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INVENTORY OF Radioactive Waste in Canada

LOW-LEVEL RADIOACTIVE
WASTE MANAGEMENT OFFICE

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<u>Photos on Front Cover Courtesy of AECL:</u>

Storage containers at Chalk River Laboratories, Chalk River, Ontario.

Low-level radioactive waste mound, Fort McMurray, Alberta.

AECL’s MACSTOR (Modular Air Cooled Storage), Gentilly 2, Bécancour, Quebec.

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Inventory of Radioactive Waste in Canada

A report prepared for

Natural Resources Canada

by the

Low-Level Radioactive Waste Management Office

Low-Level Radioactive Waste Management Office
1900 City Park Drive, Suite 200
Ottawa, Ontario, Canada
K1J 1A3

EXECUTIVE SUMMARY

This report presents the inventory of radioactive waste in Canada to the end of 2003. It is intended to provide an overall review on the production, accumulation and projections of radioactive waste in Canada. The data presented in this report has been gathered from many sources including regulatory documents, published reports and supplemental information provided by the regulatory agency, waste producers and waste management facilities.

Radioactive waste has been produced in Canada since the early 1930s when the first radium mine began operating at Port Radium in the Northwest Territories. Radium was refined for medical use and uranium was later processed at Port Hope, Ontario. Research and development on the application of nuclear energy to produce electricity began in the 1940s at the Chalk River Laboratories (CRL) of Atomic Energy of Canada Limited (AECL).

At present, radioactive waste is generated in Canada from: uranium mining, milling, refining and conversion; nuclear fuel fabrication; nuclear reactor operations; nuclear research; and radioisotope manufacture and use.

Radioactive waste is grouped into three categories: nuclear fuel waste, low-level radioactive waste, and uranium mill tailings.

In accordance with the Radioactive Waste Policy Framework, the owners of radioactive waste are responsible for the funding, organization, management and operation of disposal and other facilities required for their waste. The policy recognizes that arrangements may be different for each of the three waste categories.

Radioactive waste is currently managed in a safe and environmentally responsible manner by storing the waste in accordance with the requirements set out by the Canadian Nuclear Safety Commission (CNSC), Canada's independent nuclear regulator.

The following table presents a summary of the quantity of radioactive waste produced in 2003 and the cumulative inventory to the end of 2003.

Waste Data to 2003

WASTE CATEGORY	WASTE PRODUCED IN 2003	WASTE INVENTORY TO THE END OF 2003
Nuclear Fuel Waste	250 m^3	6,800 m^3
Low-Level Radioactive Waste	7,300 m^3	2.29 million m^3
Uranium Mill Tailings	0.6 million tonnes	213 million tonnes

In order to assess the future requirements for the management of radioactive waste, a projection of the inventory to the end of 2004 and 2033 is also provided in the table below. The year 2033 is selected as a future reference because it was forecasted as the end of operation for the last constructed power reactors (Darlington Generating Station).

Waste Inventory Projections to 2004 and 2033

WASTE CATEGORY	WASTE INVENTORY TO END OF 2004	WASTE INVENTORY TO END OF 2033
Nuclear Fuel Waste	7,300 m^3	15,000 m^3
Low-Level Radioactive Waste	2.3 million m^3	2.6 million m^3
Uranium Mill Tailings	214 million tonnes	222 million tonnes

Table of Contents

Table of Contents (cont'd)

Table of Contents (cont'd)

Page

List of Figures

1.0 INTRODUCTION

This report provides the annual accumulation rate and inventory of radioactive waste in Canada to the end of 2003.

Radioactive wastes have been produced in Canada since the early 1930s when the first radium mine in Canada began operating at Port Radium in the Northwest Territories. Radium was refined for medical use and uranium was later processed at Port Hope, Ontario. Research and development on the application of nuclear energy to produce electricity began in the 1940s at the Chalk River Laboratories (CRL) of Atomic Energy of Canada Limited (AECL).

At present, radioactive waste is generated in Canada from: uranium mining, milling, refining and conversion; nuclear fuel fabrication; nuclear reactor operations; nuclear research; and radioisotope manufacture and use.

In accordance with Canada’s Radioactive Waste Policy Framework (see Appendix A), the owners of radioactive waste are responsible for the funding, organization, management, and operation of disposal and other facilities required for their waste. The policy recognizes that arrangements may be different for each of the waste categories.

In November, 2002, the Nuclear Fuel Waste Act (NFWA) entered into force. This act requires that: nuclear energy corporations, for example, Ontario Power Generation, Hydro-Québec and New Brunswick Power, establish and maintain a Waste Management Organization (WMO); that this organization return to government in three years with a recommended approach to the long-term management of Canada’s nuclear fuel waste; and that once the government of Canada takes a decision on the approach, the WMO will then be responsible for its implementation.

Radioactive waste is currently managed in a safe and environmentally responsible manner by storing the waste under the requirements of the Canadian Nuclear Safety Commission (CNSC), Canada’s independent nuclear regulator.

2.0 REPORT OBJECTIVE

The objective of the report is to:

- provide an overall review on the production, accumulation and projections of radioactive waste in Canada.

3.0 REPORT SCOPE AND ORGANIZATION

The scope of the report includes radioactive waste of the following three categories generated from the peaceful applications of nuclear energy:

- nuclear fuel waste;
- low-level radioactive waste; and
- uranium mill tailings.

Data on radioactive waste inventory is based on regulatory documents, published reports and supplemental information provided by the regulatory agency, waste generators and waste management facilities. Regulatory documents include: annual or quarterly compliance reports, annual safety reviews and decommissioning reports submitted to AECL and the CNSC.

Section 4 of this report describes the sources and producers of each of the three categories of radioactive waste. Section 5 summarizes the accumulation rates during 2003 and waste inventory to the end of 2003. Section 6 presents projections for each of the three categories of waste to 2004 and 2033. Section 7 summarizes current and future inventories.

Appendix A provides the Federal Policy Framework for Radioactive Waste.

4.0 SOURCES

This section briefly identifies how radioactive waste is produced, where it is located and the producers and owners of the waste. Figure 4.1 provides a map showing where radioactive waste is currently located.

4.1 Nuclear Fuel Waste

Nuclear fuel waste refers to the nuclear fuel bundles discharged from:

- the CANDU power reactors;
- prototype and demonstration power reactors; and
- research and isotope production reactors.

Nuclear fuel wastes are removed from the reactor and stored in water-filled pools at the reactor site. After a number of years in the pools, nuclear fuel waste may be transferred to storage containers for on-site dry storage until a long-term management plan is implemented.

There are 22 power reactors in Canada owned by three provincial electric utilities. Ontario Power Generation Inc. (OPG) owns 20 reactors while Hydro-Québec and New Brunswick Power each own one reactor. Bruce Power Inc. currently leases and operates the Bruce nuclear power plants from OPG. The Bruce plants consist of eight CANDU nuclear reactors. These 22 reactors have a total generation capacity of 15,000 megawatts of electricity.

As of December 31, 2003, 17 nuclear reactors were operating, producing about 12% of Canada’s electricity. At present, nuclear power meets more than 40% of Ontario’s electricity needs.

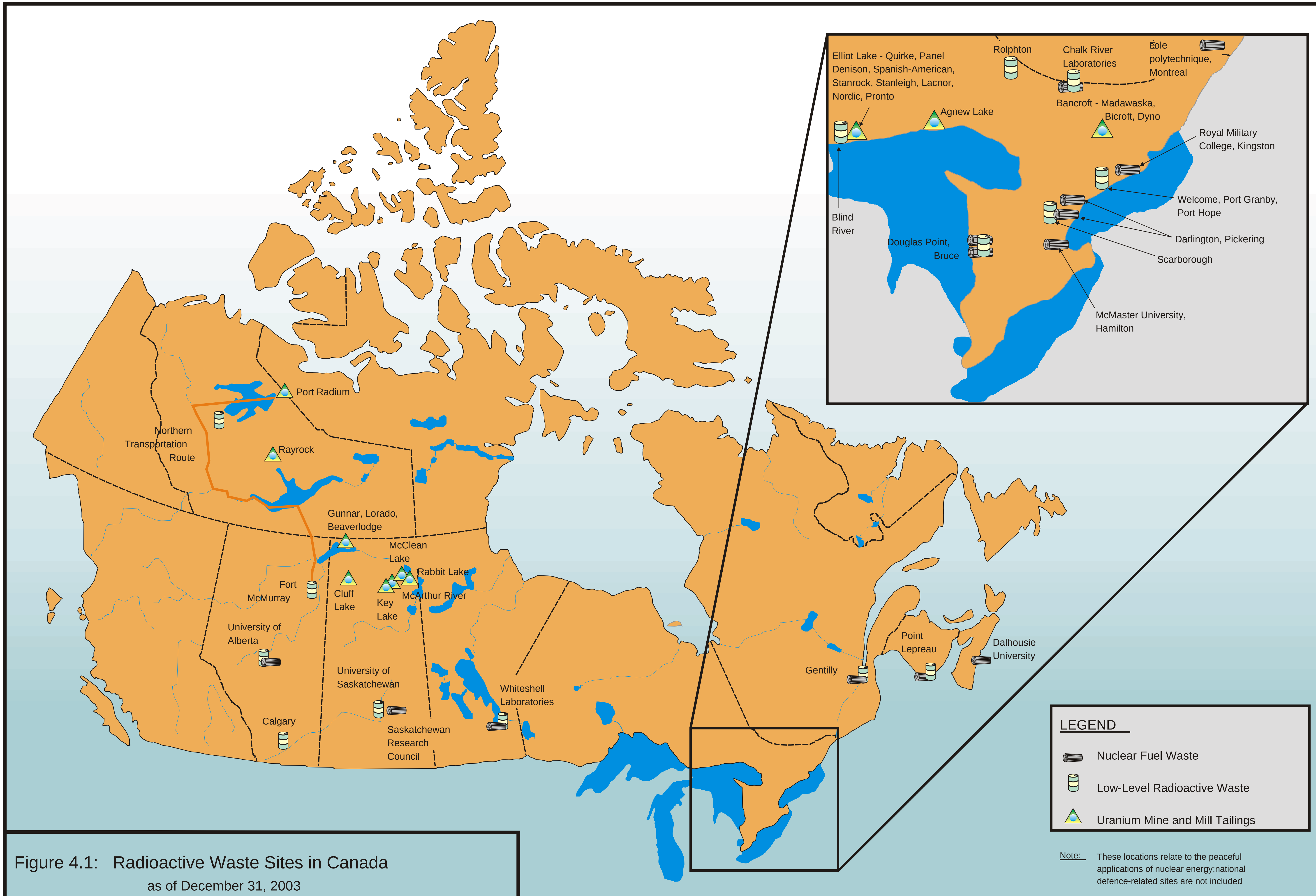


Figure 4.1: Radioactive Waste Sites in Canada

as of December 31, 2003

Ontario Power Generation Inc. has 15 reactors in operation (including six reactors operated by Bruce Power Inc.); five reactors are in voluntary layup (including two of the Bruce Power reactors). The two reactors owned by Hydro-Québec and New Brunswick Power are operational. OPG has recently announced the decision to re-start Pickering A Unit 1 by September, 2005. As of December 31, 2003, OPG has announced no plans on refurbishment of Pickering A Units 2 and 3. Bruce Power is currently studying the feasibility of restarting Bruce A Units 1 and 2.

Nuclear fuel wastes from power reactors are currently stored in pools and/or dry storage containers in waste management facilities at each of the operating power reactor sites.

There are three prototype power reactors, Douglas Point, Nuclear Power Demonstration (NPD) and Gentilly-1, located at Douglas Point and Rolphton, Ontario, and Bécancour, Quebec, respectively. Each of these facilities have been partially decommissioned and are in Phase 2 decommissioning (storage-with-surveillance). All three reactors await dismantling. Nuclear fuel waste from the Douglas Point and Gentilly-1 reactors is in dry storage at the on-site waste management facilities. Nuclear fuel waste from the NPD reactor was transferred to a waste management facility at AECL's Chalk River Laboratories (AECL-CRL).

There is also a small amount of nuclear fuel waste produced by the research and radioisotope production reactors at AECL and research reactors at universities. There are two operating research facilities in Canada - at AECL-CRL in Chalk River, Ontario and at AECL's Whiteshell Laboratories (AECL-WL) in Pinawa, Manitoba. Waste generated at these sites is stored in waste management facilities at each site. There are nine research reactors operating in Canada as of December 31, 2003. Waste generated at these sites is transferred to AECL-CRL for long-term management. The University of Toronto's SLOWPOKE-2 facility was completely decommissioned by the end of 2000.

