Lively*, and Erwin Santiago**
*Amec Foster Wheeler Environment and Infrastructure
** Port Hope Area Initiative Management Office, Canadian Nuclear Laboratories

ABSTRACT

The Port Hope Area Initiative (PHAI) is a community-based solution for the long-term management of historic low level radioactive waste (LLRW) resulting from 60 years of uranium and radium processing operations in the Town of Port Hope, Ontario. The project aims to remediate approximately 1.7 million cubic metres LLRW through the consolidation of waste within two Long-term Waste Management facilities to be constructed within the municipalities of Port Hope and Clarington. Within the Town of Port Hope, surveys are being conducted at approximately 5000 individual properties to confirm the presence of LLRW, delineate its extent and develop cost estimates for remediation. Identification of the presence of LLRW is based on multiple lines of evidence including reviews of historical information, gamma radiation surveys and sampling for four signature contaminants. Of the 5000 properties, a number are municipal rights of way, largely municipal roads, that may have been impacted through spillage of LLRW when it was historically transported through the community for disposal and/or through its use as construction backfill.

This paper describes the completion of gamma radiation surveys on these municipal rights of way and the challenges that needed to be addressed working on travelled roadways in an active community. To maximize efficiency and minimize inconvenience to motorists the gamma surveys are conducted using a mobile platform that provides high resolution spectral gamma logging coupled to GPS for geospatial referencing. The system employs large volume, spectroscopy grade, sodium iodide detectors that permit the collection radiological spectra allowing for effective discrimination of gamma radiation signals emitted from naturally occurring background sources (e.g. potassium 40) from the gamma emissions associated with the specific contaminants of concern (e.g. Ra-226). The system can be deployed on any platform including a backpack. For the majority of the roadways surveyed a small, self-contained, road-legal trailer attached to a motorized tow vehicle (e.g. side-by-side UTV or small pick-up truck) is used as the survey platform. This accommodates the mounting of multiple detectors and allows the surveys to be conducted without the need for closing traffic lanes thus improving productivity and safety while minimizing inconvenience to motorists. Data quality objectives are readily achieved through the use of multiple passes over the same target area providing a geospatially rich dataset for post-processing and imaging. Topics covered in the paper include: the logistics of completing high quality gamma surveys on travelled roadways; health, safety and traffic considerations; community outreach and response; and a comparison of isotopically-speciated data vs total gamma readings evaluating the influence of background sources. The lessons learned will be

applicable to anyone planning on conducting similar surveys in urban settings.

INTRODUCTION

The Port Hope Area Initiative (PHAI) is a community-based solution for the long-term management of historic low level radioactive waste (LLRW) in the Town of Port Hope, Township of Hope and the municipality of Clarington located on the north shore of Lake Ontario approximately 100 km east of the City of Toronto (Figure 1). A legal agreement between the government of Canada and the local municipalities forms the basis of the PHAI (1). The principal objective of this initiative is the identification, excavation and relocation of approximately 1.7 million cubic metres of low-level radioactive waste (LLRW) associated with the activities of the former Eldorado Gold Mines (which later became Eldorado Nuclear Limited) to two secure, long-term waste management facilities to be constructed in the communities of Port Hope and Port Granby.

Figure 1: Port Hope, Ontario (courtesy of Port Hope Area Initiative)

The Eldorado refinery, which began refining radium-226 from pitchblende ore, later transitioning to the refining of uranium, generated considerable quantities of LLRW and plant residues. Process residues were deposited at the Welcome Waste Management Facility until the mid-1950s switching to the Port Granby Waste Management Facility that continued to accept waste until the late 1980s (2). Typical of many refineries of the era (i.e., prior to the recognition of the hazards associated with the waste material), processing waste, construction debris and contaminated soils were deposited at numerous locations in Port Hope, ostensibly for disposal, but often for re-use as fill and building materials resulting in contamination by LLRW at individual homes and properties (referred to as "small scale sites") and larger undeveloped areas, ravines and the harbour turning basin (referred to as "large scale sites"). Properties close to the plant were also subject to deposition by material released to the air through normal or abnormal emissions.

Specific to the small scale sites program, property surveys are being conducted to: 1) identify those properties that have been impacted by LLRW; 2) delineate the extent of contamination, and 3) develop cost estimates for remediation. Identifying the presence of LLRW is based on multiple lines of evidence including: historical information; gamma radiation surveys; indoor radon gas testing; and confirmatory soil sampling for four signature contaminants (uranium, arsenic, radium 226 and thorium 230). Some 5,000 properties, most of which are residential, are being surveyed as part of the small scale sites program. Of the 5000 properties, a number are municipal rights of way, largely municipal roads that may have been impacted through spillage of LLRW when it was historically transported through the community for disposal and/or through its use as construction backfill.

