

## **The Low-Level Radioactive Waste Management Office: Thirty Years of Experience in Canada – 13308**

Liliana Benitez\*, Mark J. Gardiner\*\*, Robert L. Zelmer\*\*

\*Natural Resources Canada, 580 Booth Street, Ottawa On.

[Liliana.Benitez@NRCan.gc.ca](mailto:Liliana.Benitez@NRCan.gc.ca)

\*\*Low-Level Radioactive Waste Management Office

### **ABSTRACT**

This paper reviews thirty years of progress by the Low-Level Radioactive Waste Management Office (LLRWMO) in developing and implementing low-level radioactive waste (LLRW) remediation projects and environmentally safe co-existence strategies. It reports on the present status and the future of the national historic waste program in Canada. There are over two million cubic metres of historic LLRW in Canada. Historic LLRW is broadly defined as LLRW that was managed in the past in a manner that is no longer considered acceptable and for which the original owner cannot reasonably be held accountable. In many cases, the original owner can not be identified or no longer exists.

The LLRWMO was established in 1982 as Canada's agent to carry out the responsibilities of the federal government for the management of historic LLRW. The LLRWMO is operated by Atomic Energy of Canada Limited (AECL) through a cost-recovery agreement with Natural Resources Canada (NRCan), the federal department that provides the funding and establishes national policy for radioactive waste management in Canada. The LLRWMO expertise includes project managers, environmental remediation specialists, radiation surveyors, communications staff and administrative support staff. The LLRWMO in providing all aspects of project oversight and implementation contracts additional resources supplementing core staff capacity as project/program demands require.

### **INTRODUCTION:**

#### **The Origins of Historic Radioactive Waste**

The accumulation of historic LLRW in Canada date back to the early 1930s with the mining of radium and uranium ore at Great Bear Lake in the Northwest Territories, and subsequent refining of the ore in Port Hope, Ontario. The discovery of the waste led to an action plan and public policy initiative in the 1970s to address its environmental impacts.

There is an estimated 2.33 million cubic metres of LLRW in Canada, the vast majority of historic waste by volume is concentrated in the Port Hope, Ontario area [1]. There are additional areas across Canada which also contain a high density of sites contaminated with historic LLRW. These sites are associated with the transport of uranium ore from the Port Radium (Northwest Territories) mine to Port Hope (Ontario) refinery (i.e. along the Northern Transportation Route) and radium dial painting operations in the Greater Toronto Area (GTA). Sites impacted by artefacts utilizing radioactive materials are widely dispersed across Canada.

The historic waste, found as contaminated artefacts or at small-scale radium-use contaminated sites, is often the result of radium used in historic industrial and medical activities. A majority of artefacts consist of watch and instrument dials. These sites usually involve relatively small areas and volumes of contamination. Larger contaminated sites are usually a result of the past placement or disposal of radioactive waste in locations that were once acceptable, but are now deemed to potentially pose health, safety and environmental concerns.

Ore spill sites along the 2,000 km route of waterways and portages of the Northern Transportation Route (NTR) have typically tens to hundreds of cubic metres of contaminated soil per site at marginally elevated levels of radioactivity.

Special case accumulations such as the Surrey (British Columbia) thorium contamination, resulting from the processing of niobium ore, are typically not related to the mining or production legacy associated with the waste found in other parts of the country. The map in Figure 1 identifies the major discoveries of historic LLRW in Canada.



**Figure 1** Historic LLRW sites in Canada

### Activities of the LLRWMO

Over the past thirty years, the LLRWMO has provided a full suite of investigation, characterization, consultation, planning, remediation and information services to potentially impacted communities across Canada. The LLRWMO maintains inventories of historic LLRW at both Canadian Nuclear Safety Commission (CNSC) licensed and unlicensed sites across Canada. At its technical facility in Port Hope Ontario, it operates licensed storage sites and a licensed radioisotope laboratory. The LLRWMO possesses a CNSC licence for potential use at sites across Canada where remediation or short-term storage activities may require short term (less than 90 days) use of a CNSC licence for remediation or storage of historic LLRW. The LLRWMO also provides support to sites under CNSC institutional control associated with the management of historic waste.

Major environmental remediation activities include: cleanup of historic LLRW contaminated sites resulting from spills during the transportation of uranium ore from the mine sites in Canada's Northwest Territories for processing in the Port Hope (Ontario) area; and radium dial painting activities in the GTA (Ontario) as well as the consolidation of radium luminous devices at various types of facilities at locations

across Canada. The LLRWMO has removed contaminated soil, debris and radioactive artefacts to safe long-term storage or interim, in situ containment.

The LLRWMO continues to operate interim radioactive waste management programs in Port Hope (Ontario) which ensure historic LLRW in the community is managed to protect human and ecological health. These Port Hope programs monitor the environment near waste management facilities, ensure control over soil movement during construction activity and provide information and support to property owners especially during real estate transactions in the community.

The LLRWMO continues to consult local, national and international stakeholders, as well as provincial, territorial and federal regulatory agencies in the completion of its historic LLRW management responsibilities.

Canada has not yet secured a national disposal facility for historic LLRW. Until long-term disposal solutions are determined, the LLRWMO provides continuing support to historic LLRW management initiatives aimed at reducing or eliminating impacts from the presence of this waste. The LLRWMO works with communities and regulatory agencies to develop locally acceptable waste management solutions.

## **FEDERAL POLICIES, PROGRAMS AND OVERSIGHT**

Canada's federal government is responsible for the oversight of the use of nuclear energy and has enacted legislation and regulations to oversee the nuclear industry, including the management of radioactive waste. The primary legislative tool is the Nuclear Safety and Control Act enacted in 1997, which established the Canadian Nuclear Safety Commission (CNSC), the federal regulatory authority and a set of regulations made pursuant to the Act. The Regulations incorporate, for instance, radiation dose limits consistent with the recommendations of the International Commission on Radiological Protection (ICRP). The Act and Regulations, taken together, apply to all aspects of nuclear energy, nuclear substances and radiation devices used in industry and medicine, and the entire nuclear fuel cycle, from uranium mining to waste management.

