FIFTEEN YEARS OF EXPERIENCE IN REMEDIAL ACTION PROGRAMS FOR HISTORIC LLR WASTE IN CANADA

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ABSTRACT

The Low-Level Radioactive Waste Management Office (LLRWMO) acts on behalf of the federal government to manage historic low level radioactive waste in Canada. Over the past ten years, the LLRWMO has investigated and decontaminated structures and properties. It has removed contaminated soil, debris and radioactive artifacts to safe storage or interim, in situ containment. It has worked with communities and regulatory agencies to develop locally acceptable waste management solutions. Once a permanent disposal site for such materials is sited and operating in Canada, the LLRWMO will assist in transferring stored materials to final disposal. This paper reviews progress of programs and projects of the LLRWMO and reports on their present status. Lessons learned in community involvement, project management, environmental remediation and remedial engineering design are highlighted.

INTRODUCTION

The Low-Level Radioactive Waste Management Office (LLRWMO) was established by the federal government in 1982 and given a three part mandate: to resolve "historic" waste problems, to ensure that a user-pay service is established, as required, for the disposal of low-level radioactive waste produced on an ongoing basis, and to address public information needs about low-level radioactive waste in Canada. The LLRWMO continues the work started by a Federal-Provincial Task Force in 1977. Together, the activities of the LLRWMO and the task force span approximately fifteen years.

The LLRWMO is operated by Atomic Energy of Canada Limited (AECL) through an agreement with Energy, Mines and Resources Canada, the federal department which provides funding and establishes national policy. The LLRWMO is headquartered in Ottawa, with a field office and soils laboratory in Port Hope, Ontario.

The LLRWMO has no regulatory responsibilities. Policy and regulatory responsibility for LLR waste management in Canada rest with the federal Atomic Energy Control Board (AECB), federal government departments, including Energy, Mines and Resources Canada, and federal and provincial environmental assessment or other legislation. The organizational framework for LLR waste management in Canada, including a description of waste generators, their responsibilities and practices, is presented elsewhere. (1)

"Low-level radioactive (LLR) waste" has a different definition in Canada than in the United States. In Canada it is defined by exclusion. If a waste is radioactive, but it is not high-level waste (i.e. spent reactor fuel), nor uranium mill tailings, then it is classed as low-level waste, and comes within the mandate of the LLRWMO. In terms of equivalent US classifications, all wastes from the very lowest of the Class A waste right up to greater than Class C are included. Canada does not have the weapons-related wastes found in the USA.

Both "on-going LLR waste production" and "historic LLR waste inventories" occur in Canada. Accumulations of on-going LLR waste production at waste generator sites are the responsibility of the waste generator. However, their continued rate of generation and accumulation, and their ultimate method of disposal are also of interest to the LLRWMO. Although historic LLR waste is not generated any longer, the national inventory does increase from time-to-time when new historic waste occurrences are found or when the responsibility for disposal of an already identified inventory is assumed by the federal government.

There are substantive differences in radiological, chemical and physical characteristics between historic LLR wastes and on-going LLR wastes produced today in nuclear power production and radioisotope use.

"Historic LLR wastes" are low-level radioactive wastes which are managed in a manner no longer considered acceptable, but for which the original producer can no longer reasonably be held responsible. Responsibility is exercised by the federal government on a case-by-case basis. The LLRWMO acts as the agent of the federal government in matters related to the management of historic LLR waste.

BACKGROUND

Before 1977

Production of LLR waste in Canada started in 1933 when Eldorado Gold Mines Limited began refining radium at a plant in Port Hope, Ontario. The production of uranium was added in 1942 and, because of its strategic significance, the company was made a federal Crown Corporation (Eldorado) in 1944. Initially, the wastes from this industry were treated no differently from other types of industrial waste. Processing residues and other contaminated wastes from the refinery were used as fill materials during construction activities and sent to landfill sites. Contamination was spread by wind and water transport from storage sites, by salvage and reuse of contaminated building materials and by spillage from haul vehicles in the Port Hope area.

As the Canadian nuclear program developed after the second world war, production of uranium quickly became the most important component, and radium production ceased in 1953. As understanding of the effects of radiation improved, the indiscriminate management of wastes was replaced by the use of dumping under controlled access, and then shallow land burial of wastes in dedicated and controlled facilities. Unfortunately, when the choice of sites was made in the 1940's and 1950's, leaching and contaminant transport were poorly understood, and substantial contamination of the host soils occurred.

Two major sites, referred to as the Welcome and Port Granby sites, are maintained by Cameco, the new company formed by the merger of Eldorado and a uranium mining company. However, the federal government is mainly responsible for funding the remediation program for these old sites through its prior ownership of Eldorado. The development of this remediation program led to a radioactive waste management facility siting process for Port Hope area wastes in Ontario (2).

