MANAGEMENT OF CANADA'S URANIUM AND URANIUM MINING LEGACIES ON THE HISTORIC NORTHERN TRANSPORTATION ROUTE

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ABSTRACT

The Northern Transportation Route (NTR) was established in the 1930s to transport pitch blende ore 2,200 km from the Port Radium Mine in the Northwest Territories to Fort McMurray, Alberta. The ore was then shipped 3,000 km by rail to Port Hope, Ontario, where it was refined for its radium and uranium content. The corridor of lakes, rivers and roads that made up the NTR included a number of points where ore was transferred to other barges or trucks. Ore was occasionally spilled during these operations and, in some cases, subsequently distributed over larger areas as properties were modified.

Since 1991, the Low-Level Radioactive Waste Management Office (LLRWMO), working with communities and its consulting contractors, has characterized spill sites along the NTR where soils exhibit elevated concentrations of uranium, radium and/or arsenic. When feasible to consolidate contaminated material locally, it has been placed into Long Term Management Facilities to contain the materials over extended timelines. In those circumstances where local consolidation is not achievable, materials have been relocated to facilities outside of the region. The LLRWMO is continuing a program of consultation, technical evaluation and environmental assessment to develop management plans for the remaining ore-impacted sites on the NTR. This paper will highlight current activities and approaches for the responsible management of uranium and radium mining legacies.

Key Words: Uranium, Radium, Remediation, Port Radium, Mining, Fort McMurray.

INTRODUCTION

Since its establishment in 1982, the LLRWMO has remediated historic radioactive waste in multiple communities across Canada. Historic waste is defined for policy purposes as low-level radioactive waste (LLRW) that was inappropriately managed and for which the current owner cannot reasonably be held responsible. 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, direction and priorities for the LLRWMO.

The LLRWMO and NRCan's activities related to the management of historic LLRW have been supported by long term relationships with several organizations in the consulting community, AMEC Environment & Infrastructure (AE&I) being one of these companies. AE&I has been supporting the LLRWMO with project management, civil engineering and earth science services related to LLRW management since 1992.

This paper was developed from a paper originally presented at the 2011 International Conference on Environmental Remediation and Radioactive Waste Management in Reims, France (Geddes et al. 2011).

HISTORY OF ORE HAULS AND CONTAMINATION ALONG THE NTR

The Northern Transportation Route (NTR) was the 2,200 km marine and portage route used, beginning in the 1930s, to haul pitch blende ore from the Port Radium Mine in Canada's Northwest Territories to the community of Waterways (today Fort McMurray) in the province of Alberta. The ore was then shipped approximately 3,000 km, by rail, to Port Hope, Ontario, in southern Canada on the shores of Lake Ontario, where it was refined, initially, for its radium content and, later, for uranium. At times, aircraft were used to transport ores from the nearby Sawmill Bay airstrip to the south. Figure 1 shows the location of the NTR within Canada.

Figure 1 The Northern Transportation Route

Impacted soils and ore spills have been found along the barge haul route, at Fort McMurray and at the receiving end in Port Hope. The original spills and contamination grew in volume as materials were moved and rehandled by the actions of man and the environment over the years. To put the volumes in perspective, roughly 1,500,000 m^3 are in the Port Hope area, 40,000 m^3 at Fort McMurray and perhaps 10,000 m^3 at sites along the NTR barge haul route.

NTR Communities Impacted

Contamination occurred at several sites along the NTR, typically as a result of accidental spillage of materials, primarily at the transfer points and portages where the ore was moved from one form of transportation to another. Ores were often distributed over larger areas as sites were subsequently modified and/or redeveloped. Beyond the contamination of lands along the NTR, there also was contamination of equipment including boats, barges, and aircraft, used for the haul. Such transportation equipment was used and stored at scattered locations in the north. Most of the equipment from these earlier times is now out of service and sites have been abandoned.

In the early 1990s, the LLRWMO investigated a number of uranium ore-contaminated sites along the NTR. These sites were centred in two areas: the Sahtu Region in the vicinity of Great Bear Lake, and the South Slave Region along the Slave River to the south. Contamination was also found at Fort McMurray – the terminus of the NTR. Figure 2 illustrates the NTR and the main locations of contamination along the barge haul portion of the NTR in the Sahtu and South Slave regions. A number of other locations along the NTR between these points have been investigated by the LLRWMO over the years and found to be uncontaminated.