Table 4.1 lists power reactors operating under CNSC licences and Table 4.2 lists research reactors operating under CNSC licences. Figure 4.2 shows the location of these reactors.

Table 4.1: Summary of CNSC Power Reactor Operating Licences

FACILITY AND LOCATION	LICENSEE	TYPE AND NUMBER OF UNITS/CAPACITY
Bruce Generating Station A, Tiverton, Ontario	Bruce Power Inc.	CANDU-PHW 4 x 750 MW(e)
Bruce Generating Station B, Tiverton, Ontario	Bruce Power Inc.	CANDU-PHW 4 x 840 MW(e)
Pickering Generating Station A, Pickering, Ontario	Ontario Power Generation Inc.	CANDU-PHW 4 x 500 MW(e)
Pickering Generating Station B, Pickering, Ontario	Ontario Power Generation Inc.	CANDU-PHW 4 x 500 MW(e)
Darlington Generating Station, Clarington, Ontario	Ontario Power Generation Inc.	CANDU-PHW 4 x 850 MW(e)
Gentilly-2 Generating Station, Bécancour, Quebec	Hydro-Québec	CANDU-PHW 600 MW(e)
Point Lepreau Generating Station, Point Lepreau, New Brunswick	New Brunswick Power Corporation	CANDU-PHW 600 MW(e)

Source: *CNSC Annual Report 2002-03*, March 31, 2003.
Notes: Nuclear fuel waste from these reactors is stored at the respective sites.
MW(e) - megawatt (nominal electrical power output)

Table 4.2: Summary of CNSC Research Reactor Operating Licences

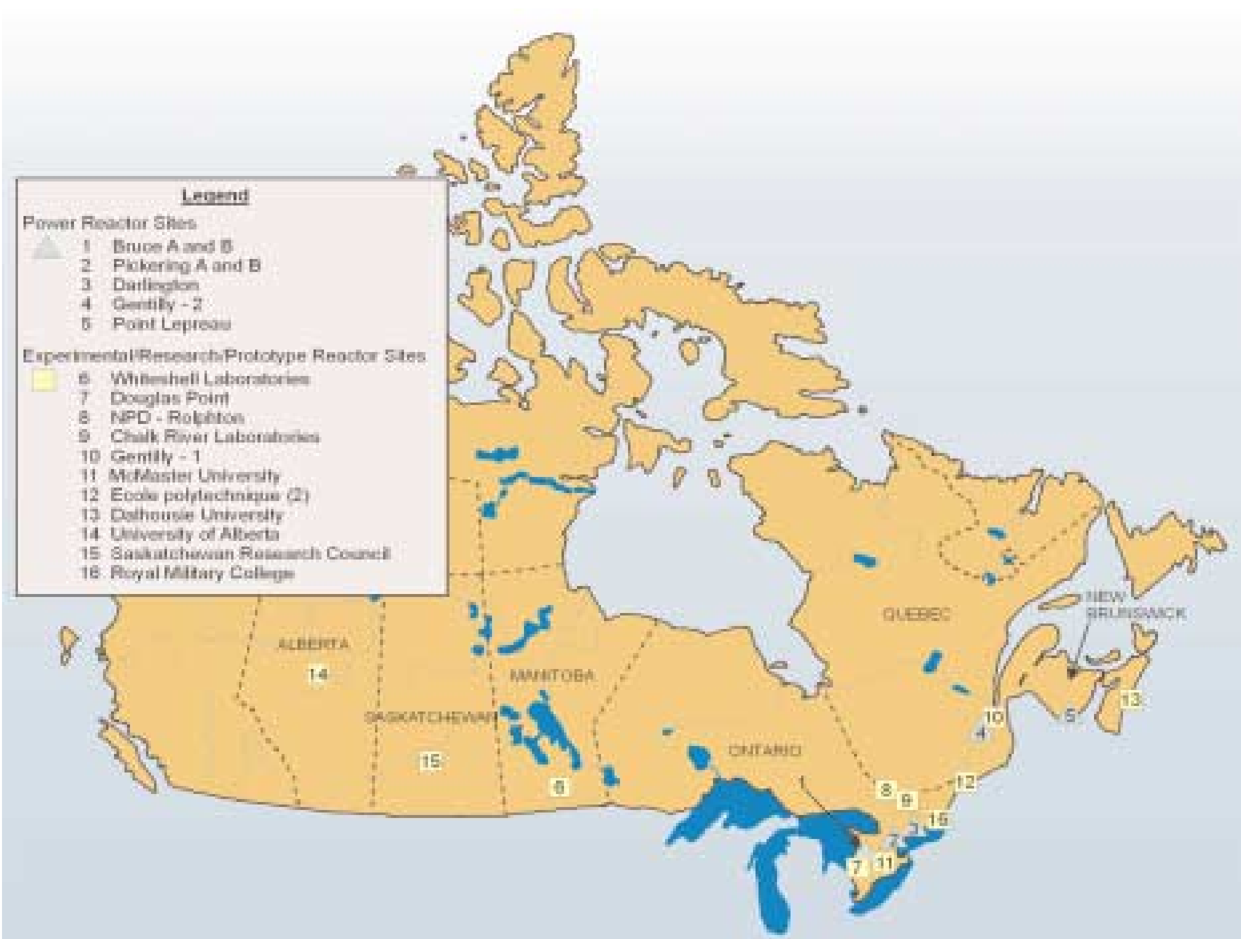
LOCATION	LICENSEE	TYPE AND CAPACITY
Hamilton, Ontario	McMaster University	Pool-type 5 MW(t)
Montréal, Quebec	École polytechnique	Subcritical Assembly
Montréal, Quebec	École polytechnique	SLOWPOKE-2 20 kW(t)
Halifax, Nova Scotia	Dalhousie University	SLOWPOKE-2 20 kW(t)
Edmonton, Alberta	University of Alberta	SLOWPOKE-2 20 kW(t)
Saskatoon, Saskatchewan	Saskatchewan Research Council	SLOWPOKE-2 20 kW(t)
Kingston, Ontario	Royal Military College of Canada	SLOWPOKE-2 20 kW(t)

Source: *CNSC Annual Report 2002-03*, March 31, 2003.

Note: In addition to the above reactors, two reactors for research and radioisotope production (NRU and ZED-2) at AECL-CRL are operating under CNSC licences issued for the AECL-CRL site. As of December 31, 2003, CNSC granted approvals for AECL to resume nuclear commissioning for an additional two non-power reactors (MAPLE 1 and MAPLE 2) at AECL-CRL.

MW(t) - megawatt (thermal power)
kW(t) - kilowatt (thermal power)

Figure 4.2: Nuclear Reactor Sites



4.2 Low-Level Radioactive Waste

Low-level radioactive waste (LLRW) includes all LLRW arising from the activities associated with nuclear electricity generation, from nuclear research and development, and from the production and use of radioisotopes in medicine, education, research, agriculture and industry. Examples of LLRW are contaminated materials, rags and protective clothing. It also includes contaminated soils and related wastes resulting from the very early operations of Canada's radium industry. LLRW is grouped into two broad categories, as follows:

- *Ongoing Waste:* LLRW that is generated from ongoing activities of companies that are currently in business, for example, nuclear electricity generators. Owners or producers of ongoing waste are responsible for its management.

- *Historic Waste:* LLRW that was managed in the past in a manner no longer considered acceptable but for which the owner cannot reasonably be held responsible. The federal government has accepted responsibility for this waste.

4.2.1 Ongoing Waste

Ongoing waste results from operation, maintenance and decommissioning of facilities related to:

- the nuclear fuel cycle;
- nuclear research and development; and
- production and use of radioisotopes.

4.2.1.1 Operations

Nuclear Fuel Cycle

The nuclear fuel cycle includes: uranium mining, refining and conversion; nuclear fuel fabrication; and nuclear power reactor operations. Wastes associated with uranium mining are dealt with in a separate section. There are five licensed uranium processing and fuel fabrication facilities operating in Ontario. One facility in Alberta is not operating but is still licensed by CNSC as a standby facility.

During refining, the ore concentrate from uranium milling operations is upgraded to uranium trioxide. The uranium trioxide is converted to ceramic grade uranium dioxide for fabrication into fuel for CANDU reactors, or processed into uranium hexafluoride for foreign light water reactors. Approximately one quarter of the uranium mined in Canada is used for domestic nuclear electricity production. Cameco Corporation operates Canada's only refinery facility at Blind River, Ontario, and the only conversion facility at Port Hope, Ontario. Earth Sciences Extraction Company in Calgary, Alberta, has an operating licence to recover high-grade uranium from fertilizer-grade phosphoric acid. However, the company's plant was shut down in 1987, partially decommissioned and no longer produces uranium.

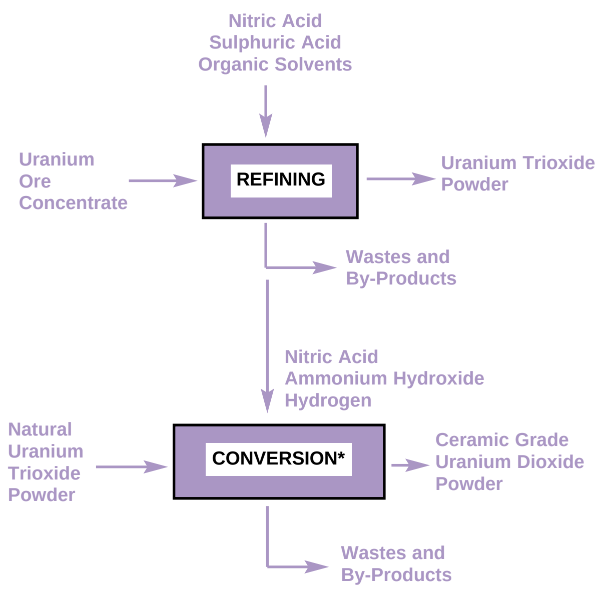
During fuel fabrication, uranium dioxide is formed into pellets, sintered and sheathed in zirconium to form fuel bundles for power reactors. General Electric Canada Incorporated and Zircatec Precision Industries Incorporated are the only fuel fabricators in Canada. General Electric Canada produces fuel pellets and fuel bundles at facilities in Toronto and Peterborough, Ontario, respectively. Zircatec Precision Industries produces both pellets and bundles at a facility in Port Hope, Ontario. Table 4.3 provides a list of CNSC licensees involved in uranium refining, conversion and fuel fabrication activities.

Table 4.3: Uranium Refinery, Conversion Facility and Fuel Fabrication Plan Licences

LICENSEE AND LOCATION	LICENSED ACTIVITY
General Electric Canada Incorporated, Toronto, Ontario	Fuel Pellets
General Electric Canada Incorporated, Peterborough, Ontario	Fuel Bundles
Zircatec Precision Industries Incorporated, Port Hope, Ontario	Fuel Pellets and Bundles
Earth Sciences Extraction Company, Calgary, Alberta	Uranium Oxide
Cameco Corporation, Blind River, Ontario	Uranium Trioxide
Cameco Corporation, Port Hope, Ontario	Uranium Hexafluoride Natural and Depleted Uranium Metal and Alloys Uranium Dioxide Ammonium Diuranate

Figure 4.3 summarizes the input and output streams and LLRW resulting from the refining and conversion of uranium. Figure 4.4 shows the process associated with nuclear fuel fabrication and fuel bundle production and the resulting LLRW.

Figure 4.3: Process Flowchart for Uranium Refining and Conversion



BY-PRODUCTS
Ammonium Nitrate Fertilizer
Raffinates (recycled)

WASTE
Combustible Waste
Uncontaminated and contaminated scrap lumber, pallets, rags, paper, cardboard, rubber and plastic

Organic Liquid Waste

Non-Combustible Waste
Uncontaminated insulation, pipe-racks, light bulbs, metal turnings, paint cans, cell gaskets, concrete, glass

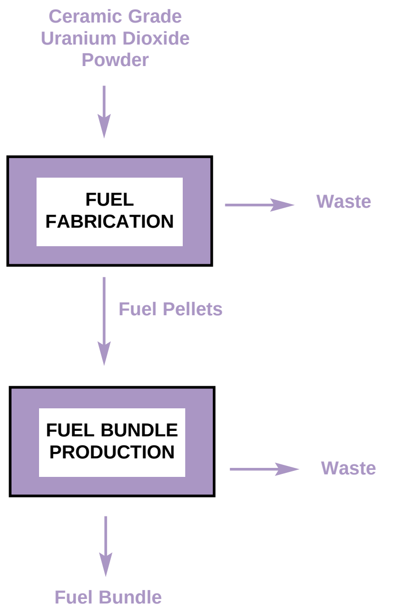
Contaminated air filters, fibreglass, PVC ductwork, floor sweepings, sandblast sand, insulation, sample bottles, scrap metal, anodes

Recyclable scrap metal

Radioactive drain wastes

*In addition to ceramic grade uranium dioxide powder for CANDU reactors, CAMECO also produces uranium hexafluoride for light water reactors.