In 1996 the Government of Canada established the Radioactive Waste Policy Framework. This policy provides the national context for radioactive waste management and a set of principles to ensure that radioactive waste management is undertaken in a safe, environmentally sound, comprehensive, cost-effective and integrated manner.

The Policy Framework specifies that:

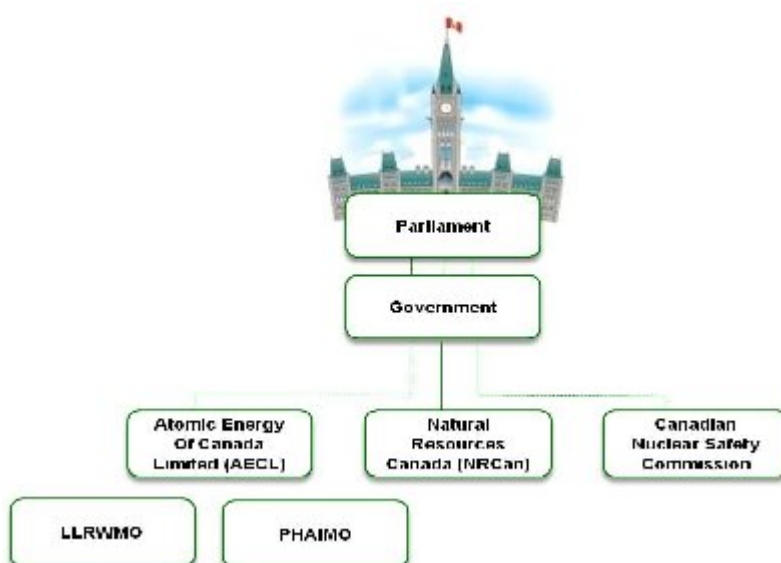
- The federal government has the responsibility to develop policy, regulate and oversee radioactive waste producers and owners so that they meet their operational and funding responsibilities in accordance with approved long-term waste management plans; and
- Waste producers and owners are responsible, in accordance with the "polluter pays principle," for the funding, organization, management and operation of long-term waste management facilities and other facilities required for their waste.

The federal government has taken the responsibility for finding long-term management solutions for historic waste, the low-level waste which was managed in a manner now considered inadequate, but for which the user or producer or owner can no longer be reasonably held responsible. This waste results from activities taking place 50 or more years ago in accordance with the requirements of that time. In addition the federal government has accepted responsibility for implementing long-term management solutions for legacy waste. Legacy wastes are decommissioning, environmental restoration and waste management liabilities associated with AECL's research and prototype reactor sites across Canada.

Natural Resources Canada (NRCan) is the lead federal department that has been given the responsibility of developing and implementing nuclear energy policy, including national policy respecting radioactive waste management. It is NRCan's role to ensure that obligations under the Radioactive Waste Policy Framework are met [2].

The federal government has accepted responsibility for developing and implementing long-term management solutions for the following historic waste:

- Contaminated soil within the Port Hope Area, of Ontario, resulting from Eldorado Resources Limited's processing plant, in Port Hope that started in 1930 to refine radium from pitchblende ore and subsequently became a uranium refining operation;
- Contaminated soil in the Malvern subdivision of Scarborough, Ontario resulting from the 1940s manufacture of luminous instrument;
- Waste resulting from smelting, during the 1970s, of niobium concentrates in Surrey, British Columbia;
- Waste along the NTR, at a number of locations in the Northwest Territories and Northern Alberta, as a result of accidental spillage during the transportation of uranium ore from the Port Radium mine on Great Bear Lake along the Great Bear and Mackenzie rivers in the Northwest Territories to Fort McMurray, Alberta; and
- On a case by case basis, for certain sites associated with the historic radium dial painting operations, in the downtown area of Toronto, Ontario.



**Figure 2 Institutions Involved In Managing & Regulating Historic Radioactive Waste in Canada**

The CNSC is the nuclear regulatory authority in Canada and is independent from government in the regulatory and licensing decisions it makes. Its role is to regulate the use of nuclear energy and materials, including radioactive waste, to protect the health, safety and security of the public; protect the environment and respect Canada's international commitments on the peaceful use of nuclear energy. An important function of the CNSC is to consider applications for the use of nuclear material and facilities, including radioactive waste, and where appropriate, to issue licences that permit the use of nuclear materials and activities. In considering applications for licences, the CNSC considers the input received from members of the public, interest groups and other levels of government.

In 2004, the CNSC issued Regulatory Policy Document, P-290, which outlines the philosophy and principles that guide the regulation of radioactive waste in Canada [3]. A major component of P-290 is the identification of the need for long-term management of radioactive waste. The principles in P-290 are in line with those recommended by the International Atomic Energy Agency (IAEA) in Safety Series 111-F, The Principles of Radioactive Waste Management.

This policy document (P-290) considers the extent to which owners of radioactive waste must address: waste minimization; the radiological, chemical and biological management of the waste; the predicted impacts on the health and safety of persons and the environment; the measures needed to prevent unreasonable risk to both present and future generations; and the trans-border effects on the health and safety of persons and the environment. It is fully consistent with the Radioactive Waste Policy Framework.

### ONGOING LLRWMO PROJECTS AND PROGRAMS

The immediate goals of the LLRWMO programs are to:

- Seek opportunities for the resolution of historic waste management issues for the long term and to reduce the footprint of historic waste in Canada;
- Undertake contamination co-existence programs which include interim remedial work and ongoing monitoring, as required, at contaminated sites in Canada to protect health and the environment, prior to the availability of long-term management solutions;
- Cleanup and manage for the long-term, Canada’s historic waste found along the Northern Transportation Route, the Greater Toronto Area and various other locations;
- Support, as appropriate, the long term remedial efforts of the Port Hope Area Initiative Management Office (PHAI MO) in Port Hope, Ontario; and
- Provide technical assessments and advice to NRCan for the development of federal government policies governing the management of historic waste.