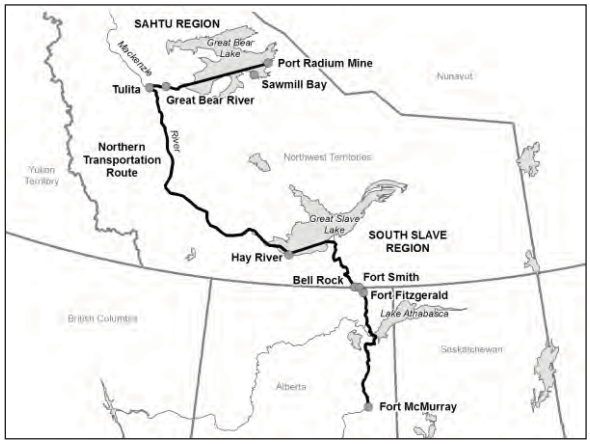

Figure 2: Sahtu and South Slave Sites on the NTR (Characterization and Remediation Sites)

Early Fact Finding and Discovery

In September 1991, consultants were retained by the LLRWMO to conduct a radiological assessment of suspected radioactive contamination at specific sites in Fort Franklin (now Déljne) and Yellowknife, Northwest Territories. The sites were suspected to have been contaminated by uranium ore being transported from the Port Radium mine. The resulting discoveries of elevated radioactivity levels on a barge historically used for ore transport (the Radium Gilbert) and at a river landing prompted a review of the entire historic uranium ore transportation network in the Northwest Territories by the LLRWMO and its consultants. Through discussions with the Northern Transportation Company Limited (NTCL) in Edmonton and museum staff at Norman Wells and Fort Smith, the details of the historic uranium transportation system were established. Through a progressive series of discussions, open houses and meetings over time with many local individuals and groups in NTR communities, much local information and many clues were discovered revealing the history, events, and practices of the time and potential locations of interest for investigation.

In August and September 1992, radiological investigations were conducted for ten vessels, three former warehouse sites, two portages, seven dock/transfer sites, one outside ore storage area, and a number of steel barges used by the NTCL for the transportation of the uranium ore. No low-level radioactive contamination was found on any of these vessels or steel barges (although contamination on two other barges used in Hay River was identified later). However, contaminated building materials and/or soil were found at most of the dock/transfer, warehouse, and storage sites (Senes Consultants Limited 1994). Discrete pieces of uranium ore were also found. The LLRWMO continues to actively monitor these NTR sites as part of its management of the contaminated soils to ensure soils are safely managed, are not further distributed and do not impact the public or the environment.

ASSESSMENT AND REMEDIATION OF SITES TO DATE

Subsequent to the initial discovery of contamination along the NTR, the LLRWMO initiated its program of gamma radiation surveys at potential transfer points along the NTR. Coincident with these surveys, the LLRWMO removed and consolidated contaminated soil from certain properties in Tulita, Fort Smith, Hay River and Fort McMurray. The contaminated material, where consolidated locally, was placed in temporary storage mounds where annual inspections are conducted to demonstrate good management and a safe environment for local residents.

The approach to assessment and remediation of the NTR sites has generally included the steps illustrated in Figure 3 and described as follows:

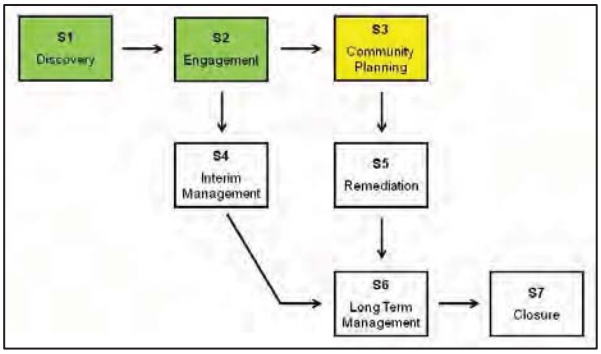

Figure 3: Typical Community Consultation and Remediation Process

- Step 1 (Discovery): in which the presence of legacy ores is discovered via historical reviews and/or community inputs, and preliminary field investigations are undertaken to characterize the general scale of the impact and its associated consequences.
- Step 2 (Engagement): in which initial contacts with the community are expanded and consultations regarding the nature, scale and significance of the impact continued.
- Step 3 (Community Planning): during which the LLRWMO and the community identify and assess alternatives for mitigating and managing the impacts over both intermediate and long term timelines.
- Step 4 (Interim Management): as soon as dialogues with the community are started (i.e., early Step 2), the preliminary characterization data (i.e., Step 1 outputs) are evaluated to determine if interim actions are required to mitigate near term risks to public health and safety. These interim actions might include access controls and/or material consolidation and temporary containment activities.
- Step 5 (Remediation): in which the outcomes of planning lead to the identification of a long term management option consistent with the community's constraints and objectives, and the development and execution of a remediation program that puts that management option in place. This step includes the transition/conversion of any interim facilities into the long term management plan.
- Step 6 (Long Term Management): during which the actions needed to validate the performance of the management system (including any containment/storage structures associated with it) are taken. In addition, the maintenance activities required to ensure the long term physical integrity of the system are applied.
- Step 7 (Closure): in which the outcomes of the remediation program are shared and celebrated with the community and ongoing activities/actions associated with long term management communicated.