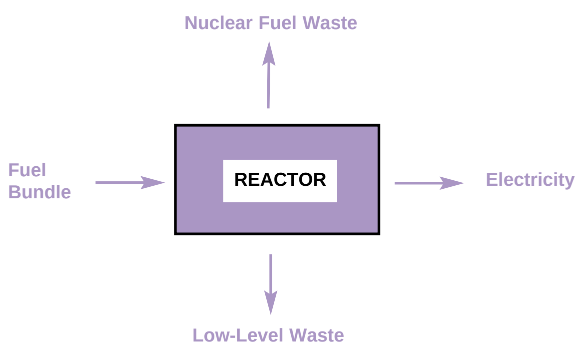
Figure 4.4: Process Flowchart for Nuclear Fuel Fabrication



WASTE
Contaminated rags, paper, gloves
Contaminated oils and oil sludges
Contaminated equipment and construction materials
Filters and dust collectors

Figure 4.5 summarizes the input and output streams and LLRW produced from reactor operations. Wastes include natural uranium, neutron activation or fission products. Both solid and liquid wastes are produced.

Figure 4.5: Process Flowchart for CANDU Reactor Operations



LOW-LEVEL WASTE
Incinerable Waste
Paper, plastic, rubber, cotton, wood, organic liquids

Compactible Waste
Paper, plastic PVC suits, rubber, fibreglass, metal pieces, empty drums

Non-Processable Waste
Filters, light bulbs cable, used equipment, metals construction debris, absorbents (sand, vermiculite, sweeping compound), ion exchange resins, reactor core components, retube wastes

Processable Liquids
Radioactive drain wastes, chemical cleaning solutions

There are 18 radioactive waste management facilities under CNSC licences as of the end of 2003. These facilities are listed in Table 4.4. Some of these facilities are licensed to manage only LLRW while some are licensed to manage both LLRW and nuclear fuel waste.

Nuclear Research and Development

Currently there are two nuclear research facilities in Canada licensed by the CNSC and operated by AECL. These facilities include the Chalk River Laboratories in Chalk River, Ontario and the Whiteshell Laboratories in Pinawa, Manitoba. Operational wastes produced at these two sites are stored in waste management facilities at each site. The Chalk River facility (AECL-CRL) has two operating reactors, the NRU reactor and the zero power ZED-2 reactor. Research and development activities at AECL-CRL include the application of nuclear science, reactor development, environmental science and LLRW management.

Research at Whiteshell Laboratories (AECL-WL) is primarily related to radioactive waste management, environmental sciences and reactor development. Operations at AECL-WL have been significantly reduced in recent years. In December 2002, the CNSC issued a six-year decommissioning licence for the WL site. This allows AECL to fully implement Phase 1 of the decommissioning program. The WR-1 reactor has been partially decommissioned and the SLOWPOKE Demonstration Reactor has been fully decommissioned.

Table 4.4: Summary of CNSC Waste Management Licences

FACILITY AND LOCATION	LICENSEE
Bruce Power Central Maintenance and Laundry, Tiverton, Ontario	Bruce Power Inc.
Radioactive Waste Operations Site 1, Bruce Nuclear Power Development, Tiverton, Ontario	Ontario Power Generation Inc.
WWMF, Bruce Nuclear Power Development, Tiverton, Ontario	Ontario Power Generation Inc.
Pickering Waste Management Facility, Pickering, Ontario	Ontario Power Generation Inc.
Gentilly-2 Radioactive Waste Management Facility, Bécancour, Quebec	Hydro-Québec
Point Lepreau Solid Radioactive Waste Management Facility, Point Lepreau, New Brunswick	New Brunswick Power Corp.
Douglas Point Radioactive Waste Management Facility, Douglas Point, Ontario	AECL
Gentilly-1 Radioactive Waste Management Facility, Bécancour, Quebec	AECL
NPD Waste Management Facility, Rolphton, Ontario	AECL
Port Hope Waste Management Facility, Port Hope, Ontario	AECL
Pine Street Extension, Port Hope, Ontario	AECL
Various locations for small decontamination projects	AECL
Chalk River Laboratories Waste Management Areas, Chalk River, Ontario	AECL
Whiteshell Laboratories Waste Management Areas, Pinawa, Manitoba	AECL
Port Granby Waste Management Facility, Clarington, Ontario	Cameco Corporation
Welcome Waste Management Facility, Port Hope, Ontario	Cameco Corporation
University of Toronto Waste Management Facility, Toronto, Ontario	University of Toronto
Monserco Waste Services Inc., Mississauga, Ontario	Monserco
Elliot Lake Historic Mines Waste Management Facility, Elliot Lake, Ontario	Rio Algom Ltd.

Notes: WWMF = Western Waste Management Facility
AECL = Atomic Energy of Canada Limited

Some of AECL's waste management sites, which began operation during the early years of nuclear research and development in Canada, will require remediation or decommissioning in the future. These sites are managed safely by AECL under CNSC licences. The wastes include both the original wastes stored at the sites and any soils contaminated by the wastes. These wastes were generated by AECL during research and development work associated with the development of CANDU reactors, the advancement of nuclear science and the production of radioisotopes.

Nine research reactors operate under licences issued by the CNSC (see Table 4.2). These reactors are used for neutron activation analyses and other nuclear research. Operation of these research reactors produces small quantities of LLRW compared with the power reactor sites. Waste from the research reactor sites is sent to AECL-CRL for management by AECL.

Production and Use of Radioisotopes

Radioisotopes, as sealed or unsealed sources, have industrial, medical and educational applications. In Canada, these radioisotopes are produced primarily at AECL-CRL. Radioistopes are primarily marketed by MDS Nordion located in Ottawa, Ontario. In 2002-2003, AECL resumed commissioning two 10 MW thermal MAPLE reactors and a new radioisotope processing facility it built at AECL-CRL for MDS Nordion. In addition to radioisotope production at AECL-CRL, Ontario Power Generation Inc., Hydro-Québec, Bruce Power Inc., TRIUMF (University of British Columbia) and the McMaster Nuclear Reactor (McMaster University) produce radioisotopes that are shipped to MDS Nordion and other marketers for further processing, packaging and distribution to secondary manufacturers, repackagers or clients. Wastes that are generated during production are managed by the respective producers.

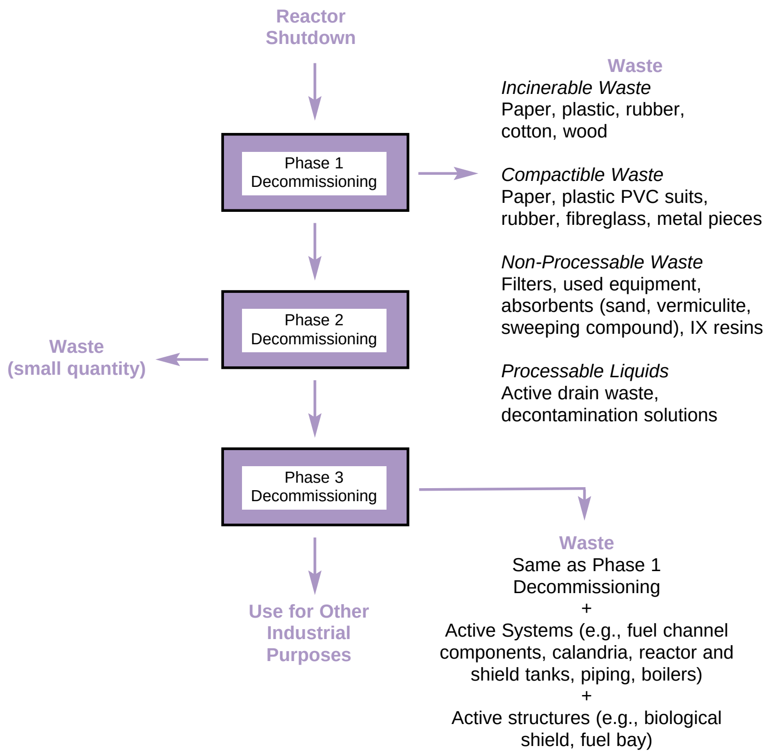
When radioisotopes have outlived their useful application, they become radioactive waste. These wastes (or spent sources) are shipped to AECL-CRL for management.

4.2.1.2 Decommissioning

Wastes are also generated when nuclear facilities are decommissioned, (i.e. decontaminated and dismantled) at the end of their operational life (see Figure 4.6). Consideration must be given to the health and safety of workers and the public, and to protection of the environment, during decommissioning. Most of Canada's decommissioning waste will be generated in the future although some inventory already exists from small decommissioning projects completed to date.

The most significant quantities of wastes will result from the decommissioning of nuclear reactors and their supporting facilities. Wastes will range from highly radioactive materials associated with the reactor core to other building components and materials contaminated during reactor operations.

Figure 4.6: Process Flowchart for CANDU Reactor Decommissioning



Based on current plans submitted to the CNSC, power reactors will be decommissioned in three phases as summarized in Figure 4.6. Spent fuel will be removed from the reactor core prior to decommissioning. Phase 1 (preparation for storage-with-surveillance) will begin soon after reactor shutdown and last for about three to four years. The purpose of Phase 1 is to isolate and stabilize the remaining reactor components for a long-term storage period to allow sufficient time for most of the radioactivity to decay to a level at which the waste can be released without hazards. Phase 1 decommissioning is expected to produce several hundred cubic metres of LLRW per reactor. Phase 2 (storage-with-surveillance) will last approximately 25 to 30 years. A very small amount of waste is generated during Phase 2. Phase 3 (dismantling) is expected to last about five to ten years. Phase 3 will generate the majority of radioactive waste. At the end of Phase 3, the site should be suitable for unrestricted use.

4.2.2 Historic Waste

As described earlier, historic waste is low-level radioactive waste for which the federal government has accepted responsibility. The Low-Level Radioactive Waste Management Office (LLRWMO) is the federal government's agent for the cleanup and long-term management of historic waste.

There are several large historic waste sites as well as numerous smaller sites throughout Canada. At many of the sites, materials have been placed in interim storage pending the development and implementation of a long-term management approach. Ongoing site monitoring, inspection and maintenance are conducted at these sites.

Wastes at some of these sites include artifacts or surficially contaminated building materials. Other sites contain large volumes of radium-contaminated soils with low radioactivity. Contaminated soils from cleanups at small sites, and contaminated artifacts and building materials from larger sites only, are removed to the LLRWMO storage buildings at AECL-CRL. Larger volumes of contaminated soils that cannot be accommodated at the LLRWMO storage buildings are managed at or near the source (see the following).

Municipality of Port Hope, Ontario

Historic waste is present in various areas in the Municipality of Port Hope, Ontario. The waste dates back to the 1930s when radium was refined for medical applications at a refinery in the municipality. The waste is primarily soil contaminated with material from the refinery. The LLRWMO is responsible for the monitoring and safe management of the waste at these sites. It is working with the municipality on the Port Hope Area Initiative to develop, evaluate, and implement a long-term management approach for these wastes.

Welcome and Port Granby, Ontario

LLRW is located at the Welcome Waste Management Facility (closed in 1955) in the Municipality of Port Hope, Ontario and the Port Granby Waste Management Facility (closed in 1988) in the Municipality of Clarington, Ontario. Cameco Corporation owns these sites which were purchased from Eldorado Nuclear Limited, a federal Crown corporation. Cameco and the federal government share financial responsibility for capital and extraordinary operating costs, including decommissioning costs, associated with the management of the waste at these facilities. The waste at both sites is included in the Port Hope Area Initiative.

Other Locations

Historic waste is stored at various other locations across Canada including sites in Ontario, Alberta, and the Northwest Territories. The LLRWMO is responsible for the cleanup and the long-term management of the waste at these sites.

4.3 Uranium Mill Tailings

Uranium mill tailings are a specific type of LLRW that are generated during the milling (processing) of uranium ore to produce uranium concentrate. As noted previously, uranium concentrate, once refined and converted, is used to make fuel for Canadian and foreign power reactors. Today, tailings are placed in mined out open pits converted to tailings management facilities (TMFs). However, this was not always the case. Historically, tailings were placed in natural containment areas such as lakes or valleys, placed in engineered surface containment areas, or disposed as backfill in underground mines.