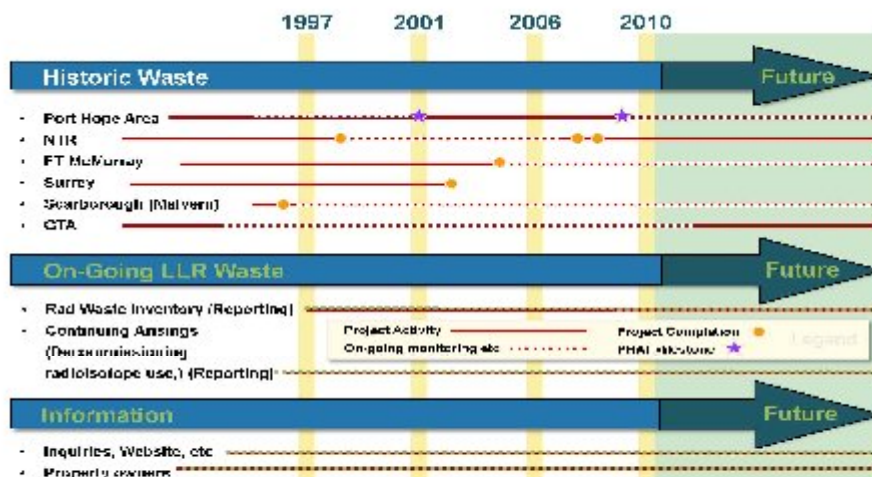


Figure 3 LLRWMO Programs

In completion of its mandated activities, the LLRWMO delivers to NRCan the following three major programs:

- Historic Waste Program - The LLRWMO carries out investigation, characterization, remediation and long-term management of historic LLRW on behalf of the federal government pursuant to a 1990 Memorandum of Understanding between NRCan and AECL. Historic LLRW contamination has been found at various locations in Canada, including Alberta, the Northwest Territories, Ontario and British Columbia. Historic radioactive artefacts continue to be recovered from numerous sites throughout the country. A key element of the historic waste program, led by the LLRWMO from 2001 was the implementation of the planned remediation of contaminated sites in the Port Hope area of Ontario. Since 2008 a new project-specific organization, the PHAI MO, has been leading this effort which is expected to continue for the next ten years.
- Ongoing Waste Program - Producers and owners are responsible for the management of their radioactive waste. Under the Ongoing Waste program, the LLRWMO supports NRCan in its development and implementation of national policies and strategies for the disposal of this radioactive waste. The LLRWMO also assists NRCan in meeting its commitment to international organizations such as the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD).
- Information Program - The LLRWMO addresses public information needs related to historic LLRW and the management of historic LLRW projects in Canada. The Office responds to inquiries from individuals and communities across Canada as well as from interested parties worldwide. The office also engages with colleagues and colleague organizations in Canada and around the world to share and advance the science of radium remediation and historic waste management. In 2011, the LLRWMO partnered with ANDRA, the French radioactive waste authority, to bring world-wide attention to the history and present day status of the work in this area. This was achieved through the production of a research compendium DVD [4] and focused participation at the 14<sup>th</sup> International Conference on Environmental Remediation and Radioactive Waste Management (ICEM) September 25<sup>th</sup> -29<sup>th</sup>, 2011 in Reims, France (see references at [www.llrwmo.org](http://www.llrwmo.org)).

The LLRWMO has addressed a wide range of challenges over the past 30 years. These can be grouped into the following subject areas: Property Contamination Surveys, Decontaminations of Sites, Waste Consolidations, Storage Facility Operations, Construction Monitoring, Disposal Facility Siting, Community Planning and Engagement Programs, Ongoing Safe Co-existence Programs, Property Value Protection, National Inventory Tracking, Environmental Monitoring, Topical LLRW Studies and Technology Development.

### **THREE DECADES OF SUCCESS (1982 – 2012)**

#### **Continuing from the Work of the Federal-Provincial Task Force on Radioactivity – Canada-Wide. (Ongoing)**

The LLRWMO was formed in part to take on the federal government responsibilities for LLRW in 1982 previously managed through the Federal-Provincial Task Force on Radioactivity (FPTFR). This included the transfer of case files on historic contamination for sites and communities across Canada, including those in Bancroft, Deloro, Elliot Lake, Port Hope, Toronto and Uranium City [5]. The majority of the case load came from the several thousand files that were created through the initial characterization and remediation efforts in the Port Hope area from 1976 through 1981.

The FPTFR cleanup criteria, based on safe present occupied use, are still in effect today at sites under LLRWMO “*institutional control*” and CNSC licensing exemption across Canada. As such sites are developed or experience changes in use, then additional site characterization, or potentially site remediation, may be required to ensure the continued safety of the site or building occupants. However project-specific criteria will be used at the time final remedial work is implemented.

As an example, project-specific cleanup criteria were developed for the pending cleanups in the Port Hope area subsequent to the signing of the 2001 “*Agreement for the Cleanup and the 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*” [6]. A process involving the technical, regulatory and municipal participants ensured the selection of the locally acceptable criteria. As the licensing process for the PHAI proceeded, and prior to initiation of remedial work, cleanup criteria were updated to reflect regulatory changes.

### **Former Radium-Luminous Dial Painting Operations – Canada-wide (Ongoing)**

Between the 1920s and 1950s radium-luminous paint was used as indicator markings on gauges, watches, alarm clocks, switches and many other novelty items from jewellery to fishing lures. Glow in the dark articles were quite popular novelty items at the time. Today, we expect our watches and clocks to be visible in the dark, though new technologies have replaced radioactive materials.

During this time there were many facilities in operation for preparation and the application of radium-luminous paint, both for the purposes of new production and repair. There were, and continue to be, businesses involved in the re-calibration of instrumentation to which radium-luminous paints were applied. All of these facilities were at risk of spreading radium contamination from the work bench to beyond the building.

The LLRWMO and the CNSC have been working cooperatively for many years. The identification of historic LLRW contaminated sites by either party results in the other being notified.

Many sites and hundreds of historic radioactive artefacts from the radium industry have been safely recovered to date. The need continues to the present day and the CNSC launched a radium-luminous device public awareness program in 2006 to make both industry and the public aware of safe handling practices and disposal options.