In all, there are about 800,000 cubic meters of processing residues and contaminated soils in the Port Hope area, from the waste management practices of the radium and uranium industry in the 1930's, 1940's and 1950's. At many of the old sites, for every cubic meter of waste that was originally produced, there are now about 10 cubic meters of contaminated soil, which has become part of the overall problem. The contaminants are natural uranium with radionuclides and heavy metals present in the original ores that were processed. Arsenic is the most significant in terms of amount, mobility and toxicity.

From 1977 Through 1981

The problem in Port Hope was recognized in the mid-1970's and a large scale cleanup program carried out. This work concentrated on developed properties. As a result, quantities of contaminated materials remain in a number of large undeveloped areas and in smaller pockets.

A Federal/Provincial Task Force on Radioactivity, headed by the Atomic Energy Control Board (AECB), was established to develop cleanup criteria and to carry out remedial work at properties exceeding these criteria in Canada, and specifically in Port Hope, and in the uranium mining communities of Elliot Lake, Ontario and Uranium City, Saskatchewan. The primary criteria established by the Federal/Provincial Task Force for initiating remedial work were 0.02 Working Levels (WL) for indoor radon progeny, 0.05 milliroentgen per hour (mR/hr) for interior gamma radiation, and 0.100 mR/hr for exterior gamma radiation (3).

Over 4000 properties in Port Hope were radiologically surveyed for compliance with the criteria and remedial work was carried out on about 400 properties between 1977 and 1981. However, the radioactive waste management storage site at the Chalk River Laboratories (CRL) of AECL Research, where the Port Hope wastes were trucked, had limited capacity. Remedial work concentrated on developed residential and commercial properties. Large volumes of contaminated soil in mainly vacant areas, and the contaminated sediments in the Port Hope harbor, were left for cleanup at a later date. As well, small quantities of slightly contaminated soils, that is soils with above background radioactivity content but below cleanup criteria activity, exist along some public roads and on some private and public properties.

Since 1982

The LLRWMO was established in 1982 and is responsible for cleanup of historic LLR wastes remaining in Port Hope and elsewhere in Canada. The LLRWMO operates in partnership with Energy, Mines and Resources Canada and federal siting task forces established to address LLR waste disposal in regions of Canada. Two such task forces are presently seeking sites for specific waste inventories in the province of Ontario (4) and British Columbia (5) and are working with potential host communities to assess options and locations. The inventory at Port Hope is by far the largest in the nation.

The programs and projects of the LLRWMO in the period 1982 through 1992 are discussed in detail in the following sections of this paper. Some of the highlights over the past ten years are listed here. The LLRWMO completed the remediation of properties, contaminated beyond the 1977 cleanup criteria, in Port Hope and Elliot Lake by 1985. Community consensus was reached in 1989 to proceed with interim consolidation and on-site storage of historic waste at two major sites in the Town of Port Hope. By 1991 the LLRWMO had completed this work and began operation of its first licensed waste management facilities. A fundamental change in disposal siting philosophy occurred in Canada in approximately 1986 and since then voluntary siting processes have been used. The LLRWMO established a national LLR waste tracking database in 1991 and continues to maintain statistics on waste accumulation in the country. Sites at Port Hope, Scarborough, Surrey and Fort McMurray have been delineated, characterized and have undergone interim remediation. Programs aimed at environmental monitoring, technology development and safe development of contaminated land have been established.

STATUS OF LLRWMO PROGRAMS

The LLRWMO has addressed a wide range of subject areas over the past ten years. These can be grouped into the following program areas which are discussed below.

1. Property Contamination Surveys
2. Site Decontaminations
3. Waste Consolidations
4. Storage Facility Operations
5. Construction Monitoring
6. Disposal Facility Siting
7. National Inventory Tracking
8. Environmental Monitoring
9. Topical LLR Waste Studies
10. Technology Development

Property Contamination Surveys

Every year, LLRWMO staff perform manual surficial gamma surveys on land parcels at various locations in Canada. Most such surveys are performed in the vicinity of historic waste sites in Port Hope and Scarborough. Over the past two or three years the LLRWMO has been developing protocols, hardware and software to advance surface radiation survey approaches. This is discussed later in this paper.

Indoor contamination surveys have also been performed from time-to-time. Often, this is associated with former radium dial painting sites or at sites where contaminated building materials have been used in structures.

Subsurface investigations using gamma logging in boreholes has been a major technique used by the LLRWMO to delineate and characterize subsurface contamination. Application of this technology is mainly associated with our waste consolidation activities discussed below. Advances in protocol and technology development associated with borehole logging is described below.