Owing to the large volumes and low activity levels, tailings sites are decommissioned in place. Decommissioning of surface tailings sites usually includes improvement or construction of dams to provide long-term containment, flooding or covering of tailings to reduce acid generation and the release of gamma radiation and radon gas, and management/monitoring of tailings and effluent.

At all of the newer operations in Saskatchewan, tailings are managed in mined out pits converted to TMFs. The TMFs feature hydraulic containment during operation (that is, the pit is maintained in a partially dewatered state relative to the surrounding natural water table so that all groundwater flow is towards the tailings facility), and passive long term containment following decommissioning. The latter results from a zone of high hydraulic conductivity material which surrounds the much lower hydraulic conductivity consolidated tailings that channels groundwater flow around rather than through the tailings. The high hydraulic conductivity zone may either be constructed as the tailings are emplaced, referred to as pervious surround (i.e., Rabbit Lake TMF), or exist naturally by virtue of the type of rock, referred to as natural surround (i.e., McClean Lake and Key Lake Dielmann TMF).

Uranium tailings exist at operating uranium mill sites in northern Saskatchewan and at inactive or decommissioned sites in Saskatchewan, Ontario and the Northwest Territories. Table 4.5 provides a list of uranium mine and mill facilities licensed by the CNSC. Figure 4.7 shows the locations of uranium mining and milling projects in Canada. Figures 4.8 and 4.9 show the locations of mines and tailings sites in the Elliot Lake and Bancroft areas in Ontario.

Table 4.5: Uranium Mine and Mill Facility Licences

FACILITY AND LOCATION	LICENSEE	LICENSED ACTIVITY
Key Lake Operation, Saskatchewan	Cameco Corporation	Operation
McArthur River Operation, Saskatchewan	Cameco Corporation	Operation (Mining Only)
Rabbit Lake Operation, Saskatchewan	Cameco Corporation	Operation
McClean Lake, Saskatchewan	COGEMA Resources Inc.	Operation
Cluff Lake Project, Saskatchewan	COGEMA Resources Inc.	Decommissioning
Denison Mine, Elliot Lake, Ontario	Denison Mines Inc.	Decommissioning
Stanrock Mine, Elliot Lake, Ontario	Denison Mines Inc.	Decommissioning
Madawaska Mine, Bancroft, Ontario	EnCana Corporation	Decommissioning
Stanleigh Mine, Elliot Lake, Ontario	Rio Algom Limited	Decommissioning
Panel Mine, Elliot Lake, Ontario	Rio Algom Limited	Decommissioning
Quirke Mine, Elliot Lake, Ontario	Rio Algom Limited	Decommissioning
Beaverlodge Mining Operations, Beaverlodge, Saskatchewan	Cameco Corporation	Decommissioning
Rayrock, Northwest Territories	Indian and Northern Affairs Canada	Waste Management
Elliot Lake Historic Mines, Elliot Lake, Ontario	Rio Algom Limited	Waste Management
Agnew Lake, Ontario	Ontario Ministry of Northern Development and Mines	Waste Management
Cigar Lake Project, Saskatchewan	Cameco Corporation	Construction
Midwest Joint Venture, Saskatchewan	COGEMA Resources Inc.	Care and Maintenance

Figure 4.7: Uranium Mine and Mill Tailings Sites in Canada

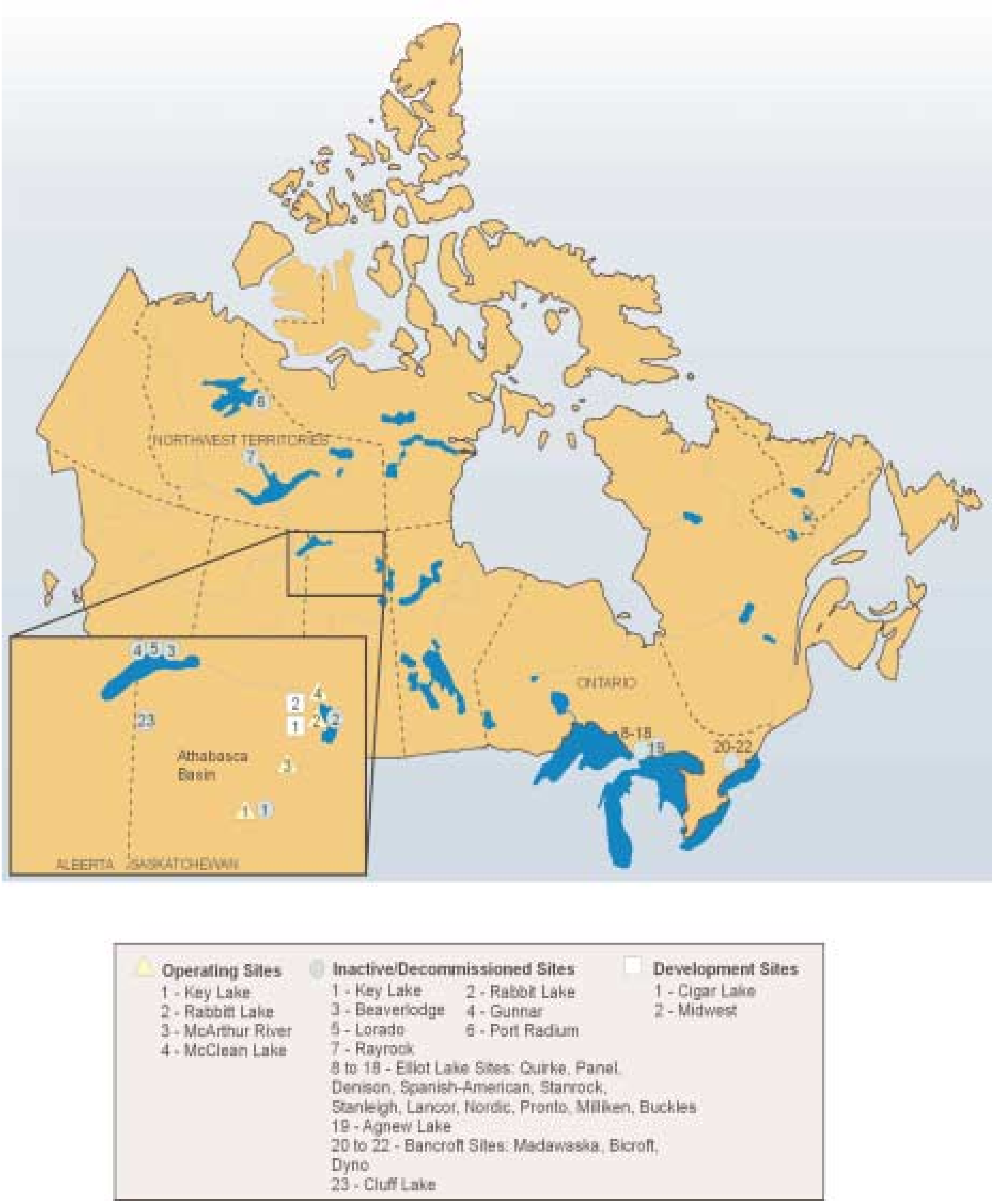


Figure 4.8: Uranium Mine and Mill Tailings Sites near Elliot Lake, Ontario

MINE/MILL FACILITIES

A/B - Quirke	F - CANMET	J - Lacnor
C - Panel	G - Stanrock	K - Nordic
D - Denison	H - Stanleigh	L - Pronto
E - Spanish-American	I - Milliken	M - Agnew Lake

TAILINGS AREAS

1 - Quirke	4 - Spanish-American	7 - Lacnor
2 - Panel	5 - Stanrock	8 - Nordic/Buckles
3 - Denison	6 - Stanleigh	9 - Pronto
		10 - Agnew Lake

Figure 4.9: Uranium Mine and Mill Tailings Sites near Bancroft, Ontario

4.3.1 Operating Sites

At present, all uranium production in Canada is located in Saskatchewan. Sites with active tailings management facilities include Key Lake and Rabbit Lake, operated by Cameco Corporation, and McClean Lake, operated by COGEMA Resources Inc.. The McArthur River mine (operated by Cameco Corporation) is operational, however there is no tailings management facility at this site since the ore is transported to Key Lake for milling.

The Key Lake site has been operating since 1984. The last ore was mined from the Deilmann Open Pit in 1997, after which mining was stopped. Initial tailings at the Key Lake site were deposited in a purpose-built surface tailings management area until late 1995. In late 1995/early 1996, deposition of tailings was transferred to the Deilmann Tailings Management Facility (DTMF). Since February 1996, all tailings have been deposited in the DTMF. In January 2000, the Key Lake operation began processing ore from the McArthur River mine, which began production in December 1999.

Rabbit Lake, the longest-operating uranium production facility in Saskatchewan, began operating in 1975. Tailings were deposited at a surface tailings management area until 1985 when deposition of tailings into the Rabbit Lake Pit TMF began. Open pit uranium deposits have been mined out, but underground mining at the Eagle Point ore zone continues . In the future, the final processing step for some of the ore originating from Cigar Lake is planned for Rabbit Lake.

The McClean Lake site began uranium production in 1999. It is the first new uranium mill constructed in North America in 15 years. The mill will be expanded in the future to process ores from two development sites, the Cigar Lake and Midwest projects. Open pit mining of the initial deposit (JEB ore body) began in 1995. Once the ore was removed and stockpiled, the pit was developed as a tailings management facility.

4.3.2 Inactive or Decommissioned Sites

Key Lake and Rabbit Lake, operated by Cameco Corporation, each have an inactive tailings management area from earlier operations. The Cluff Lake Project, operated by COGEMA Resources Inc., ceased production at the end of 2002 and began with decommissioning in 2004. There are also three older inactive tailings sites or areas in Saskatchewan. The Beaverlodge operation was shut down in 1982 and decommissioned in 1985. Cameco Corporation is managing the decommissiong of the sites. The Lorado and Gunnar sites have been closed since 1960 and 1964, respectively, and have not been adequately decommissioned. The Saskatchewan Government is the land owner responsible for both sites, with the exception of a portion of the Lorado tailings owned by EnCana Corporation.

There are two inactive uranium sites in the Northwest Territories. The Port Radium site was decommissioned in 1984. The Rayrock site was abandoned in 1959. Performance monitoring of the Rayrock site began in 1996. Indian and Northern Affairs Canada is responsible for these two sites.

There are nine inactive uranium tailings sites in and around Elliot Lake, Ontario. Rio Algom Ltd. is responsible for seven waste management sites:

i. Quirke, inactive since 1992;
ii. Panel, inactive since 1990;
iii. Spanish-American, inactive since 1959;
iv. Stanleigh, inactive since 1996;
v. Lacnor, inactive since 1960;
vi. Nordic/Buckles, inactive since 1968; and
vii. Pronto, inactive since 1960.

Denison Mines Inc. is responsible for two sites:

i. Denison, inactive since 1992; and
ii. Stanrock, inactive since 1964.

The Agnew Lake Mine north of Espanola, Ontario, was decommissioned and monitored by Kerr Addison Mines in the 1980s. The site was turned over to the Ontario Ministry of Northern Development and Mines in the early 1990s.

Inactive uranium tailings sites in the Bancroft, Ontario area include Madawaska, Dyno and Bicroft mines. The Madawaska Mine has been inactive since 1983, while operations at the Dyno and Bicroft sites ceased in the early 1960s. EnCana Corporation has completed decommissioning activities at the Madawaska and Dyno Mine sites. Lac Properties Inc. has completed decommissioning activities at the Bicroft Mine site.

4.3.3 Development Sites

At the end of 2003, there were two uranium development sites in Saskatchewan with CNSC licences. In 1998, the federal and provincial governments approved Cigar Lake Project (operated by Cameco Corporation) and Midwest Joint Venture (operated by COGEMA Resources Inc.) for advancement to the next stage of the regulatory approval process, based on the recommendations of a Joint Federal/Provincial Environmental Assessment Panel. Construction of the Cigar Lake mine is expected to start in 2005, with development of the Midwest mine expected later in the decade, depending upon regulatory approval and market conditions.

There are no tailings at these sites at present, and this will continue to be the case, since ore from these sites is expected to be transported to McClean Lake for milling (with some of the final processing at Rabbit Lake to produce uranium concentrate from Cigar Lake ore).

5.0 CURRENT INVENTORY AND ACCUMULATION RATE

This section summarizes the annual rates of waste accumulation during 2003 and the accumulated waste volumes to the end of 2003.