The LLRWMO continues to support the CNSC’s institutional control of known former radium-luminous dial painting operations in Canada through the provision of oversight to property development. Properties the CNSC has exempted from licensing which may contain residual radium contamination behind walls or below floors are attended by the LLRWMO when the owners plan renovation work that may result in the exposure of the remaining radium contamination [7]. The LLRWMO relies on notification from the public and the CNSC in the identification of previously unknown sites.

### **Artefact Recovery – Canada-wide. (Ongoing)**

The Canadian federal government has accepted the responsibility for the recovery of historic radioactive artefacts, predominantly items that had radium-luminous paint markings. Under the Historic Artefact Recovery Program (HARP) the LLRWMO has collected and placed in long-term storage alarm clocks, watches, switches, gauges, dials, etc. from various aircraft and military vehicles. Other instruments and devices which include previously unregulated radioactive materials have also been recovered through the LLRWMO’s HARP. These include static eliminator bars, radium-sourced smoke detectors, and thoriated camera lenses. The LLRWMO’s HARP does not recover americium-based smoke detectors, Fiesta dinnerware, or other naturally occurring radioactive materials (NORM).

The LLRWMO’s HARP has had increases in the number of recoveries in recent years, likely owing to increased knowledge of the program in the scrap metal recycling community, and also through the increased number of installations of radiation portal monitors at landfill sites and metal recycling facilities.

### **The Greater Toronto Area (GTA) and Malvern – Ontario. (Ongoing)**

The challenge in the Malvern community and the GTA is related to recovery and decontamination of structures and soils impacted by radium use and experimentation. Some occurs in dense urban portions of the city while other sites are found in 1970s suburban expansion areas of the city. The GTA is also the focus of many of the artefact recovery operations in Canada. There is a marked similarity between the nature of contamination found in Canada in the GTA and even at some Port Hope area small scale sites, and those currently being remediated in Paris, France, by the French national radioactive waste authority (ANDRA) [4].

### **Remediation at Malvern Community-Ontario (Completed)**

While the initial Port Hope remediation activities were the first urban community remediation of historic waste in Canada, and undertaken by the FPTFR (1977 – 1981), the Malvern Remedial Project [8] was the first urban community remediation conducted by the LLRWMO (1995-1996).

Initially, the siting of an interim storage location for recovered material was a significant holdup to progress on the Malvern Remedial Project involving legal proceedings spanning more than five years and eventually the negotiation of a federal-provincial cooperation agreement. In the Malvern community of Scarborough (eastern Toronto), at the McClure Crescent and the McLevin Avenue sites, 68 residential properties and three significant land development sites (commercial and residential) were cleaned up in successive stages. An extensive property contamination survey program ending in 1996 investigated several hundred off-site properties in the vicinity, to ensure contaminated sites had not been overlooked. Approximately 16,600 m<sup>3</sup> of radium contaminated soil was excavated, and underwent mechanical sorting and segregation. Approximately 50 m<sup>3</sup> of licensable material was recovered and transferable to an LLRWMO interim storage facility at AECL's Chalk River Laboratories. Separation of clean soil, interspersed throughout the excavated material, then reduced the original volume by about half. The remaining 9,000 m<sup>3</sup> of mildly contaminated soil was placed in an engineered storage mound nearby at the Passmore Avenue sorting site, in an undeveloped part of an industrial area. Ultimately, the soils in this mound will be relocated by the LLRWMO to a permanent long-term management location.

A construction-monitoring program was established to ensure that oversight continues at municipal servicing projects or reconstruction in the vicinity of the cleanup sites for areas potentially having residual contamination. The growing body of experience to date increases confidence that further discoveries in the vicinity are unlikely. In addition, a post-project environmental monitoring committee was established to receive annual reports on the performance of the Passmore Avenue storage mound until the removal of the waste from this interim location.

This project successfully resolved the long-standing problem of contaminated properties in this community and provided a demonstration of the application of soil sorting techniques. The project demonstrated a successful partnership among the federal government, provincial government and the local host community.

### **Surrey Disposal Project – British Columbia (Completed).**

At Surrey, quantities of niobium refining waste containing thorium were placed into on site storage at two sites, the Anvil Way site and the Thornton yard site in the Vancouver area in 1985. Regular inspections and maintenance at these sites continued until 1997, during which time a Surrey Siting Task Force, researched disposable siting options and engaged a Community Liaison Committee. The project received the cooperation of the provincial ministries of Environment, Lands and Parks, and Health. The Surrey Disposal Project, which included waste recovery from the two sites, was brought to successful



completion, in 2000 to the satisfaction of property owners and the federal government. The Surrey Siting Task Force which had been instrumental in exploring disposal options, first within the province of British Columbia, and later, beyond the province, concluded operations in late 2000 once facilities were identified and contracts in place for all waste removal. The secretariat of the Siting Task Force remained to operate a public information office until the completion of all site work.

At the Thornton Yard site, the final solution involved the conditioning, packaging and transport of the radioactive and industrial waste across four provinces to storage at the LLRWMO's licensed storage facility in AECL's Chalk River Laboratories. In December 1999, the contaminated Thornton Yard site waste was placed in 83 one cubic-metre metal boxes and then placed in six shipping containers for rail transport to Toronto where it was then taken by truck to Chalk River and placed in the LLRWMO's licensed storage facility.

At the Anvil Way site, approximately 5,000 m<sup>3</sup> of thorium contaminated soil and slag waste was successfully excavated from open areas and beneath industrial buildings. Remedial work occurred while two businesses maintained their independent activities on site. An on-site interim waste storage facility was unloaded and dismantled. Floor slabs and foundations of buildings were removed to access underlying contamination. The LLRWMO shipped the waste in securely covered trucks to an industrial disposal facility located approximately 400 km from the site. The waste from the Thornton Yard site did not meet the waste acceptance criteria at this site, hence the decision to transport that waste to Chalk River.