Generally, the approach is aimed at gaining control and putting in place management of the contaminated materials as soon as possible, reflecting the appropriate level of concern and response.

NTR Remediation Chronology

The process outlined in Figure 3 has been applied in full or in part to a range of sites and former facilities on the NTR. Key remediation milestones for activities completed along the NTR are summarized below.

1978/79 Investigation and remediation of COSMOS 954 satellite crash impacts leads to identification of historic uranium ore impacts related to the NTR in Fort Smith, NWT.

1992 First comprehensive survey of potential ore impacts on transfer points and other facilities/ equipment related to the NTR conducted by the LLRWMO.

Remedial activities initiated in the Lower Town area of Fort McMurray, Alberta.

1993 Interim consolidation of materials in a dedicated local mound constructed at the Tulita airport (400 m^3).

Initial stage of Fort McMurray Long Term Management Facility (LTMF) developed.

1993-95 Remediation of eight sites in Fort McMurray completed (30,000 m^3).

1998 Impacted soils from Sawmill Bay and Hay River consolidated and shipped to LLRWMO storage facility in Chalk River, Ontario (15 m^3).

Former Fort Smith NTCL warehouse containing radioactive building components demolished and transferred to a dedicated cell at the municipal landfill site for storage.

1999 The most active materials from the Tulita storage mound are segregated and shipped to the LLRWMO's Chalk River, Ontario, storage facility.

2001 Additional soils added to the Tulita mound from local lands identified by residents (a former over winter storage site).

Removal of impacted soils from three properties in Fort Smith and placement in the dedicated cell at the municipal landfill site.

2003 Remediation of the final property in Fort McMurray completed along with final phase of LTMF development.

Decontamination of two barges used for ore transport in Hay River and the dismantling of a third in Déljne.

Attenuation of a local ore accumulation in Fort Fitzgerald via the placement of a sand cover.

2005 The Canada-Déljne Uranium Table (CDUT) releases a series of some 26 recommendations for actions at Port Radium including one to initiate remedial activity at the site.

2006 Contents of Tulita storage mound reconsolidated into some 755 bulk shipping bags.

2007-08 Remediation completed at the Port Radium site by the federal Department of Indian and Northern Affairs (INAC).

2008-09 Tulita mound materials shipped via Hay River to final disposition at a commercial facility in the United States (800 m^3).

2010 The final pocket of ore-impacted soil in Fort Smith (Peregrine Street) was excavated and consolidated with other LLRW materials at the dedicated municipal landfill cell.

First phase of remediation (housekeeping/barrel crushing) initiated at Sawmill Bay. A joint federal activity will be the outcome at Sawmill Bay with INAC and NRCan sponsoring their respective activities.

2011 Interim consolidation of impacted materials impeding roadway improvements in Fort Fitzgerald, Alberta.

Remedial activities at two of the key sites referenced in the above chronology are described in more detail in the following sections.

Port Radium

The Port Radium Site is the original source of radium in Canadian pitch blende. It is also a former uranium and silver mine located on a peninsula along the eastern shore of Great Bear Lake in the Northwest Territories, 450 km north of Yellowknife and 265 km east of Déljne within the Sahtu Dené and Métis traditional lands. The site was decommissioned in 1982 to the standards of the day. Due to more than 40 years of mining, silver, copper and uranium were present in soils and surface water at the immediate site. The site also had waste rock and tailings containing radionuclides. Small amounts of hydrocarbons and asbestos residue were also present at the site. Physical hazards, such as mine openings, were the most immediate safety issues on the property.

Remediation work was completed at the site in 2007/08 and included:

- improving drainage to reduce leaching of silver, copper and uranium into soils and surface water around the immediate site;
- reducing gamma radiation levels by covering waste rock and tailings;
- removing small amounts of hydrocarbons and asbestos residue;
- covering exposed waste materials or moving them to a landfill on-site; and
- closing mine openings.

Long term monitoring is an important element of the Port Radium Remediation Plan. The first four years of monitoring included inspections intended to confirm that the site remains in a stable condition and that the remediation solutions are working. In year five of the monitoring program, a more detailed study of the site looked at the health of fish in the Great Bear Lake area around Port Radium, as well as soil and lake sediments. Finally, a complete gamma survey of the entire Port Radium Site will be completed to make sure that the radiation covers are working as designed (Indian and Northern Affairs Canada 2009).