An initial gamma radiation survey was completed for the 320 kilometres of municipal roadways in Port Hope in 2001 (3). Based on a 10 metre by 10 meter grid spacing, the survey identified a number of areas where with elevated gamma readings that were attributed to naturally occurring material in the roadbed (e.g. potassium-40) as well as a number of areas suspected of having elevated levels of uranium and/or impacts from LLRW. As a result, the PHAI identified the need for follow-up to better define the areas of elevated gamma activity and, where confirmed, the development of intrusive subsurface work plans to assess for the presence of the four primary COCs to determine the need for remediation. On the basis of the historical information, including the initial gamma radiation survey PHAI identified some 174 sites encompassing (approximately 300,000 square metres in area), requiring further investigation. These are shown in Figure 2.

Figure 2: Road Allowance Sites - Port Hope, Ontario

The objective of this work is to develop sub-surface investigation work plans to confirm the presence/absence of LLRW at municipal road allowances. This involves 1) completing a high spatial resolution gamma survey of municipal rights of way; 2) completing topographic and property boundary surveys to define property boundaries and physical features; 3) completing utility locates to identify subsurface and above-surface utilities that need to be accounted for when planning and conducting subsurface investigations; and 4) developing subsurface investigation work plans identifying the number and location of boreholes needed to confirm and delineate the presence of LLRW.

Port Hope is an active and vibrant community and the PHAI management office has worked diligently to develop an effective working relationship with the community. As this work is being conducted in on active roadways, including the main street through town, in addition to providing data of consistently high quality, a critical success factor was ensuring that the survey was sensitive to the needs of the community and proceeded safety with minimal disruption to traffic and the day-to-day activities of the community's residents.

METHODLOGY

*ScanPlot*SM is an Amec Foster Wheeler brand name for a family of advanced overland radiation scanning/logging instrumentation systems. The *ScanPlot*SM systems used to collect radiological data for this survey were equipped with large volume, spectroscopy grade, NaI gamma radiation detectors and survey grade global positioning system (GPS) sensors. Three different platforms were deployed to provide effective coverage of roadways, adjacent boulevards and culverts and ditches. Figure 3 provides an illustration of the platforms used. These included a towed array, which was used for surveying roadways, a push-buggy unit and a backpack unit. The towed array is equipped with two large volume (4.2-litre) NaI detectors placed 1 metre apart 0.15 metres above the road surface and two 3"x3" (0.35-litre) NaI detectors also one metre apart placed 1 metre above the road surface. The buggy is similarly equipped relying on only one set of 4.2-litre and 0.35-litre detectors at 0.15 and 1 metre above the road surface respectively. For reasons of weight, the backpack is equipped with only a single 0.35-litre detector located at 0.15 metres above surface. All units were equipped with Javad commercial survey grade global positioning system (GPS) units with real time kinematic correction providing positional accuracy to within centimetres.

Figure 3: Examples of ScanPlot[SM] Platforms used for the Gamma Surveys

Each unit was initially calibrated using certified standards at the U.S. Department of Energy's large scale calibration facility located in Grand Junction, Colorado. Once in Canada they were normalized using the calibration pads at the Low Level Radioactive Waste Management Office's (LLRWMO) facilities in Port Hope providing a traceable exposure rate standard. Owing to the fact that LLRWO's calibration pads could not accommodate the larger detectors being used in the survey, these were normalized using a transfer calibration process based on the relative response of the 0.35-litre detectors vs. the 4.2-litre detectors at the Grand Junction facility. In this way, all detectors were normalized to provide readings in micro-Roentgen per hour (μR/h) based on an emission source certified by LLRWMO. This ensures that all survey instruments are normalized in order to provide consistent responses to the same gamma radiation signal.

During use a number of quality control checks were performed on the units to ensure data quality. These included source response checks using a Cs-137 source and spectral alignment at the beginning of each shift and every four hours using both Cs-137 and K-40. The energy spectra were aligned so that the K-40 peak and Cs-137 peak were within +/- 2 (i.e. +/- <0.5%) channels of their target channel. The tolerance limit for the response checks of the measured variance in gamma radiation response for the gamma sensors is the mean of all RSC measurements collected to date, ± 20%.

The global positioning satellite system (GPS) sensors were tested each day prior to system deployment against a GPS measurement control point to assess their ongoing accuracy and precision. These sensor response checks were performed as a static GPS measurement over the known control point and recorded for quality assessment purposes.