Site Decontaminations

A follow-up program carried out by the LLRWMO completed the work of the Federal/Provincial Task Force and remediated about 40 properties to at least the 1977 criteria. These were the initial property decontaminations undertaken by the LLRWMO. Sites at Port Hope, Elliot Lake and recently, Serpent River, Ontario comprised the work.

The LLRWMO and the Town of Port Hope have jointly developed a Construction Monitoring Program, which from time to time identifies contamination at excavations for new construction (6). This program facilitates the cleanup and interim storage of small quantities of contaminated soil at new construction sites. From time-to-time this triggers remedial work at individual properties. The program is discussed further below.

Additional site decontaminations can be required anywhere in Canada when old radium painting operations or equipment are encountered. The LLRWMO has recently assisted metal recyclers in two cities when radioactive materials were inadvertently admitted to sites, shredded and distributed among product inventory.

Waste Consolidations

A program of contamination delineation and waste consolidation has been underway in Port Hope since 1988 (7). Typically each consolidation involves a site specific remedial program and construction of an on-site containment. Engineered mounds and concrete block storage structures have been used. This has resulted in immediate environmental improvement (8) and has rendered sites useful for unimpeded development and use.

This program resulted in construction, by 1990, of two in situ consolidation sites in Port Hope containing a total of more than 30,000 cubic meters of contaminated soil and waste. An earlier consolidation of 4,000 cubic meters of waste on a small industrial property in Surrey, British Columbia was conducted in 1985. The potential for further waste consolidation exists in Port Hope and Scarborough at the option of the local community.

Storage Facility Operations

The LLRWMO now operates several storage facilities. These include two engineered mound sites and two temporary storage sites in Port Hope, Ontario; one concrete bunker site in Surrey, British Columbia; and two metal storage buildings at Chalk River, Ontario. Work in progress at Scarborough, Ontario will lead to an additional storage facility there in the near future.

In the Town of Port Hope, the Pine Street Extension Consolidation Site was completed in 1990 and the Strachan Street Consolidation Site, was completed in 1988. Both are located within the urban area of the Town and have developed residential properties abutting them. These sites are now licensed to the LLRWMO by the Atomic Energy Control Board (AECB) and will be monitored and maintained by the LLRWMO until such time as a site for disposal of the wastes becomes available.

Construction Monitoring

The Construction Monitoring Program (CMP), was developed in cooperation with the Town of Port Hope (9). It addresses contaminated soil found from time to time at minor excavations at new construction sites. Under the program, private land owners and their contractors request help with survey and removal of contaminated soil at a site. A volume limit of 100 cubic meters of eligible soil per property controls program use.

This program began in January 1990. After 3 years of operation the program has seen approximately 3,500 cubic meters of soil moved from approximately 50 projects in the Town of Port Hope. Protocols for safely handling slightly elevated material have been developed. Effective administrative procedures for tracking contaminated material, and approval of routine and special actions have been developed. A track record of cooperation and success has been established.

The principles and procedures of the Port Hope CMP are being considered for use in other communities. Where uncertainty and concern can be eliminated by minor survey, supervision and removal actions, the LLRWMO assists property owners wherever possible.

Disposal Facility Siting

The initial effort to develop a new site for the Port Hope area wastes was undertaken by the waste generator. By late 1986 the federal government appointed a Siting Process Task Force (SPTF) to find a new approach. The SPTF recommended a new process having as its cornerstone voluntary participation of potential disposal host communities (2). A new Siting Task Force (STF) was appointed in late 1988 to implement the process. This process continues today and shows positive signs of identifying and constructing Canada's first LLR waste disposal site.

The Surrey Siting Task Force (SSTF) was established by the federal government in 1989 to find a disposal opportunity for 4,000 cubic meters of Niobium slag waste and thorium contaminated soil in British Columbia. Following the voluntary siting process approach, the SSTF has been making steady progress and resolution of the problem is expected shortly.

The role of the LLRWMO is to provide technical assistance to both siting task forces and the affected communities in Ontario and British Columbia. In addition to work directly undertaken by the task forces themselves, the LLRWMO has addressed some matters related to waste characterization and delineation, interim remediation and waste handling, environmental impact monitoring, technology development and remedial work design.

National Inventory Tracking

The LLRWMO developed a national database to track on-going production and accumulation of LLR waste in 1991. An initial annual report on the national waste inventory was prepared in 1992 (10).

The database will be regularly updated to facilitate annual reports. This work is part of the mandated program of the LLRWMO to provide information to Canadians on LLR waste and assists the LLRWMO in advising Energy, Mines and Resources, Canada.

Topical LLR Waste Studies

Over the past ten years, the LLRWMO has investigated issues of interest to Canadian waste generators and environmental managers. Particular waste streams, their environmental impact, and safe management practices are the main focus of these studies. Where possible, these studies are jointly addressed with interested parties.