5.1 Nuclear Fuel Waste

Operation of the CANDU power reactors generates nuclear fuel waste, also known as spent fuel or high-level waste. There is also a small amount of nuclear fuel waste resulting from past operation of nuclear power demonstration reactors, as well as historic and ongoing operation of AECL's research and radioisotope production reactors and research reactors at universities. The long-term management of nuclear fuel waste is proceeding under the Nuclear Fuel Waste Act. At present, nuclear fuel waste is kept in wet or dry storage at the reactor sites and at AECL's waste management facilities at Chalk River, Ontario or Pinawa, Manitoba.

Table 5.1 summarizes the annual accumulation and inventories of nuclear fuel wastes from nuclear power and AECL's prototype/demonstration/research reactors to 2003 December 31. Inventories do not include fuel bundles currently in the reactors.

In 2003, the 17 operating power reactors produced 61,645 bundles of nuclear fuel waste. This represents approximately 246 m^3 of waste based on a volume of 0.004 m^3 for a typical CANDU fuel bundle. The accumulated nuclear fuel waste inventory to the end of 2003 for the power reactors was 1,657,938 bundles or approximately 6,632 m^3 of waste.

Table 5.1: Nuclear Fuel Waste Accumulation Rate and Inventory, 2003

Site Name	Source Company Name	Nuclear Fuel Waste Generated in 2003		On-Site Waste Inventory to 2003 December 31				Reactor Status as of 2003 December
				Dry Storage	Wet Storage	Total Storage		
		No. of Fuel Bundles/yr	Estimated Volume[c] (m^3/yr)	No. of Fuel Bundles	No. of Fuel Bundles	No. of Fuel Bundles	Estimated Volume[c] (m^3)	
POWER REACTORS								
Bruce A	Bruce Power Inc.	0	0	0	354,567	354,567	1,418	Operational lay-up of reactors 1 &2[1]
Bruce B	Bruce Power Inc.	21,179	85	3,840[2]	373,858	377,698	1,511	Operating
Darlington	Ontario Power Generation	20,601	82	0	234,433	234,433	938	Operating
Pickering A and B	Ontario Power Generation	11,449	46	118,306	385,935	504,241	2,017	Operational lay-up of Pickering A reactors 1-3[3]
Gentilly-2	Hydro-Québec	3,608	14	51,000	37,789	88,789	355	Operating
Point Lepreau	NB Power	4,808	19	57,240	40,970	98,210	393	Operating
Subtotal Power Reactors		**61,645**	**246**	**230,386**	**1,427,552**	**1,657,938**	**6,632**	
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS								
Douglas Point	AECL	0	0	22,256	0	22,256	89	Shutdown and partially decommissioned
Gentilly-1	AECL	0	0	3,213	0	3,213	13	Shutdown and partially decommissioned
Chalk River Laboratories[a]	AECL	863	3	25,136	0	25,136	101	Operating
Whiteshell Laboratories[b]	AECL	0	0	2,268	0	2,268	9	Shutdown and being decommissioned
Subtotal Research Reactors		**863**	**3**	**52,873**	**0**	**52,873**	**212**	
Total		**62,508**	**249**	**283,259**	**1,427,552**	**1,710,811**	**6,844**	

Notes: AECL = Atomic Energy of Canada Limited

1 Bruce A Unit 4 was restarted on October 7, 2003.

2 Bruce Power has no dry storage facility. Bruce B (and eventually Bruce A) transports used fuel bundles for dry storage to the Western Waste Management Facililty which is operated by OPG.

3 Pickering A Unit 4 was restarted on September 25, 2003.

a Includes fuel waste from NPD reactor (4,853 bundles).

b Nuclear fuel wastes at Whiteshell from WR-1 reactor.

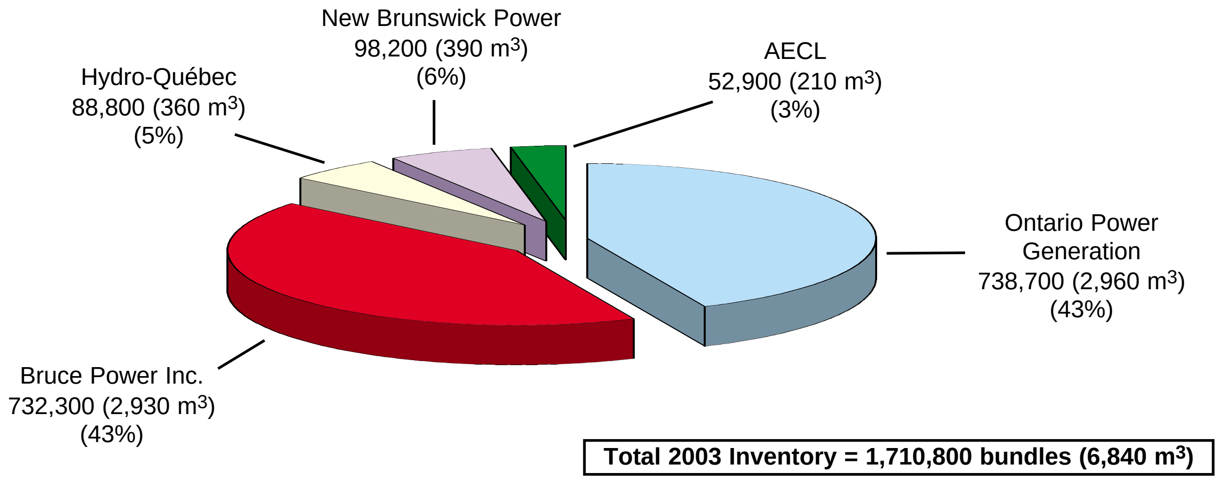
c Nuclear fuel waste volume calculated assuming a typical volume of 0.004 m^3 for a CANDU fuel bundle.

Nuclear fuel waste inventory to the end of 2003 for the three shutdown prototype/demonstration reactors (Douglas Point, Gentilly-1, and NPD) remained at 30,322 bundles (121 m^3). The balance of the nuclear fuel waste inventory of 22,551 bundles (91 m^3) comes from the research reactor operations at AECL's Chalk River and Whiteshell facilities.

Figure 5.1 shows the distribution of nuclear fuel waste inventories by major producers. This figure shows the number of fuel bundles rounded to the nearest 100, and estimated volume to the nearest 10 m^3. The distribution was approximately as follows: Ontario Power Generation, 43%; Bruce Power Inc., 43%; Hydro-Québec, 5%; New Brunswick Power, 6%; and AECL, 3%.

Figure 5.1: Nuclear Fuel Waste Inventory, 2003

(number of fuel bundles)



5.2 Low-Level Radioactive Waste

At the end of 2003, there were about 2.29 million m^3 of LLRW stored in Canada. At present, wastes are being managed in storage sites throughout the country pending the development and licensing of long-term waste management facilities.

Table 5.2 summarizes the 2003 accumulation rates and accumulated inventory for ongoing and historic LLRW.

Figure 5.2 shows the accumulation rate and accumulated inventory for each source. This figure shows the estimated volume of LLRW rounded to the nearest 10 m^3.

This section provides further breakdowns for each source of LLRW.

5.2.1 Ongoing Waste

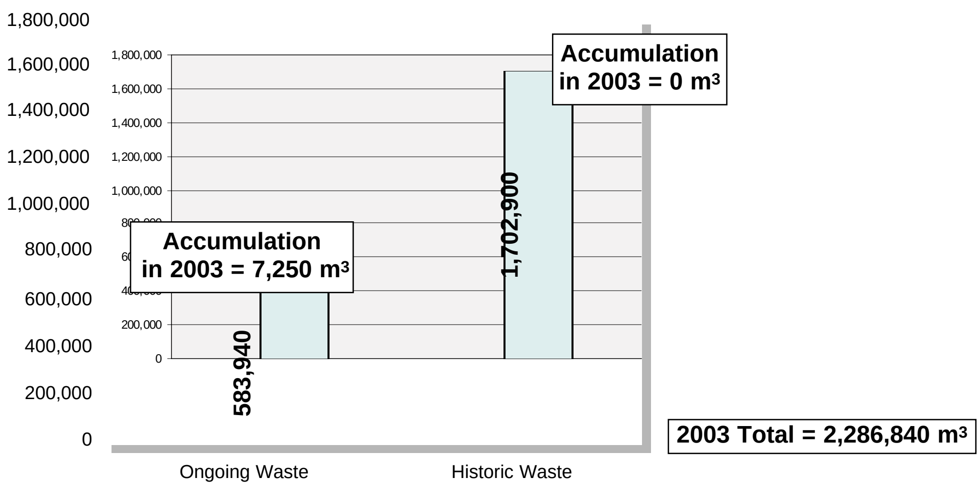
About 7,250 m^3 of ongoing waste was generated in 2003. The inventory of this waste to the end of 2003 was 583,940 m^3 (see Table 5.2).

Table 5.2: LLRW Accumulation Rate and Inventory, 2003

WASTE SOURCE		LLRW[a] Accumulation Rate in 2003 (m^3/yr)	LLRW Inventory to 2003 December 31[a] Waste (m^3)	Contaminated Soil (m^3)	Total (m^3)
A. ONGOING WASTE					
Operations	Nuclear Fuel Cycle	5,770	64,440	0	64,440
	Nuclear R&D	1,250	112,180	382,800	494,980
	Radioisotope Production and Use	200	18,360	0	18,360
	Subtotal	**7,220**	**194,980**	**382,800**	**577,780**
Decommissioning	Nuclear Fuel Cycle	0	3,860	0	3,860
	Nuclear R&D	40	2,300	0	2,300
	Radioisotope Production and Use	0	0	0	0
	Subtotal	**40**	**6,160**	**0**	**6,160**
	Total Ongoing Waste	**7,250**	**201,140**	**382,800**	**583,940**
B. HISTORIC WASTE[b]					
	Port Hope	0	0	500,000[c]	500,000
	Welcome and Port Granby	0	0	1,150,000[c]	1,150,000
	Other Locations	0	0	52,900	52,900
	Total Historic Waste	**0**	**0**	**1,702,900**	**1,702,900**
TOTAL		**7,250**			**2,286,840**

Notes: [a] Ongoing waste volumes have been rounded to nearest 10 m^3. Volume presented is as-stored waste (i.e., after processing); as-generated volume may be approximately three times greater.
[b] Historic waste volumes have been rounded to nearest 100 m^3.
[c] Volume represents a revised estimate as of December 31, 2003.

Figure 5.2: LLRW Inventory, 2003
(m^3)



Figures 5.3 and 5.4 provide a further breakdown of the sources, accumulation rate and inventory of ongoing LLRW. These figures show the estimated volume of each source of ongoing waste rounded to the nearest 10 m^3.

Figure 5.3: Ongoing LLRW Accumulation Rates, 2003
(m^3)

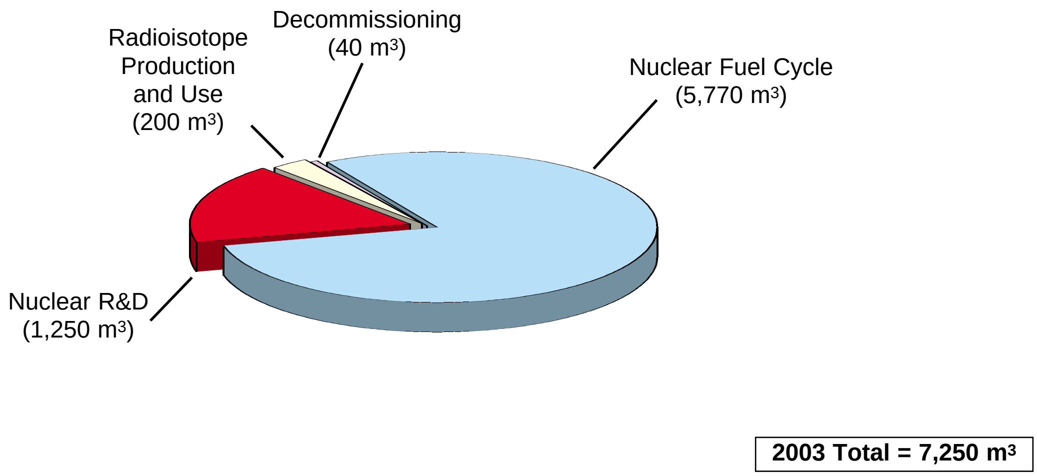
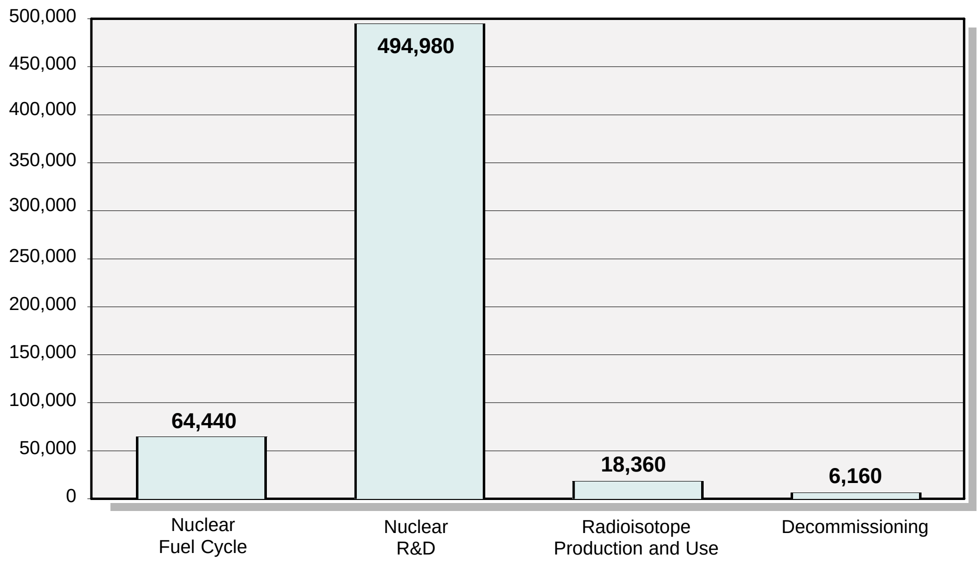


Figure 5.4: Ongoing LLRW Inventory, 2003
(m^3)



5.2.1.1 Operations

Waste from operations constitutes the majority of LLRW. This trend will continue until significant decommissioning of nuclear facilities commences. In 2003, about 7,220 m^3 of waste was produced from operational activities. The inventory to the end of 2003 was 577,780 m^3. A detailed breakdown follows.