The platforms were run at a speed of approximately 1-3 metres per second with the radiological data and the spatial position data programmed to log every second and storing data on onboard computers for subsequent uploading for post-processing data plotting, mapping, and analysis. As radiological data is continuously acquired, it is integrated over the logging interval such that 100% coverage within the field of view of the radiation detector is achieved over the path or track of the survey. The array of measurements collected over multiple tracks and passes are assimilated into a geospatial database for assessment. Post-processing uses proprietary spectroscopy software that produces data relative to specific energy regions-of-interest within the entire spectrum scanned.

Prior to beginning work each day, field crews completed a tailgate health and safety briefing covering the potential hazards associated with the individual tasks to be performed that day. This was recorded in daily field logs along with the results of system checks. Deployment followed the project specific health and safety plan and traffic management plan.

RESULTS

Community Engagement

Maintaining the community's strong support for the overall program that has been fostered by the PHAI management office was a critical outcome of the work. This required notifying the community prior to undertaking the work and providing community awareness training to all workers so they understood "*do's and don'ts*" and could readily respond to enquiries when approached.

Prior to undertaking field work, field staff received community awareness training that covered everything from obeying traffic speed limits, to how to behave when staying in the community and frequenting stores and restaurants. While in the field staff carried cards containing contact information for the PHAI Public Information Exchange. These were provided to anyone who had any questions that could not be addressed in the field.

Coincident with the start of the program, PHAI posted information on their website providing details of the program, what to expect while workers were in the neighbourhood and a picture so that our field teams could be easily recognized. This is illustrated in Figure 4. This was supplemented by notices in the local media and an Open House where the purpose of the program was explained. Amec Foster Wheeler provided a ScanPlot^{SM} unit at the Open House so those interested could obtain a better understanding of the equipment being used and its purpose. Finally, prior to beginning work at a particular location, field crews deployed a sign indicating testing was being conducted in the area and where to obtain additional information if required (Figure 5).

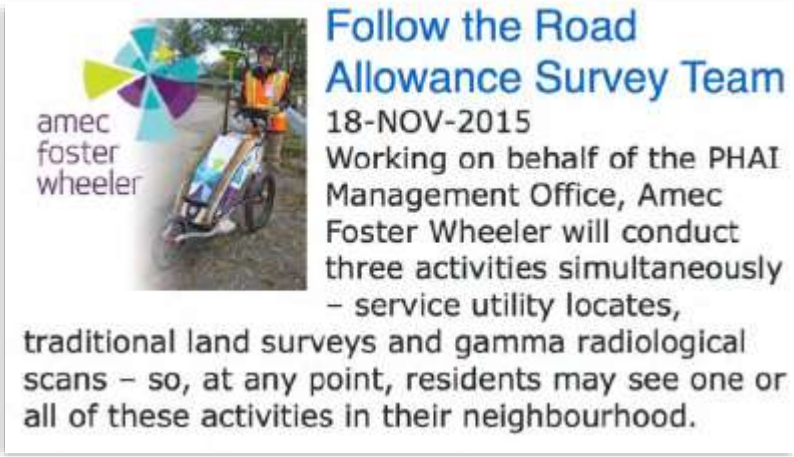


Figure 4: PHAI Public Notice of Commencement of Work in the Community

Figure 5: Daily Notification of Work in the Immediate Area

In terms of traffic management, as the work involved encroachment on travelled roadways, Road Occupancy Permits were obtained from the Municipality of Port Hope.

Properties were grouped into six priority areas, facilitating the issuance of Occupancy Permits for each area.

Critical to program, both in terms of safety to the survey crews and members of the community was the use of a road-legal vehicle for conducting surveys within the travelled portion of each roadway. While this meant roads could remain open while the survey was being completed, thereby minimizing inconvenience, the survey equipment needed to be road legal and of high visibility. This was accomplished using a licensed trailer towed by a small, off-road utility vehicle. An off-road utility vehicle was selected over on-road vehicle as it had better capability of maintaining a specific speed thereby enhancing the quality of the survey. Both the tow vehicle and trailer were equipped with amber flashers when in use while the trailer was equipped with a slow moving vehicle sign consistent (Figure 6) with the requirements of the *Highway Traffic Act*.

Figure 6: High Visibility Road Survey Vehicle

Efforts to engage the community were successful as the survey teams received no complaints during their work. Any questions received by members of the community typically related to the overall Port Hope Area Initiative.

In terms of traffic management and safety, the program readily accommodated the

needs of local traffic while no safety or traffic-related incidents were reported by field crews.