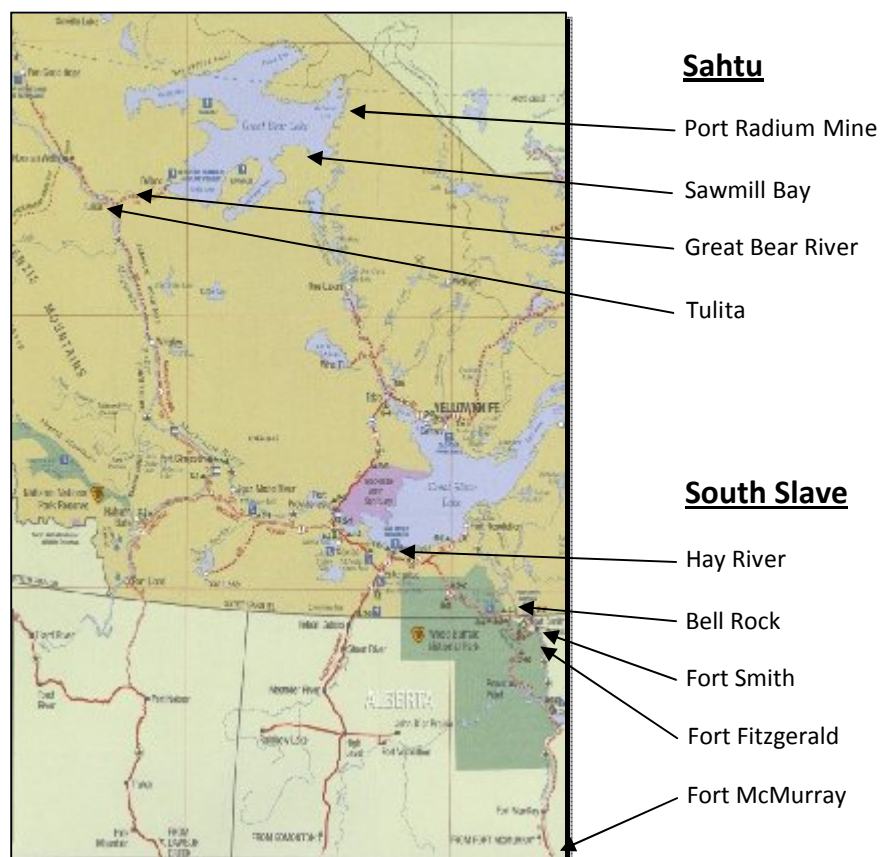
The Surrey Disposal Project demonstrated the federal government's commitment to resolving long-standing environmental concerns. The overall success of this project is largely due to the continued cooperation and support of the site owners, provincial officials and the maintenance of public support by the Surrey Siting Task Force.

### **The Northern Transport Route (NTR) and Fort McMurray – Alberta, Northwest Territories. (Ongoing)**

In the early 1990s, a thorough investigation of sites along the transportation route by the LLRWMO identified a number of uranium ore-contaminated sites along the NTR. Contamination was centred in two areas of the NTR: the Sahtu Region in the north in the vicinity of Great Bear Lake; and the South Slave Region along the Slave River in the south. It was also found at Fort McMurray – the terminus of the NTR. Figure 4 illustrates the NTR and the locations of contamination in the Sahtu and South Slave regions.

To carry out its work in the north, the LLRWMO is adapting methods of community engagement and technical approaches that have led to successful remediation projects in Canada's southern regions. Adjustments are being made to meet the realities of the north. Those realities include the challenges of Canada's northern geography and environment and the need for understanding the ways of northern peoples. Currently, dialogue is taking place with three First Nations and communities in order to plan the remediation of sites located along the Slave River and in the Sahtu [9].

Remaining contamination exists at sites in both the South Slave Region and in the Sahtu Region. Consideration of cleanup options for these areas began in 2007, when NRCan and the LLRWMO convened a meeting of all government stakeholders in Yellowknife to discuss contamination issues and the process for moving forward on these remaining cleanups. Since that time, local communities have also come forward again expressing interest and some urgency in advancing the cleanup. This has led to community meetings with community leaders and others in both the Sahtu and the South Slave.



**Figure 4 Sahtu and South Slave Sites on the NTR**

In the Sahtu, the primary historic waste sites of interest include the land at Sawmill Bay, and shoreline sites along the Great Bear River. Partnering in the Sahtu Region has begun. Fact-finding meetings held in 2010 October in Déline have been a significant step in advancing planning. These meetings have been used to update the information collected initially in the early 1990s on the status of contamination at Great Bear Lake and Great Bear River sites. Planning has begun for characterization and remediation planning the Great Bear River sites.

In the South Slave, the primary historic waste sites of interest have been identified at Fort Fitzgerald, Bell Rock and Hay River. Community engagement in this region has now begun. Good progress was made at initial meetings with representatives of the Smith's Landing First Nation beginning in May 2009, concerning contamination in the Fort Fitzgerald area. Similarly, good progress has been made at initial meetings in June 2010 with Salt River First Nation concerning Bell Rock area sites. In 2011 a roadway project at Fort Fitzgerald prompted the remediation of 300 m<sup>3</sup> of contaminated soils and the establishment of an interim storage mound in the community.

#### **Remediation at Tulita, Northwest Territories (Completed)**

During the 1992 inspection of transfer points along the NTR by the LLRWMO it was discovered that during a wintering-over period in the Hamlet of Tulita in the early 1940s, handling and storage activities resulted in the spillage of uranium ore, thereby contaminating soils on two private properties in the community. This material was being transported along the NTR from the mine site at Port Radium when conditions on the Mackenzie River kept it from being barged to the rail head at Fort McMurray, Alberta.

The location of the material, its accessibility, its concentration level and the likelihood of its redistribution indicated the need for prompt interim action. Approximately 200 m<sup>3</sup> of uranium ore-contaminated soil was removed from these private properties and placed in temporary mound storage at the old landfill site near the Tulita airport in 1992. The storage area was purpose built by the LLRWMO for receipt of this material. It was inspected by the LLRWMO and the CNSC on a regular basis thereafter, pending a future long-term management approach for the contained soil. Assistance from local individuals and authorities was instrumental in the success of this activity.