Nuclear Fuel Cycle

In 2003, the 17 operating power reactors in Canada produced 5,637 m^3 of the total amount of LLRW. Ontario Power Generation Inc., operating 9 reactors, produced the majority of waste (3,950 m^3), while Bruce Power Inc. produced 1,606 m^3, and Hydro-Québec and New Brunswick Power produced a combined 81 m^3.

Total waste inventory from nuclear fuel cycle facilities at the end of 2003 was 64,440 m^3.

Nuclear Research and Development

Nuclear research and development activities at AECL generated 1,250 m^3 of LLRW in 2003. AECL has about 300,000 m^3 of contaminated soils resulting from its long history of nuclear research and development. In addition, some volumes of LLRW from other producers are taken to AECL's Chalk River Laboratories for management. Included in these volumes are historic wastes that have been removed from various location across Canada and consolidated at AECL-CRL.

Total waste inventory attributed to research and development was 494,980 m^3 at the end of 2003.

Radioisotope Production and Use

Wastes in this category are generated by radioisotope users from across Canada and eventually sent to AECL-CRL for storage. In 2003, approximately 200 m^3 of waste were received and the total inventory of radioisotope-related waste increased to 18,360 m^3.

5.2.1.2 Decommissioning

There continues to be only limited decommissioning of nuclear facilities in Canada. Most facilities have conceptual decommissioning plans in place. However, many facilities are currently preparing formal, detailed plans that will include waste volume estimates.

Nuclear Fuel Cycle

There were no decommissioning activities at the nuclear fuel cycle facilities in 2003. Waste inventory at the end of 2003 was 3,860 m^3, which included 2,210 m^3 of waste from the Pickering A retubing program.

Nuclear Research and Development

Decommissioning projects are ongoing at AECL's research facilities in Chalk River and Whiteshell. Phase 1 decommissioning of the WR-1 reactor at Whiteshell was completed in 1994. There is also ongoing limited decommissioning of some buildings and facilities at Chalk River. The University of Toronto completed decommissioning of its sub-critical assembly in 2000.

The waste accumulation rate for 2003 was 40 m^3 arising from decommissioning wastes generated at Chalk River. The national waste inventory from decommissioning activities associated with research and development facilities amounted to 2,300 m^3 at the end of 2003.

Radioisotope Production and Use

There were no decommissioning wastes accumulated in 2003 nor was there any inventory at the end of 2003. The MDS Nordion facility in Ottawa, which is the main manufacturer of commercial isotopes, is relatively new and is not expected to generate decommissioning wastes in the near future. Commercial isotope users may generate some small volumes of wastes in the future during decommissioning or refurbishment of laboratories or other facilities.

5.2.2 Historic Waste

The inventory of historic waste to the end of 2003 was 1.7 million m^3 (see Table 5.2).

For 2003, the total inventory of historic waste in low-level radioactive waste facilities, for which the LLRWMO has management responsibility on behalf of the federal government, is 552,900 m^3. The waste consists of the following:

Municipality of Port Hope, Ontario	500,000 m^3
Other locations:	
Toronto (Scarborough), Ontario	9,100 m^3
AECL-CRL, Ontario	600 m^3
Fort McMurray, Alberta	42,500 m^3
Northwest Territories	675 m^3
	52,875 m^3

Cameco Corporation continues to manage its two waste sites at Welcome and Port Granby in the Municipalities of Port Hope and Clarington, Ontario, respectively. The Welcome Waste Management Facility contains about 650,000 m^3 of wastes and contaminated soils. The Port Granby Waste Management Facility contains about 500,000 m^3 of wastes and contaminated soils. The total volume of these wastes to the end of 2003 is 1,150,000 m^3.

5.3 Uranium Mill Tailings

Table 5.3 summarizes the waste accumulation rates, accumulated mass and site status for operating uranium tailings sites, inactive/decommissioned sites and development sites in Canada as of December 31, 2003. Figure 5.5 shows the 2003 accumulated inventory rounded to the nearest 100 tonnes.

Uranium mill tailings are presented as mass in tonnes since this is how the mining industry commonly tracks and reports materials. Waste amounts can be converted to volume (m^3) using assumed or measured densities. A typical dry density for tailings would be 1.0 to 1.5 tonnes/m^3. However, tailings densities vary significantly from site to site and with location or depth at a specific site.

At the operating sites, the annual accumulation rate of tailings in 2003 was approximately 0.6 million tonnes with an accumulated inventory to the end of 2003 of 8.2 million tonnes.

Total accumulated inventory of tailings at inactive/decommissioned sites to the end of 2003 was about 205 million tonnes.

There are no tailings at the two development sites licensed by the CNSC.

The total annual accumulation rate of mining and milling wastes in 2003 was 0.6 million tonnes with a total accumulated inventory to the end of 2003 of 213 million tonnes (142 million m^3).

6.0 PROJECTIONS

Radioactive waste inventory in Canada has been projected to the end of 2004 and the end of 2033 for the three major waste groups including: nuclear fuel waste, LLRW and uranium mill tailings. The year 2033 was selected as a reference because it corresponds approximately to the forecasted end of operations for the last constructed power reactors (Darlington Generating Station).

6.1 Nuclear Fuel Waste

Projection of nuclear fuel waste is provided to 2004 and 2033. This assumes that no new nuclear generating stations will be commissioned before the year 2033 and that all current operating reactors will have ceased operations by this time.

Projected nuclear fuel waste is summarized in Table 6.1. Projected waste quantities were provided by the utilities operating the power reactors and are based on the current operating plans for each reactor. End of operations for the operating power reactors range from year 2011 to 2033. Total lifetime inventory of nuclear fuel waste from these reactors is approximately 3.7 million bundles (14,685 m^3).

Table 5.3: Uranium Mill Tailings Accumulation Rate and Inventory, 2003

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Source Company Province	Tailings Site	Accumulation Rate 2003 (tonnes/year)	Accumulated Mass 2003 Dec. 31 (tonnes)	Waste Site Status as of 2003 December
1. OPERATING TAILINGS SITES						
Key Lake[a]	Cameco Corp.	Saskatchewan	Deilmann Tailings Management Facility (DTMF)	192,200	2,099,290	Operating since 1995
Rabbit Lake	Cameco Corp.	Saskatchewan	Rabbit Lake In-Pit TMF	294,546	5,530,000	Operating since 1985
McClean Lake Operation	COGEMA. Resources Inc.	Saskatchewan	JEB TMF	142,000	529,000	Operating since 1999
			Subtotal Operating Sites	**628,746**	**8,158,290**	
2. INACTIVE/DECOMMISSIONED TAILINGS SITES						
Cluff Lake	COGEMA Resources Inc.	Saskatchewan	Tailings Management Area	0	3,280,000	Inactive since 2002/ decommissioning expected to begin 2004
Key Lake	Cameco Corp.	Saskatchewan	Surface Tailings (Old Tailings Pond)	0	3,586,000	Inactive since 1996/ ongoing monitoring
Rabbit Lake	Cameco Corp.	Saskatchewan	Surface Tailings	0	6,500,000	Inactive since 1985/ being decommissioned
Beaverlodge	Cameco Corp.	Saskatchewan	Surface Tailings and Underground/Mine Backfill	0	10,100,000[1]	Decommissioned since 1982/ongoing monitoring
Gunnar	Saskatchewan Government	Saskatchewan	Surface Tailings	0	4,400,000	Inactive since 1964
Lorado	Saskatchewan Government and EnCana Corporation	Saskatchewan	Surface Tailings	0	360,000	Inactive since 1960
Port Radium	Indian and Northern Affairs Canada	Northwest Territories	Surface Tailings - Four Areas	0	907,000	Decommissioned since 1984/ongoing monitoring
Rayrock	Indian and Northern Affairs Canada	Northwest Territories	North and South Tailings Piles	0	71,000	Inactive since 1959/ongoing monitoring
Quirke 1 and 2 - Elliot Lake	Rio Algom Ltd.	Ontario	Quirke Mine Tailings Management Area (TMA)	0	46,000,000	Decommissioned/ ongoing monitoring
Panel - Elliot Lake	Rio Algom Ltd.	Ontario	Panel Mine TMA, Main Basin (North) and South Basin	0	16,000,000	Decommissioned/ ongoing monitoring
Denison - Elliot Lake	Denison Mines Inc.	Ontario	Denison Tailings Management Area (TMA1, TMA2)	0	63,800,000	Decommissioned/ ongoing monitoring
Spanish-American - Elliot Lake	Rio Algom Ltd.	Ontario	Spanish American Tailings Management Area	0	450,000	Decommissioned/ ongoing monitoring
Stanrock/ CANMET Elliot Lake	Denison Mines Inc.	Ontario	Stanrock Tailings Management Area (TMA)	0	5,750,000	Decommissioned/ ongoing monitoring

Table 5.3: Uranium Mill Tailings Accumulation Rate and Inventory, 2003 (cont'd)

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Source Company Province	Tailings Site	Accumulation Rate 2003 (tonnes/year)	Accumulated Mass 2003 Dec. 31 (tonnes)	Waste Site Status as of 2003 December
Stanleigh - Elliot Lake	Rio Algom Ltd.	Ontario	Stanleigh Tailings Management Area (TMA)	0	19,953,000	Decommissioned/ ongoing monitoring
Lacnor - Elliot Lake	Rio Algom Ltd.	Ontario	Lacnor Waste Management Area	0	2,700,000	Decommissioned/ ongoing monitoring
Nordic - Elliot Lake	Rio Algom Ltd.	Ontario	Nordic Waste Management Area	0	12,000,000	Decommissioned/ ongoing monitoring
Pronto - Blind River	Rio Algom Ltd.	Ontario	Pronto Waste Management Area	0	2,100,000	Decommissioned/ ongoing monitoring
Agnew Lake Mines - Espanola	Ontario Ministry of Northern Development & Mines	Ontario	Dry Tailings Management Area	0	510,000	Decommissioned since 1990/ ongoing monitoring
Dyno - Bancroft	EnCana Corporation	Ontario	Surface Tailings	0	600,000	Inactive since 1960/ ongoing monitoring
Bicroft - Bancroft	Lac Properties Inc.	Ontario	Bicroft Tailings Management Area	0	2,000,000	Inactive since 1964/ ongoing monitoring
Madawaska - Bancroft	EnCana Corporation	Ontario	Surface Tailings - Two Areas	0	4,000,000	Decommissioned/ ongoing monitoring
		Subtotal Inactive/Decommissioned Sites		**0**	**205,067,000**	
3. DEVELOPMENT SITES						
Cigar Lake Project	Cameco Corp.	Saskatchewan	No tailings on site	0	0	Project approved in 1998/construction to begin in 2005/start-up expected in 2007
Midwest Project	COGEMA Resources Inc.	Saskatchewan	No tailings on site	0	0	Project approved in 1998/startup date undetermined
			Subtotal Development Sites	**0**	**0**	
Totals				**628,746**	**213,225,290**	

Notes: [a] Includes tailings accumulated from the processing of ores from McArthur River (operating since 1999).
[1] Includes 4,289,590 tonnes that have been placed underground.