Fort McMurray, AB - The NTR Terminus

The Fort McMurray Historic Uranium Cleanup Project involved the removal of some 42,000 m^3 of soils contaminated with uranium ores and ore concentrates from nine properties in the City of Fort McMurray, Alberta. These soils were placed into long-term management in a dedicated, locally developed and secure facility. The project was executed over a 10-year time period, involved the participation of the local community at critical junctures, and restored 28 ha of land to productive use. The remedial work completed at Fort McMurray was the largest and most comprehensive program completed on the NTR to date, and is given proportionate emphasis in this paper (Geddes et al. 2005).

Program Development and Planning

A program of public consultation and engagement was initiated to identify possible solutions to the uranium ore contamination and to guide the execution of remedial plans. A Working Group comprised of

the local municipality, regulators, health authorities and the LLRWMO was maintained as work was planned and executed. The LLRWMO and the Working Group developed a solution that involved removing the materials from the subject sites and placing them into long-term management in a dedicated cell at the local municipal landfill site.

Cleanup Criteria

The principal contaminants of concern for the Fort McMurray Cleanup Project were radium, arsenic and uranium. The cleanup criteria adopted by the Working Group for these parameters were 0.1 Bq/g radium and 30 µg/g for both arsenic and uranium.

These criteria were selected on the basis of unrestricted future use of the lands, including residential use. While residential development was unlikely for the lands in question over the near term, it was felt that adopting relatively conservative criteria was an appropriate way of minimizing long-term land use restrictions.

Site Remediation

The remediation plan provided for mildly contaminated soil, described as Category B material, to be placed in the management cell constructed at the municipal landfill. Materials considered low-level radioactive waste, or Category A material, were shipped to the LLRWMO storage facility at Chalk River Laboratories in Chalk River, Ontario. Between 1993 and 1995, a total of eight properties in the Lower Town area were remediated (Figure 4). Cleanup of the last remaining property in the Waterways area was planned and undertaken between 2000 and 2003.

Figure 4: Cleanup Operations in Lower Town

The contaminated materials excavated from the subject sites (Figure 5) were transferred into long-term management at a dedicated facility constructed at the Fort McMurray landfill site (Figure 6). The management facility is a secure mound structure equipped with engineered containment, cover and leachate management systems.

Figure 5: Contaminated Soil Identification and Excavation

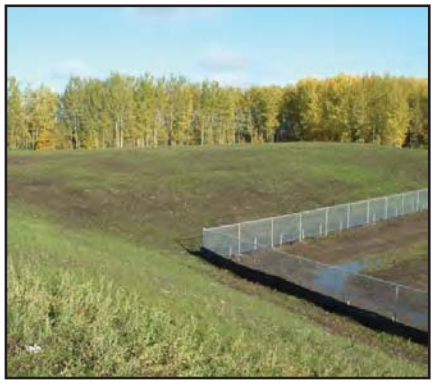

Figure 6: The Long Term Management Facility

The following features or protocols were applied as the LTMF was developed:

- Mound Design – the structure was developed with an engineered liner and cover, and a leachate collection and monitoring system;
- Contamination Control Procedures – a set of operating protocols designed to prevent the spread of both chemical and radioactive contamination and, as such, mitigate potential radiological impacts to the public, workers and the environment;
- Utilization of Dedicated Equipment – as part of the contamination control program, equipment was dedicated exclusively to site operations to ensure that all potentially contaminated items were maintained within a restricted area until such time as they had been monitored and decontaminated;
- Erosion Control – dust control protocols were applied to mitigate wind erosion and surface waters were directed and stored in ways that minimized sediment transport; and
- Monitoring – a comprehensive monitoring program was put in place to ensure that radiological exposures to workers and the public were maintained within acceptable limits.

Following completion of the LTMF, a program of long-term management, surveillance and monitoring was implemented to demonstrate that the facility is performing as designed and is in compliance with regulatory standards. This program was developed to fulfill the LLRWMO's obligations with respect to monitoring that are outlined in a legal agreement with the Regional Municipality of Wood Buffalo.

Consultation Program Overview

An effective process of engaging and informing the local community was always an integral component of the remedial program in Fort McMurray. A public participation program was implemented through the Working Group that guided the planning and implementation of the Project. In addition to the Working Group as key stakeholders, the consultation program extended into the community in several ways, including:

Figure 7: Open House Display

- local community consultation through one-on-one interviews and tracking of concerns and issues;
- information events (e.g., open houses) conducted in the community at appropriate project junctures (Figure 7); and
- media notices to advise the public about the project and its progress, and to provide details regarding pending information events.