Subsequently, as an interim management step in 1999, sorting of mound material enabled the removal of licensable material (significantly less than one cubic metre) to storage at an LLRWMO facility at Chalk River Laboratories (CRL), Chalk River, ON. In the fall of 2001, the remediation of approximately 300 m<sup>3</sup> of soil from the same two properties was undertaken and recovered material was added to the mound. The final steps at Tulita included the establishment of the Tulita Uranium Working Group in 2000 and the successful Tulita Disposal Project undertaken in the years 2006 through 2009, which saw the removal of the waste from the community.

### **Remediation at Fort Smith, Northwest Territories (Completed)**

In the fall of 1999, the LLRWMO provided technical support to the Town of Fort Smith during its demolition of a former Northern Transportation Company Limited (NTCL) warehouse building located within the municipal boundary. Approximately 100 m<sup>3</sup> of uranium ore-contaminated building materials was segregated and transported to a newly constructed, dedicated temporary storage mound (constructed, operated and monitored by the LLRWMO) located at the Town of Fort Smith municipal landfill site.

In September of 2001 the LLRWMO, assisted by a local contractor, excavated and removed approximately 125 m<sup>3</sup> of uranium ore-contaminated soil from three previously identified impacted private properties and a section of a municipal roadway, in Fort Smith. The contaminated soil was transported to an expanded LLRWMO operated temporary storage mound located at the local municipal landfill site.

In September of 2010 the LLRWMO, working with the Town of Fort Smith Planning Department and again assisted by a local contractor, completed the excavation and removal of approximately 60 m<sup>3</sup> of uranium ore-contaminated soil from the municipal roadway mentioned above. The soil was transported to the expanded temporary storage mound at the Fort Smith municipal landfill site. The remedial work was completed in conjunction with the Town of Fort Smith's 20 year road maintenance program. This was a noteworthy event given that this contaminated soil was recovered from the last known occurrence of historic waste contamination in the developed area of the town.

### **Remediation at Fort Fitzgerald, Northwest Territories (Ongoing)**

Fort Fitzgerald is located at a uranium ore transfer point required for the portage of material around rapids on the Slave River. In the summer of 2011, the LLRWMO supported the roadway infrastructure improvements by the settlement of Fort Fitzgerald (Alberta) through the recovery of spilled uranium ore in the area of the construction activity. The LLRWMO created a storage cell on adjacent federal lands for the temporary storage of the impacted soil.

The LLRWMO continues to maintain an open dialogue with the community to ensure that ongoing development of the land can continue without concern of the impacts due to potential spills of uranium ore during its transportation through the community en route to the railhead in Fort McMurray to the south.

Future work will be required to recover the remaining impacts to the barge transfer area from its use in supporting the transport of supplies to the north and the movement of resources to the south.

### **Remediation at Fort McMurray, Alberta - The NTR Terminus (Completed)**

Investigation, characterization and remediation work first began in Fort McMurray in 1992. Between 1993 and 1996, the LLRWMO excavated and removed mildly contaminated soil including a small quantity of licensable material (approximately 100-150 m<sup>3</sup>) from eight riverside properties in the Lower Town and Waterways areas. Licensable material was segregated and shipped to the LLRWMO licensed storage facility at Chalk River Laboratories, Chalk River (Ontario). Non-licensable material was moved to a purpose built cell at the local municipal landfill site [10]. This cell remains under the oversight of the LLRWMO.

The completion of the Fort McMurray Historic Uranium Cleanup Project in 2002 marked the resolution of a decade-long endeavour to clean up and safely manage approximately 42,500 m<sup>3</sup> of marginally contaminated soil from several sites in this northern Alberta city. The Waterways property, the last site to be remediated, is now part of the community's public park and trail system.

The Long-Term Management Facility (LTMF) housing the non-licensable material is a dedicated, secure storage cell constructed with a compacted clay liner, leachate collection and management systems and an engineered cover. The LTMF is located approximately 2 km south of Fort McMurray within the boundaries of the local municipal landfill. The facility is monitored on an annual basis by the LLRWMO.

The LLRWMO continues to provide annual inspections of consolidation sites along the NTR. This is in addition to the ongoing annual monitoring and analysis of groundwater, leachate, gamma radiation surveys and slope stabilization studies (conducted every five years) at the Fort McMurray LTMF. This program is conducted pursuant to the Agreement between the LLRWMO and the Regional Municipality of Wood Buffalo (RMWB). While the site is not licensed, it remains of interest to the CNSC and it receives, along with the RMWB, a copy of the annual monitoring report for the storage facility.

### **The Port Hope Area –Ontario. (Ongoing)**

The Municipality of Port Hope, Ontario lies on the north shore of Lake Ontario, approximately 100 km to the east of Toronto. The Port Hope area contains approximately a million and a half cubic metres of Canada's historic LLRW. This is the single largest component of the national inventory of historic LLRW. The presence of historic LLRW in Port Hope dates back to the early 1930s when a refinery was established for the extraction of radium from pitchblende ores at a facility purpose-built in the town. Medical and industrial applications of radium made it extremely valuable justifying transportation from its source in the Northwest Territories. In 1975, radioactive contamination resulting from practices in the early years of radium and uranium production was discovered in parts of the town.

The FPTFR, headed by the Atomic Energy Control Board (the Canadian nuclear regulator of the day), was established to develop cleanup criteria and to carry out remedial work at properties exceeding these criteria in Canada, specifically in Port Hope and in the uranium mining communities of Elliot Lake, Ontario and Uranium City, Saskatchewan.

In the late 1970s, a remediation of the most contaminated areas of Port Hope was completed as part of a dose reduction program in the area. Some 120,000 m<sup>3</sup> of contaminated soil was excavated and disposed of at AECL's Chalk River Laboratories in Deep River, Ontario. While the work of the late 1970s focused on reducing the dose from radioactive materials, associated non-radioactive and residual radioactive materials remain.