Figure 5.5: Inventory of Uranium Mill Tailings, 2003

(tonnes)

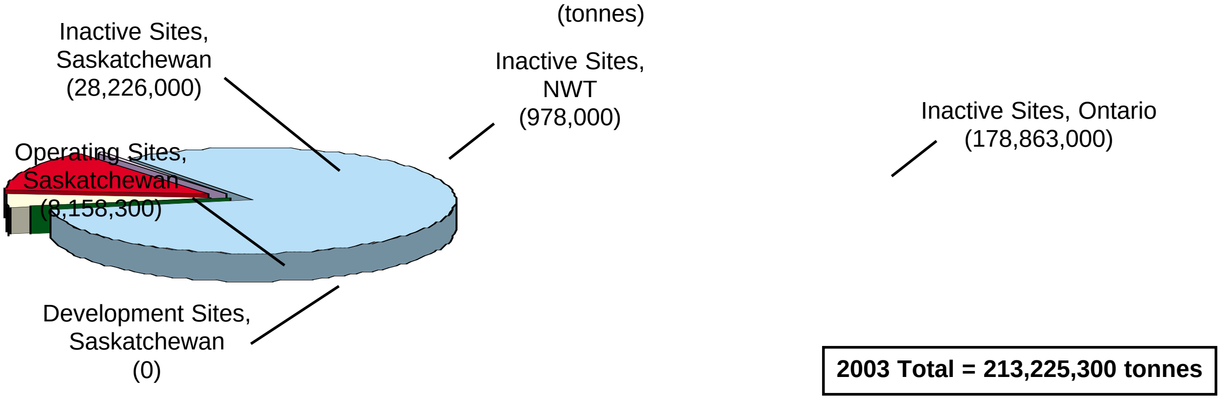


Table 6.1: Projected Nuclear Fuel Waste Inventory to 2004 and 2033

Site Name	Source Company Name	End of Reactor Operations	Nuclear Fuel Waste Inventory: To End of 2003 — Number of Fuel Bundles	To End of 2003 — Estimated Volume[c] (m^3)	Projected to End of 2004 — Number of Fuel Bundles	Projected to End of 2004 — Estimated Volume[c] (m^3)	Projected to End of 2033[b] — Number of Fuel Bundles	Projected to End of 2033[b] — Estimated Volume[c] (m^3)
POWER REACTORS								
Bruce A	Bruce Power Inc.	2015-2020	354,567	1,418	363,567	1,454	427,791	1,711
Bruce B	Bruce Power Inc.	2025-2030	377,698	1,511	424,282	1,697	1,006,266	4,025
Darlington	Ontario Power Generation	2030-2033	234,433	938	257,158	1,029	876,445	3,506
Pickering A and B	Ontario Power Generation	2011-2025	504,241	2,017	519,653	2,079	896,245	3,585
Gentilly-2	Hydro-Québec	2010-2015[1]	88,789	355	93,289	373	223,789	895
Point Lepreau	NB Power	2034	98,210	393	102,960	412	240,710	963
	Subtotal Power Reactors		**1,657,938**	**6,632**	**1,760,909**	**7,044**	**3,671,246**	**14,685**
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS								
Douglas Point	AECL	1984	22,256	89	22,256	89	22,256	89
Gentilly-1	AECL	1978	3,213	13	3,213	13	3,213	13
Chalk River Laboratories[a]	AECL	N/A	25,136	101	25,999	104	51,026	204
Whiteshell Laboratories	AECL	1997	2,268	9	2,268	9	2,268	9
	Subtotal Research Reactors		**52,873**	**212**	**52,636**	**215**	**78,763**	**315**
Total			**1,710,811**	**6,844**	**1,813,545**	**7,259**	**3,750,009**	**15,000**

Notes: AECL = Atomic Energy of Canada Limited

1 Projected end of operations not provided by Hydro-Québec, therefore, reported date is same as that reported in the 1999 Inventory Report.

a Forecasted end of operations for Chalk River Laboratories selected as 2033 to compare fuel inventories; for planning purposes, end of operations for CRL is currently indicated by AECL as indefinite.

b Waste forecasts to end of 2033 based on projected generation rates for 2004, except for which more accurate estimates were provided.

c Nuclear fuel waste volume calculated assuming a typical volume of 0.004 m^3 for a CANDU fuel bundle.

Projected nuclear fuel waste inventory to 2033 for the existing prototype/demonstration research reactors owned by AECL is 79,000 bundles (300 m^3).

Figure 6.1 shows the forecasted distribution of the nuclear fuel waste inventory in year 2033 by major producers: Ontario Power Generation, 47%; Bruce Power Inc., 39%; Hydro-Québec, 6%; New Brunswick Power, 6% and AECL, 2%. Figure 6.1 shows the number of fuel bundles rounded to the nearest 100, and the estimated volume to the nearest 10 m^3. Figure 6.2 compares estimated volumes (rounded to the nearest 10 m^3) of nuclear fuel waste inventories to the end of 2003 with inventories projected to 2033.

Nuclear fuel waste inventory at AECL-CRL was estimated to the end of 2033, although AECL-CRL is likely to continue operations beyond this date.

Figure 6.1: Nuclear Fuel Waste Inventories Projection, 2033
(number of fuel bundles)

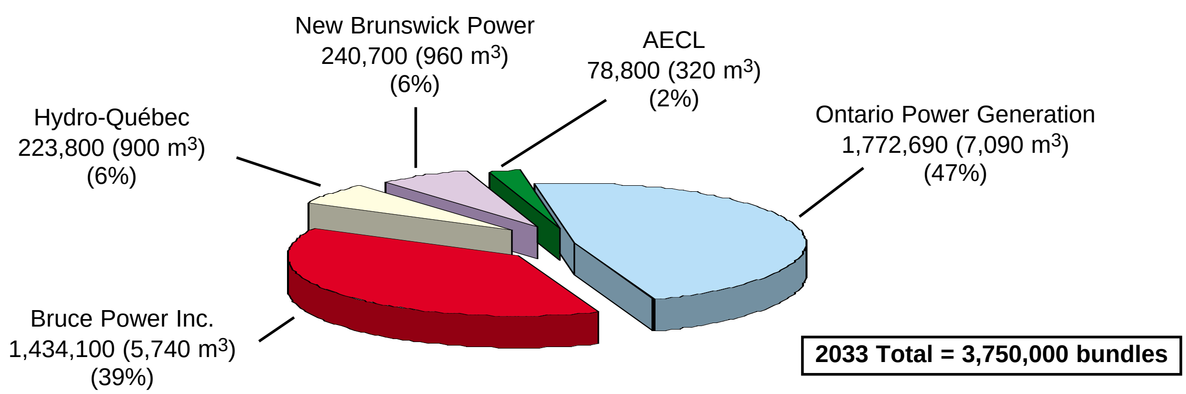
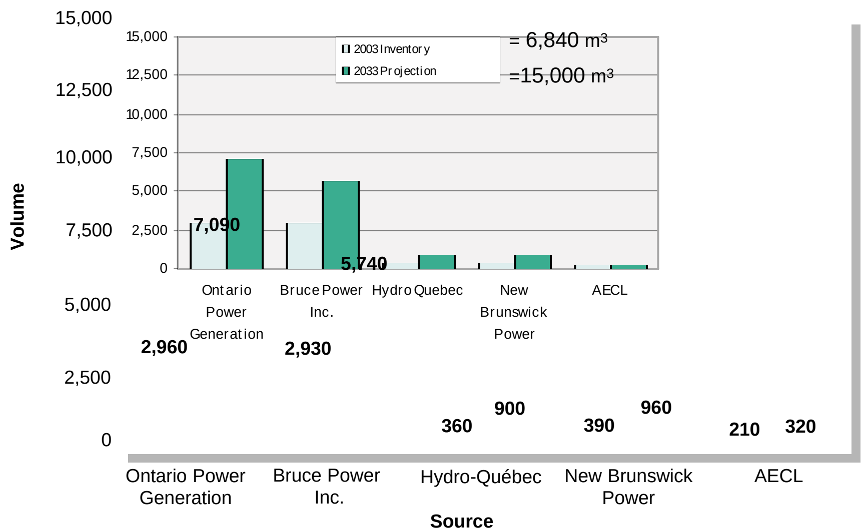


Figure 6.2: Nuclear Fuel Waste Inventory, 2003 and Projection to 2033
(m^3)



6.2 Low-Level Radioactive Waste

Projected inventory of LLRW is summarized in Table 6.2. It is estimated that the 2003 inventory of 2.3 million m^3 will increase to approximately 2.6 million m^3 by 2033. Projected inventories and the assumptions used to develop these projections are described in the following sections. Figure 6.3 provides a comparative status of LLRW inventory to 2033.

Table 6.2: Projected LLRW Inventory to 2004 and 2033

WASTE SOURCE		Inventory to End of 2003 (m^3)	Projected Inventory to End of 2004 (m^3)	Projected Inventory to End of 2033 (m^3)
A. ONGOING WASTE				
- Operations	Nuclear Fuel Cycle	64,400	70,200	237,500
	Nuclear R&D	495,000	496,200	532,480
	Radioisotope Production and Use	18,400	18,600	24,300
	SUBTOTAL	**577,800**	**585,000**	**794,300**
- Decommissioning	Nuclear Fuel Cycle	3,900	3,900	121,600
	Nuclear R&D	2,300	2,400	3,800
	Radioisotope Production and Use	0	0	0
	SUBTOTAL	**6,200**	**6,300**	**125,400**
	TOTAL ONGOING WASTE	**584,000**	**591,300**	**919,700**
B. HISTORIC WASTE				
	Port Hope	500,000	500,000	500,000
	Welcome and Port Granby	1,150,000	1,150,000	1,150,000
	Other Locations	53,200	53,400	59,200
	TOTAL HISTORIC WASTE	**1,703,200**	**1,703,400**	**1,709,200**
TOTAL LLRW		**2,287,200**	**2,294,700**	**2,628,900**

Note: Waste volumes have been rounded to the nearest 100 m^3.

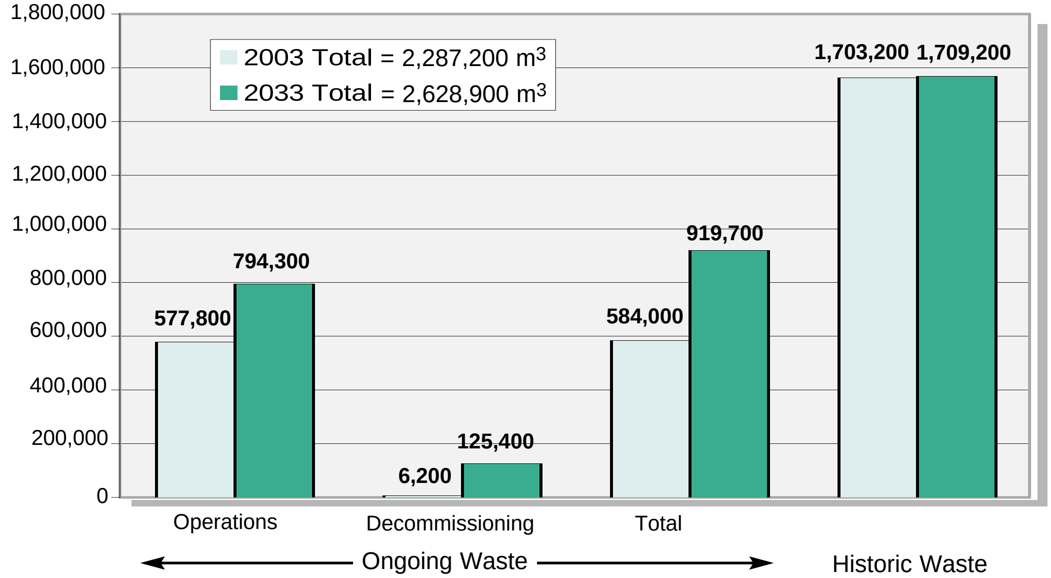
6.2.1 Ongoing Waste

Total inventory projected to 2033 from ongoing operations and decommissioning will be about 0.9 million m^3.

6.2.1.1 Operations

Projection of LLRW volumes assumes that no new major nuclear facilities, including new nuclear power reactors, will be commisioned before 2033 and, therefore, there will be no new sources of LLRW. It is also assumed that the 2003 waste accumulation rates will remain constant in the future except where otherwise forecasted by the producers (e.g. electric utilities).