The Result

The end result of the Historic Uranium Cleanup Project in Fort McMurray has been that nine properties covering about 28 ha have been made available for alternate uses. Many of these properties are in prime commercial locations, and as a consequence, have already been redeveloped into retail outlets. This rehabilitation was completed at minimal risk to the community and by devoting only 1.5 ha of non-productive land to the long-term management of contaminated materials.

ADVANCING THE NEXT PHASE OF REMEDIATION IN THE NORTH

The success of remedial programs to date on the NRT has created increased expectations in the remaining communities where contamination is still present. The Government of Canada continues to be committed to the remediation of this remaining contamination at sites in both the South Slave Region and in the Sahtu Region. Consideration of cleanup options for these areas had begun in 2007, prior to the completion of the Tulita cleanup, when NRCan and the LLRWMO convened a meeting of all government stakeholders in Yellowknife to discuss contamination issues and the process for moving forward. Since then, local communities have also come forward expressing interest and some urgency in advancing the cleanup. This has led to community meetings and the initiation of continuing dialogue with local leadership and others in both the Sahtu and the South Slave. Interest is rising and progress is being made.

CONCLUSIONS

For some 30 years, the LLRWMO and NRCan, along with their partners in other government agencies, and within the consulting community, have developed processes and precedents for managing the legacies of uranium and radium mining in Canada's north. This experience has demonstrated that the critical determinants of success are those efforts directed towards engaging the local communities to fully understand the locations, scale and significance of impacts, and in the development of plans for the long term management of those impacts. The Office's seven step process for working with communities from issue discovery to closure has provided a framework that has facilitated the effective mitigation of a large proportion of concerns generated by NTR legacies. Current activities underway with communities in the Sahtu and South Slave regions of northern Canada are applying these and related techniques towards moving the remaining NTR uranium and radium mining legacies in Canada's north to closure.

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Overcoming Northern Challenges

Proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop and

38th Annual Meeting of the Canadian Land Reclamation Association

Whitehorse, Yukon September 9 – 12, 2013

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Polster	Natural Processes: An Effective Model For Mine Reclamation
Dustin	Implementation of contaminated water management system upgrades to allow for dewatering of two open pits at the Vangorda Plateau, Faro Mine Complex, Yukon
Kempenaar, Marques and McClure	Tools for Arctic Revegetation: What's in Your Toolbox?
Smreciu, Gould, and Wood	Establishment of Native Boearl Plant Species On Reclaimed Oil Sands Mining Disturbances
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Pedlar-Hobbs, Ludgate and Luchinski	Key Factors in Developing and Implementing a Successful Reclamation Plan
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Janin	Passive treatment of drainage waters: Promoting metals sorption to enhance metal removal efficiency
Stewart and Siciliano	Biological Soil Crusts and Native Species for Northern Mine Site Restoration
Nadeau and Huggard	Restoration Planning and Application of Ecological Succession Principals
Simpson	Defining Disturbance and Recovery - the influence of landscape specific ecological responses to oil and gas linear disturbances in Yukon

NORTHERN LATITUDES MINING RECLAMATION WORKSHOP

The Northern Latitudes Mining Reclamation Workshop is an international workshop on mining, land and urban reclamation and restoration methods. The objective of the workshop is to share information and experiences among governments, industry, consultants, Alaska Natives, northern First Nations and Inuit groups which undertake reclamation and restoration projects, or are involved in land management in the north or in comparable environments.

The first Workshop was held in Whitehorse, Yukon Territory, Canada in 2001 and it has been held every two years since, alternating between Canada and Alaska. The primary sponsors of the Workshop include the Yukon Geological Survey, Indian and Northern Affairs Canada, Natural Resources Canada, US Department of the Interior Bureau of Land Management, and the State of Alaska Department of Natural Resources.

CANADIAN LAND RECLAMATION ASSOCIATION

The CLRA/ACRSD is a non-profit organization incorporated in Canada with corresponding members throughout North America and other countries. The main objectives of CLRA/ACRSD are:

- To further knowledge and encourage investigation of problems and solutions in land reclamation.
- To provide opportunities for those interested in and concerned with land reclamation to meet and exchange information, ideas and experience.
- To incorporate the advances from research and practical experience into land reclamation planning and practice.
- To collect information relating to land reclamation and publish periodicals, books and leaflets which the Association may think desirable.
- To encourage education in the field of land reclamation.
- To provide awards for noteworthy achievements in the field of land reclamation.

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