The LLRWMO's involvement in the Port Hope area came about through its inception as the agent to manage Canada's responsibility for its national historic low-level radioactive waste issues. Following historic LLRW management oversight by the FPTFR, the LLRWMO became its successor in 1982 and became the managing agent for this waste. The LLRWMO has provided a continuing presence in Port Hope since the mid 1980s.

To date, the LLRWMO has advanced the consolidation of the LLRW, established coexistence programs and facilities, enabled continued interim safe use of land with residual contamination and partnered with others in advancing the ultimate remediation of the area. These activities continue today [11]. From 2001 through 2008 the LLRWMO launched and led the Port Hope Area Initiative through Phase 1 of the project [12],[13] under the terms of the Agreement of 2001 [6]. The current focus of the LLRWMO in Port Hope is the continuation of the long-established Interim Waste Management (IWM) Program and providing support to the PHAI MO established in 2008. The PHAI MO is now advancing the next phase of the project and the remediation and transfer of the local historic LLRW to new long-term waste management facilities.

The LLRWMO provides regular inspection and ongoing monitoring of its licensed and unlicensed sites, and of any sites that are discovered during routine IWM Program activities. The IWM Program provides assurance that known inventories of historic LLRW in the Port Hope area are properly maintained, and also provides monitoring of property development to ensure that any previously unknown historic LLRW is identified and appropriately managed.

An additional key component to the oversight of remaining historic LLRW in Port Hope is the provision of an information program to property owners in the area. The LLRWMO maintains a database of current radiological status information on the developed properties in the area. Real estate transactions often result in prospective buyer inquiry into the potential for contaminated materials to remain on private properties. The LLRWMO provides a detailed technical review of the property file and prepares a radiological status letter for the property owner or other parties (realtor, lawyer, etc) to support real estate transactions.

## **LESSONS AND REFLECTIONS**

LLRWMO remedial projects over the years provide guidance on suitable approaches for the future as we approach closure on Canada's historic waste issues. Observations on aspects of public acceptance, design and operations, project management and environmental benefit are presented below. Though implementation of the necessary remedial work and construction of long-term management facilities will have a timeframe of more than another decade, it is expected that community agreement on the solutions needed at all known remaining sites will be clear within the next 10 years. The record of building trust and working co-operatively with communities clearly marks the pathway to success [14].

### **Social Aspects and Public Participatory Decision Making Processes**

The community must shape and support remedial or disposal projects. Therefore, selection of a preferred strategic approach must be done in partnership with local stakeholders. Decisions that may have a social and environmental impact should be made in consultation with those that may be affected and any potential health effects should be explained to the affected communities. Dialogue on options and focus on a review of environmental screening documentation have been the two steps used by the LLRWMO. The roles of Task Forces, Liaison Committees and workshop engagement are part of a deliberative decision making process.

On reflection, the LLRWMO has developed a practice for interacting with communities in the development of locally acceptable remediation solutions. This “assessment and remediation process” developed over many years of evolving experience, can be described as a seven step process with some steps conducted in parallel. The process consists of the following steps:

1. Discovery: Legacy ores or artefacts are discovered via historical reviews and/or community inputs; field investigations are undertaken.
2. Engagement: Initial community contacts are expanded to fact finding and decision making workshops.
3. Community Planning: The LLRWMO and community identify alternatives for managing the impacts. Input from external agencies and contractors is often obtained.
4. Interim Management: Interim actions to mitigate near term risks to public health and safety are taken. Monitoring, waste consolidation and some removals occur. Waste co-existence programs often play a role.
5. Remediation: Identification and execution of an option consistent with the community’s constraints and objectives advances.
6. Long Term Management: A long term approach is found and implemented. This may involve waste removal or the development of a long term local management option. Validation of management system performance occurs through monitoring and operation.
7. Closure: Outcomes are shared and celebrated with the community.

Step four is undertaken in parallel with steps two through six to ensure safe co-existence with contamination in communities and to build trust.

Public acceptance of projects is earned with the help of a governance scheme provided by the government on the steering and coordination of the remediation process through a governance network. This process focuses on modalities to interact between the state and the actors interested in a solution. Competent work and a local track record in the community appear to build credibility and acceptance. The assurance of an independent regulatory review also enhances acceptance. Free flowing information and staff accessible to local citizens are necessary. Providing suitable forums for dialogue is essential.

### **Organizational Aspects**

Flexibility must be maintained in long-term-waste management projects. Contracts, commitments and design aspects of the work must reflect this. The proponent must be ready to redirect the work depending on conditions encountered. To do so the proponent must have expert, adaptive, technical staff in-house and must be vigilant to the need to act in a timely fashion to meet stakeholder expectations. Experience has shown that the unexpected must be expected and even considered, even after as many variables as possible have been anticipated.

Specific devices which can be used to maintain flexibility and enhance preparedness include the following: work should be staged and review points should be pre-set; separate contracts should be established for construction, engineering and environmental contractors; an environmental auditor should participate throughout the work; multiple construction parties should be engaged, possibly under separate contracts.

Remedial projects are custom efforts that require a degree of circumstance-specific crafting. Frequently, time, cost, volume forecasts and method must be adjusted to respond to discoveries or circumstances encountered during the conduct of the work. The experience garnered in actually undertaking projects in the field guarantees future success. On project completion, time spent reflecting on both the successes and areas for improvement greatly increase the opportunities for future successes.

## **Technical Aspects**

LLRWMO experience with in situ consolidation and interim storage projects has shown a number of advantages. Containment of the waste prevents further spread of contamination thereby limiting the problem and reducing remedial costs. Barriers applied over the waste protect potential intruders from any hazards and also lessen the probability that unsuspecting parties will relocate and further spread the problem. Covering the waste affords physical shielding to reduce gamma fields and provide a barrier against radon emanation. An accurate understanding of the characteristics and volume of the waste requiring further long-term management is obtained when the materials are delineated and excavated for interim consolidation. Interim consolidation allows for easy follow-up removal and restoration once a long-term storage or disposal option is identified.