Total Gamma Survey

The survey data are planned to be used for developing intrusive sub-surface work plans to confirm the presence or absence of LLRW. Accordingly, survey results were presented as a two dimensional colour representation using 1 metre by 1 metre grid pattern for properties less than 5000 m^2 and 1 x 3 metres for properties greater than 5000 m^2. For the total gamma survey, data were presented as open scans representing a very wide window set within the spectrometer's software that collects count rate data from the full range of channels (~500 channels representing the photon energy range between 0 and 3 MeV). This provided data on total gamma activity which was represented geo-spatially as area-weighted average readings over the grid spacing of interest.

To facilitate the development of subsurface work plans, each property surface inclusive of gamma readings was overlain with the property boundaries and location of utilities, both of which were confirmed by separate crews as part of the field program. Figure 7 provides an example of a typical property layout while Figures 8 provides the results of the topographic survey and utility survey (top panel) and the overlay of gamma readings at a 1 metre grid spacing (bottom panel). Based on the results of the surveys and taking into considerations restrictions imposed by utilities, recommended sampling locations are included in the figure to investigate areas of where gamma readings are above regional background which is considered to be 4-7 µR/h.

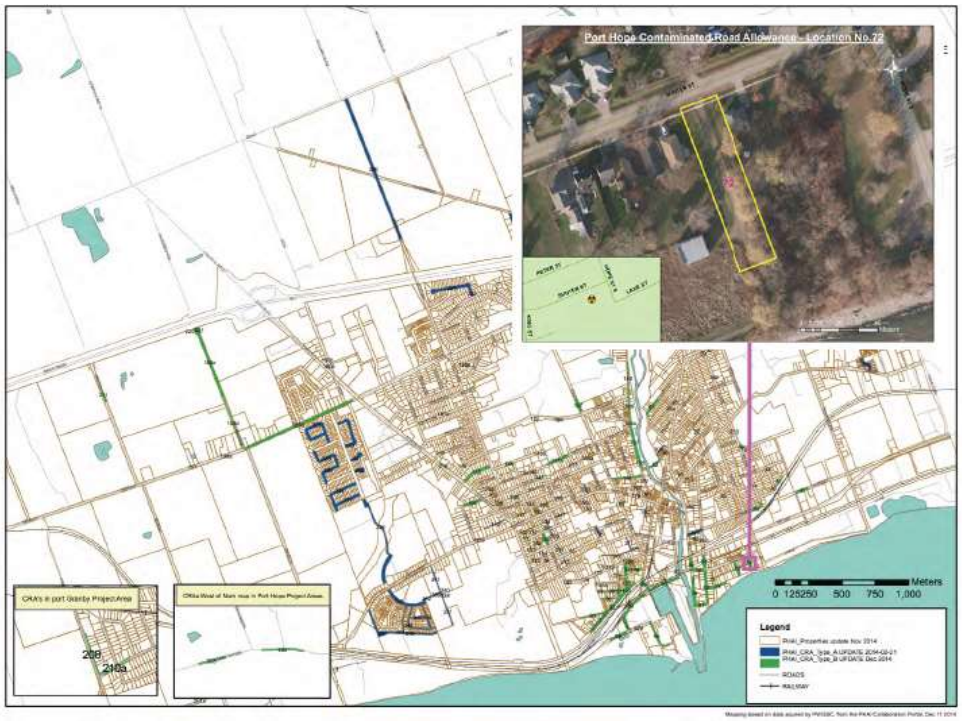


Figure 7: Typical Municipal Right of Way

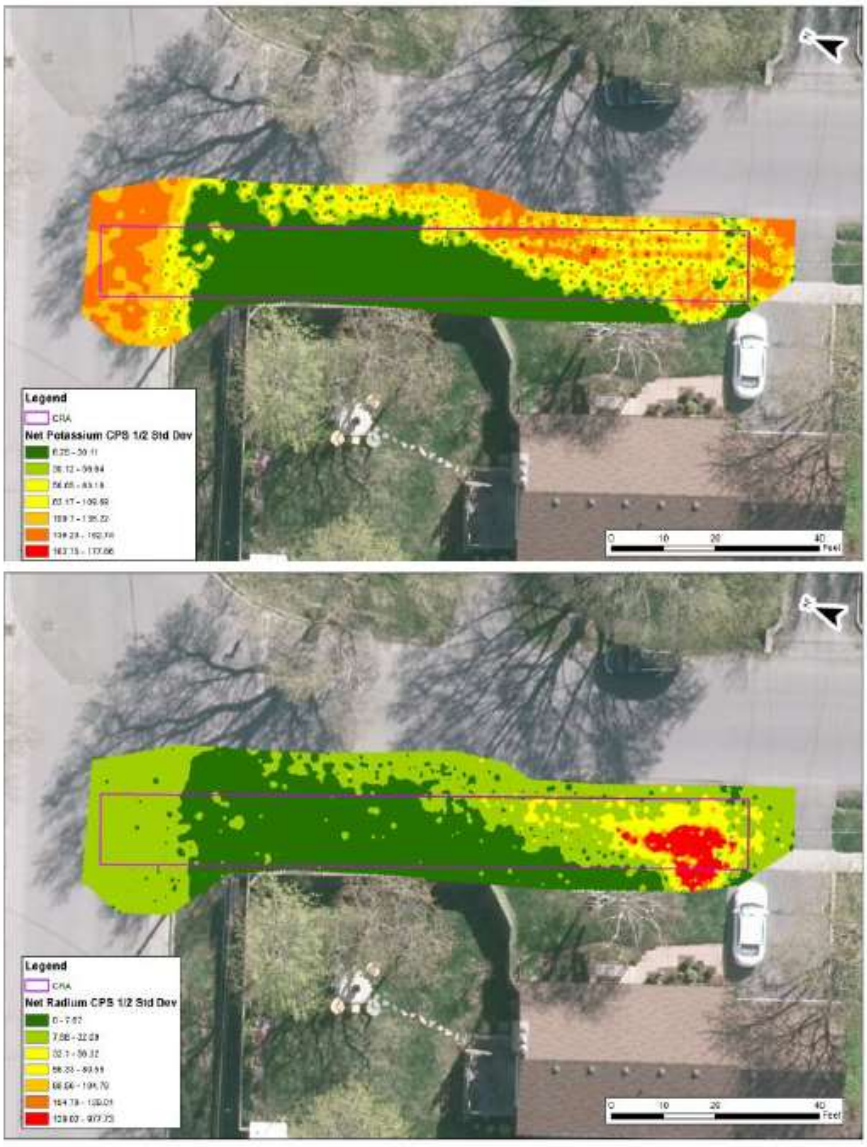
Figure 8: Property Survey, Utility Survey and Total Gamma Survey

Speciated Gamma Survey Data

While the reporting of total gamma was used for the purposes of identifying the possible presence of LLRW, *ScanPlot*^{SM} has the capability of providing speciated data based on the energy spectra of individual radionuclides. This allows for the distinction between naturally occurring radionuclides such as K-40, which can be elevated in

gravel deposits used in roadways, vs uranium, radium and thorium which are the signature elements of LLRW originating from the former Eldorado facility.