Figure 6.3: LLRW Inventories, 2003 and 2033
(m^3)



The total projected inventory of waste to 2033 from operation and maintenance is 794,300 m^3. Waste from operations will continue to be a major contributor to LLRW inventory until 2014 when Phase 3 decommissioning of the prototype power reactors (Gentilly-1, Douglas Point and NPD) begins.

6.2.1.2 Decommissioning

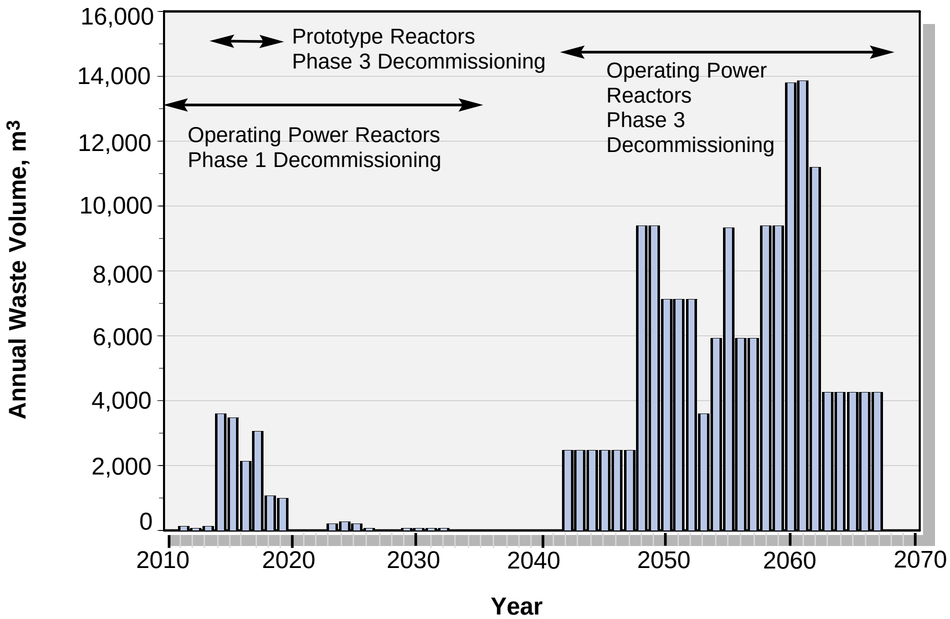
Projected inventories of decommissioning waste were determined based on decommissioning plans submitted to the CNSC. Preliminary decommissioning plans exist for many sites with uncertainties with respect to timing and waste volumes. Decommissioning waste estimates for the nuclear fuel cycle were obtained from a report prepared by Monserco Ltd. for the LLRWMO on this topic. Figure 6.4 shows the projected annual decommissioning waste volumes for the power reactors through to 2070 when all the currently operating power reactors will have completed Phase 3 decommissioning.

The following assumptions were used in projecting decommissioning waste inventory to year 2033:

- Decommissioning or major site refurbishment may be required at the uranium refining and conversion, and fuel fabrication facilities between the years 2020 and 2025, with the exception of the Blind River refinery, which is relatively new. These activities will result in the generation of approximately 102,000 m^3 of LLRW.

- The three partially decommissioned prototype power reactors will undergo Phase 3 decommissioning from year 2014 to 2019, which will generate approximately 13,000 m^3 of LLRW.

Figure 6.4: Annual Volume of Radioactive Wastes from Decommissioning of Power Reactors to 2070



- Barring the decisions to extend the operating lives of currently operating power reactors, Phase 1 decommissioning of the operating power reactors will occur at various dates from 2011 through year 2033. Each of these decommissioning projects will generate approximately 300 m^3 of wastes per reactor from Phase 1 decommissioning activities.

- There will be no decommissioning of waste management areas prior to year 2033.

The total projected inventory of decommissioning waste to year 2033 is 125,400 m^3.

6.2.2 Historic Waste

An accumulation rate of 200 m^3/year has been assumed to account for future discovery of historic waste for which the LLRWMO is responsible on behalf of the federal government. The inventory of LLRW at the Port Hope site is expected to remain unchanged at the current volume of 500,000 m^3. The total projected inventory of historic waste for sites managed by the LLRWMO in year 2033 is 559,200 m^3.

The volume of waste managed by Cameco at its Welcome and Port Granby sites is expected to remain unchanged at the current volume of 1,150,000 m^3.

The total volume of historic waste in year 2033 will be 1.71 million m^3.

6.3 Uranium Mill Tailings

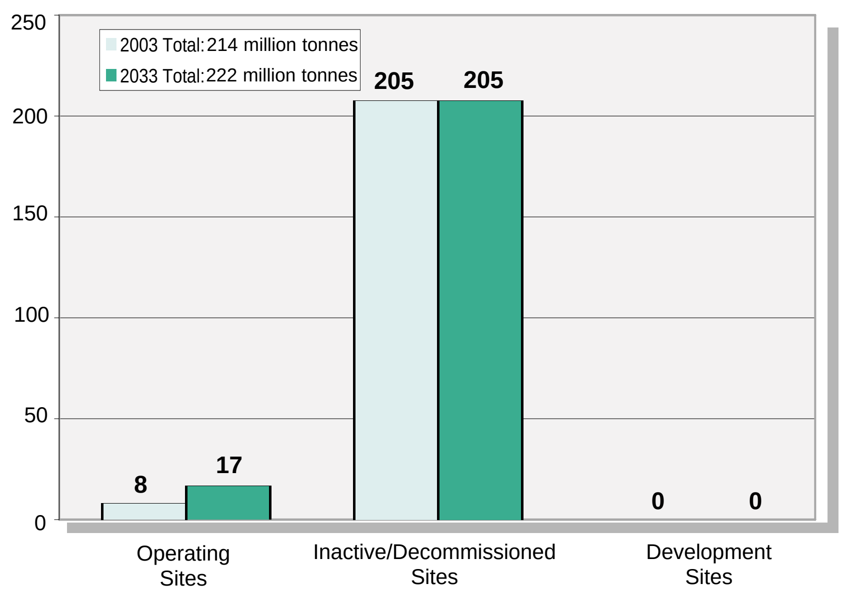
Table 6.3 provides a projection of tailings volume to 2004 and 2033 and Figure 6.5 illustrates the comparative tailings volume (rounded to the nearest 1 million tonnes) between 2003 and 2033.

Table 6.3: Projected Uranium Mill Tailings Inventory to 2004 and 2033

Status of Tailings Site	Accumulation Rate 2003 (tonnes/yr)	Accumulated Mass 2003 Dec. 31 (tonnes)	Projected Inventory to End of 2004[a] (tonnes)	Projected Inventory to End of 2033[a] (tonnes)
Operating Tailings Sites	628,746	8,158,290	8,847,310	16,659,956
Inactive/Decommissioned Tailings Sites	0	205,067,000	205,067,000	205,067,000
Development Sites	0	0	0	0
TOTAL	**628,746**	**213,225,290**	**213,914,310**	**221,726,956**

Notes: [a] Projected inventory based on milling schedule for operating tailings sites. Projected end of operations for Rabbit Lake and Key Lake is 2006 and 2021, respecitively. Projected inventories include tailings accumulated from the processing of ores from current development sites, as these sites do not have on-site tailings management facilities.

Figure 6.5: Tailings Volume to 2003 and 2033
(million tonnes)



6.3.1 Operating Sites

Future uranium production rates could increase depending on the timing and market conditions. Ore grades from Cigar Lake will be higher and, as a result, will reduce the tailings production rates relative to uranium production. Cameco Corporation will continue to blend Key Lake special waste with high grade ore from McArthur River. At Rabbit Lake, mixing of tailings with waste rock or till prior to deposition is also considered. Due to these possibilities, it is difficult to forecast the final tailings mass from the operating mill sites. For the purpose of the inventory forecast, however, the Canadian uranium production is assumed to remain at the current level. The projected inventory for 2004 and 2033 is based on the milling schedule for operating tailings sites. It is also assumed that the development sites will continue to have their ore processed at operating sites, therefore, this is reflected in the projected inventories for operating tailings sites. Based on these assumptions, total accumulated mass of tailings at the operating sites would increase from the 2003 value of approximately 0.6 Mt to approximately 16.7 Mt by the year 2033, as shown in Table 6.3.

6.3.2 Inactive or Decommissioned Sites

Decommissioning of uranium mill tailings generally involves management in place. The current mass of tailings at all inactive or decommissioned sites is approximately 205 Mt and is assumed to remain unchanged through 2033.

6.3.3 Development Sites

The two development sites will likely become operating sites in the future, however the ore is to be milled at existing operating sites. Therefore, there will be no tailings accumulated at these sites.

7.0 SUMMARY

Radioactive waste has been produced in Canada since the early 1930s when the first radium mine began operating at Port Radium in the Northwest Territories. At present, radioactive waste is generated from: uranium mining, milling, refining and conversion; nuclear fuel fabrication; nuclear reactor operation for electricity generation; nuclear research; and radioisotope production and use.

Radioactive waste is grouped into three categories: nuclear fuel waste; low-level radioactive waste; and uranium mill tailings. The accumulated inventory of these wastes to the end of 2003 and a projection to 2033 are provided in Table 7.1.

Table 7.1: Summary of Current and Future Inventories

Waste Category	Waste Inventory to 2003 December	Waste Inventory to End of 2004	Waste Inventory to End of 2033
Nuclear Fuel Waste	6,800 m^3	7,300 m^3	15,000 m^3
Low-Level Radioactive Waste	2.29 million m^3	2.3 million m^3	2.6 million m^3
Uranium Mine and Mill Tailings	213 million tonnes	214 million tonnes	222 million tonnes

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Appendix A
Policy Framework for Radioactive Waste

News Release

96/79
July 10, 1996

McLELLAN ANNOUNCES POLICY FRAMEWORK FOR RADIOACTIVE WASTE

OTTAWA — Anne McLellan, federal Minister of Natural Resources, today announced government approval of a radioactive waste policy framework that will guide Canada's approach for radioactive waste disposal into the next century.

The framework is the result of consultations with waste producers and owners to establish a comprehensive and integrated approach to the long-term management and disposal of radioactive wastes in Canada.

"The Policy Framework lays out the ground rules for radioactive waste disposal in Canada. It defines the role of government and waste producers and owners, and recommends that disposal proceed in a comprehensive and integrated manner," Minister McLellan noted.

"With the Policy Framework in place, the context is set for the further development of the financial and institutional arrangements that will govern waste disposal. Over the coming months, my officials will begin discussions with waste producers to ensure that radioactive waste disposal takes place in a manner that respects the principles in this policy framework," Minister McLellan added.

The Policy Framework recognizes the role of the federal government to develop policy, to ensure that waste producers and owners comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste disposal plans, as well as the role of the federal Atomic Energy Control Board to regulate waste disposal activities.

Under the framework, waste producers and owners are responsible, in accordance with the principle of "the polluter pays," for the funding, organization, management and operation of disposal and other facilities required for their wastes. This principle recognizes that arrangements may be different for nuclear fuel waste, low-level radioactive waste and uranium mine and mill tailings.

- more -

The federal government has already taken leadership on this issue in announcing, last week, its intention to evaluate the suitability of a low-level radioactive waste facility in Deep River, Ontario.

"The Policy Framework emphasizes the Government of Canada's commitment to the principles of sustainable development. Nuclear energy is an environmentally sound-energy option that does not contribute to climate change or acid rain. Taking action to dispose of radioactive waste is an environmentally responsible initiative that will ensure that the costs related to nuclear activities are not simply passed from one generation to the next," Minister McLellan concluded.

- 30 -

For further information, please contact: Pierre Gratton
Press Secretary
Minister's Office
(613) 996-2007

96/79 (b)

BACKGROUNDER

RADIOACTIVE WASTE POLICY FRAMEWORK

The elements of a comprehensive radioactive waste policy framework consist of a set of principles governing the institutional and financial arrangements for disposal of radioactive waste by waste producers and owners.

- The federal government will ensure that radioactive waste disposal is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner.

- The federal government has the responsibility to develop policy, to regulate, and to oversee producers and owners to ensure that they comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste disposal plans.

- The waste producers and owners are responsible, in accordance with the principle of "polluter pays", for the funding, organization, management and operation of disposal and other facilities required for their wastes. This recognizes that arrangements may be different for nuclear fuel waste, low-level radioactive waste and uranium mine and mill tailings.

Inventory of Radioactive Waste in Canada

Low-Level Radioactive Waste Management Office
1900 City Park Drive, Suite 200
Ottawa, Ontario
K1J 1A3

Telephone: (613) 998-9442
Fax: (613) 952-0760
E-Mail: info@llrwmo.org

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