Strong emphasis on contamination control and health physics procedures enhances responsible conduct of the work. Clear delineation of the contaminated work zones, thorough briefing of workers, and policing of procedures is required. Where practical, site-dedicated equipment and vehicles are preferred. Continuous environmental monitoring during the work and post project environmental tracking is the norm in LLRWMO projects.

Effort is well spent characterizing the contaminated materials requiring remediation. Project momentum is at significant risk when strategies change as a result of new information mid-project. Thorough initial site investigations, including radiological surveys of the surface and subsurface conditions, are undertaken and factored into conceptual engineering plans. Rigorous inventory control and verification processes ensure completeness of work and provide reference for all stakeholders, including owners (current and future) and regulators.

## **CONCLUSIONS**

Thirty years of experience in remedial action programs at historic waste sites has been accumulated by the LLRWMO following on from the FPTFR. Steady progress has been made through a time of change in public attitudes toward environmental protection and decision making processes.

The historic LLRW problem has been stabilized in Canada. Waste sites have been identified, characterized and remediated. Where immediate action was necessary to protect public health and environmental safety, such action has been taken. The present challenge is dealing with long-term hazards by relocating the waste to permanent management.

The LLRWMO, a series of siting task forces and responsible federal government departments have successfully advanced LLRW management in Canada. An ambitious environmental review program complete with a community-level decision process and on-going remedial work have shown progress arising from the commitment by all parties involved.

In summary, the LLRWMO has brought a better understanding and better management of materials to historic LLRW sites in Canada. Stored waste is currently managed as part of the LLRWMO's IWM program in Port Hope, Scarborough, Fort Fitzgerald and Fort Smith, awaiting the development of appropriate long-term storage or disposal facilities. Significant benefits have occurred to date from interim measures already undertaken. In addition to eliminating certain health risks and mitigating potential environmental issues, other benefits are some reduction of public concern and successful co-existence during continuing remedial operations. Programs have been established to address specific sites of concern and to facilitate responsible handling of soil and other material found to be contaminated. A partnership has been established at Port Hope with community officials to address day-to-day matters arising from residual contamination. Interim measures in other communities have also been applied

previously in Surrey, Fort McMurray and Scarborough. For the future, the LLRWMO continues to prepare for completion of work in communities as community planning advances and disposal facilities become available. In the interim, the normal development of communities and properties is facilitated by lessons learned to date.

## REFERENCES

- [1] Low-Level Radioactive Waste Management Office, “*Inventory of Radioactive Waste in Canada*”, p. 25, ISBN CC3-1-2012, 978-1-100-54191-4, Ottawa, Canada (2012)
- [2] Canadian Nuclear Safety Commission, “*Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*”, p. 13-15, Final Report, Ottawa, Canada (2011)
- [3] Canadian Nuclear Safety Commission, “*Managing Radioactive Waste*” Regulatory Document P-290”, Ottawa, Canada (2004)
- [4] LLRWMO (Canada) & ANDRA (France), “*Radium Remediation, History and Present Day, A Worldwide overview (DVD), 1<sup>st</sup> Edition*”, Ottawa, Canada (2011)
- [5] B.A. McCallum, D.E. Main and R.L. Zelmer, “*Reductions in Environmental Impacts at Interim Remedial Work Sites in Canada*”, Radiation Protection Symposium and Joint Conference of the Canadian Radiation Protection Association (CRPA), Canadian Radiation Safety Officers (CRSO), Canadian College of Physicists in Medicine (CCPM), and Canadian Organization of Medical Physicists (COMP), June 16-22, 1991, Winnipeg, Canada (1991)
- [6] Natural Resources Canada, the Town of Port Hope, the Township of Hope, and the Municipality of Clarington, “*Agreement for the Cleanup and the 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*”, Ottawa, Canada (2001)
- [7]. Canadian Nuclear Safety Commission, “*Historic Contaminated Lands Under CNSC Exemption Three Year Status*” (CMD 10-M8), Ottawa, Canada, (2009)
- [8] R.W. Pollock and B.J. Franklin, “*The Malvern Remedial Project – A Case History*”, International Conference on Deep Geological Disposal of Radioactive Wastes, September 16 -19, 1996, Winnipeg, Canada (1996)
- [9] L. Benitez, J. Brown, D. McCauley and R. Zelmer, “*Early Progress in Building Confidence and Partnerships with Northern First Nations and Communities in LLRW Remediation Projects in Canada (11321)*”, WM 2011 Conference, February 27 – March 3, 2011, Phoenix, USA (2011)
- [10] R. Pollock, B. McCallum, B. Fedorak, R. Scotten, A. MacKenzie, “*A Cooperative Approach to Conducting an Environmental Cleanup Project – Experience of the Working Group for the Fort McMurray Historic Uranium Cleanup Project*”, Fourth International Conference on Safe Communities, June 6 -8, 1995, Fort McMurray, Canada (1995)



WM2013 Conference, February 24 – 28, 2013, Phoenix, Arizona USA

- [11] M.J. Gardiner, R.L. Zelmer and M.J. Owen, “*Safe Community Co-existence with Long-Term Low-Level Radioactive Waste Contamination in Canada – Port Hope Example*” (11314), WM 2011 Conference, February 27 – March 3, 2011, Phoenix, USA (2011).
- [12] G.G. Case, G.G. Vandergaast, R.L. Zelmer, “*Making Conceptual Design Choices For A Long-Term Waste Management Facility-Environmental Impact vs. Environmental Performance*” (8166), Port Hope, Canada, -WM2008 Conference February 24-28, 2008, Phoenix, USA (2008)
- [13] H.R. Kleb and R.L. Zelmer, “*Planning for the Recreational End Use of a Future LLR Waste Mound in Canada – Leaving an Honourable Legacy*”, ICEM 2007 Conference September 2-6, 2007, Bruges, Belgium (2007)
- [14] P. Arthurs, J.L. Herod and S.E. Stickley “*Communicating Risk with a Concerned Public in Historic Low-Level Radioactive Waste (LLRW) Projects*”, WM’07 conference, Feb 25-Mar 1, 2002 Tucson, USA (2007)