Figure 9 provides an example of the results of the energy spectrum for K-40 vs Ra-226. It is evident that the distribution of K-40 is not aligned with the distribution of RA-226 indicating that basing the subsequent investigative work plans on the results of the total gamma survey will results in a number of false positives. As such, the ability to provide results for speciated gamma emitters that are directly aligned with the parameter of interest has the potential to improve the quality of the work plans for subsurface investigation.



CONCLUSIONS

The completion of gamma radiation surveys on municipal rights of way in support of the Port Hope Area Initiative (PHAI) involved relied on family of advanced overland radiation scanning/logging instrumentation systems. This provided a number of advantages including the ability to complete the surveys using towed arrays meaning the surveys could be completed safely and in compliance with the *Highway Traffic Act* without the need for road closures. The system also has the capability of operating as a digital spectrometer providing results speciated results for individual radionuclides of interest. This allows for the ability to distinguish the contribution from elements such as K-40, which can be naturally elevated in gravel used in road bed materials, from LLRW characteristic of the former Eldorado facility.

Importantly, a critical success criterion for the project was maintaining and enhancing the positive relationship that had been fostered by the PHAI management office and the community. This was accomplished through early communication with the community by PHAI which was enhanced through effective community awareness training for all field staff ensuring they were aware of and could respond to sensitivities within the community. The ability to complete gamma radiation surveys, topographic surveys and utility locates on 174 municipal road rights of way with minimal disruption to local traffic and no safety issues is testament to the effectiveness of the program.

REFERENCES

(1) An Agreement for the Clean-up and Long-Term Safe Management of Low-Level Radioactive Waste Situate in the Town of Port Hope the township of Hope and the Municipality of Clarington 2001 (as amended 2006, 2009)
(2) Government of Canada, Environmental Assessment Screening Report for the Port Hope Long-Term Low-Level Radioactive Waste Management Project, 2006 December.
(3) Low Level Radioactive Waste Management Office 2002, Gamma Ray Survey of Roads in the Port Hope Area LLRWMO-03901-ENA-12012 February 2002