Examples of studies undertaken include national investigations of phosphogypsum tailings (11), liquid scintillation waste (12), power reactor and fuel cycle decommissioning waste (13), long-lived wastes (14), wastes generated from non-nuclear industry activities (15), and mixed waste (16).

Environmental Monitoring

A routine Environmental Monitoring Program was launched in Port Hope in 1986 by the LLRWMO, prior to the consolidation of any waste at the major sites. The program included monitoring areas around all major waste sites for radon in air using electrostatically enhanced alpha track detectors, measuring gamma radiation at fence lines around the sites using thermoluminescent dosimeters (TLD's), and monitoring the water quality of streams flowing past contaminated deposits. Local, uncontaminated areas were monitored for a local background comparison (17).

Other environmental monitoring and studies undertaken by the LLRWMO in Canada have included radon in air investigations in Manitoba (18) and radium content in typical Ontario soils (17).

Since 1987 the LLRWMO has participated in an international measurement intercomparison for radon and radon progeny conducted by the Environmental Measurements Laboratory, US Department of Energy in New York City. The LLRWMO has participated at least annually in this effort, which includes grab samples, integrating devices, and continuous radon and progeny measurement devices.

Technology Development

The LLRWMO has recently investigated subsurface borehole gamma logging, surface gamma surveying, and soil sorting systems. Such investigations occur as integral components of remedial work planning.

In 1992 the LLRWMO, together with the Borehole Geophysics Section of the Geological Survey of Canada, experimented with the installation of boreholes and use of spectral logging protocols at an historic waste contaminated municipal landfill site (19). The experimentation has produced an improved field protocol for subsurface investigations in radon gas influenced subsurface settings.

Over the past two years, the LLRWMO has been developing large area surface gamma survey protocols (20). Areas as large as school yards are of interest. A battery powered detection system with twin sodium iodide scintillating detectors and on-board lap-top computer mounted on a golf hand-cart comprise the hardware. The software and field scanning protocol are undergoing statistical sensitivity analysis and software quality assurance. This approach is integral to preliminary work at Scarborough, Ontario and Fort McMurray, Alberta remedial sites.

In 1991 an experimental soil sorting operation was applied to the McLevin Avenue work site in Scarborough, Ontario. Largely mechanical and manual techniques followed by a detector-controlled compliance conveyor was used to handle soil contaminated with discrete particle contamination. Further work in this area will be undertaken in support of planning for future work in Scarborough.

Present Program Priorities

The LLRWMO is currently preparing for remedial actions at sites in Ontario, Alberta and British Columbia. To aid these initiatives the LLRWMO is currently pursuing with great interest:

- cleanup criteria development
- soil sorting and contaminant removal technology
- surface and subsurface radionuclide detection at low concentrations and activities.

In 1993 January the LLRWMO initiated a concentrated program of data analysis and computer modelling of a radium and uranium-contaminated municipal landfill site. A groundwater plume model will be developed for the site and adjacent areas.

ISSUES AND LESSONS

LLRWMO remedial projects in recent years provide guidance on suitable approaches for the future. Observations on aspects of public acceptance, design and operations, project management and environmental benefit are presented below.

Social Aspects

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. Dialogue on options and focus on a review of environmental screening documentation have been the two steps used by the LLRWMO (21).

Public acceptance of projects is earned, not assumed. 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 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 technically competent staff in-house and must be vigilant to the need to act. Experience has shown that the unexpected must be expected, 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, possibly under separate contracts, should work separate sites, especially if work progress lags; and penalty provisions for environmental performance in all contracts should be considered.

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.

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. In fact, the act of excavating and stockpiling waste provides self-shielding layers. 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. Progress is made toward final completion of remedial activities since most of the affected areas are cleaned and restored to the ultimate desired level. Material is also prepared for easy future removal.

Thorough initial site investigations, including radiological surveys of the surface and subsurface conditions, are undertaken and factored into conceptual engineering plans. However, supplementary investigations during the progress of the excavation work, as well as direct supervision at the work face, is now common practice in LLRWMO projects. Rigorous attention to materials excavated reduces volumes for future management and ensures site cleanup to criteria levels.

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.

CONCLUSIONS

Fifteen years of experience in remedial action programs at historic waste sites have been accumulated by the Federal/Provincial Task Force on Radioactivity and its successor, the LLRWMO. Steady progress has been made through a time of change in public attitudes toward environmental protection and decision making processes.

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

The LLRWMO, two siting task forces and the responsible federal government department are actively addressing current priorities in LLR waste management in Canada. An ambitious study program complete with a community-level decision process and on-going remedial work show evidence of progress and commitment by all parties involved.

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