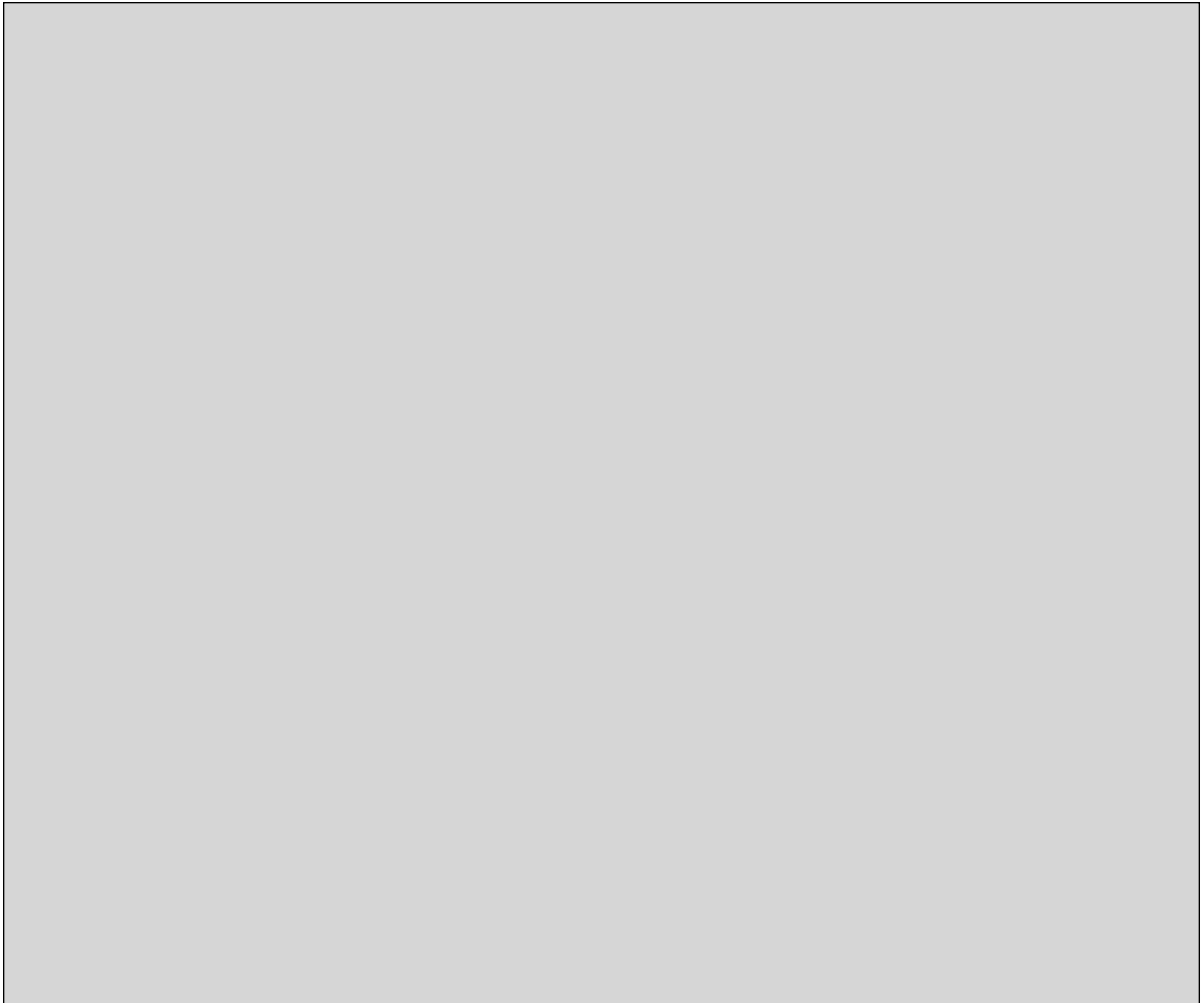


**NWMO BACKGROUND PAPERS**  
**7. INSTITUTIONS AND GOVERNANCE**

**7-2 THE STATUS OF THE LEGAL AND ADMINISTRATIVE ARRANGEMENTS  
FOR LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT IN CANADA**

**Rennick & Associates**



## **NWMO Background Papers**

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts** – describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety** – provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment** – provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

### **Disclaimer**

This report does not necessarily reflect the views or position of the Nuclear Waste Management Organization, its directors, officers, employees and agents (the "NWMO") and unless otherwise specifically stated, is made available to the public by the NWMO for information only. The contents of this report reflect the views of the author(s) who are solely responsible for the text and its conclusions as well as the accuracy of any data used in its creation. The NWMO does not make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information disclosed, or represent that the use of any information would not infringe privately owned rights. Any reference to a specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or preference by NWMO.

## EXECUTIVE SUMMARY

The Nuclear Waste Management Organization (NWMO) is authorized to deal with the management of used nuclear fuel. The purpose of this paper is to summarize the legal and administrative arrangements for low level radioactive waste (LLRW) management in Canada, and to provide observations that may be helpful for the long term management of used nuclear fuel.

The primary purpose of the legal and administrative arrangements governing the management of all radioactive waste is to safeguard the health of the people and the environment. This paper begins, therefore, with a brief primer on radioactivity, ionizing radiation, sources of radiation and dose limits designed to protect the health of occupationally exposed workers. This is followed by an explanation of the categories of the wastes, the types of radioactive waste materials in each category and how LLRW are classified in Canada.

Since the operation and maintenance of nuclear power stations produces both used nuclear fuel and LLRW (including intermediate level radioactive wastes), this paper discusses how radioactive wastes are managed by Ontario Power Generation, Hydro Quebec and New Brunswick Power, the three utilities in Canada that have nuclear reactors. Atomic Energy of Canada Limited (AECL) is also discussed since AECL produces LLRW and provides storage facilities for LLRW that others producers are unable to store. Currently, there is no long-term disposal or management facility in Canada for LLRW.

The principal legislative and administrative arrangements governing LLRW in Canada are then discussed followed by observations on LLRW management in the United States of America and France.

Many of the lessons learned from the management of LLRW that may be helpful for the management of used nuclear fuel are not found in the legal and administrative arrangements themselves. Rather, they are found in the application of the legal and administrative arrangements and in the decision-making processes involved. The paper ends with some observations on these matters.

Following are the key elements in this paper.

### *Ionizing radiation*

Each form of ionizing radiation has its own level of activity and potential to affect matter. Exposures from man-made sources of ionizing radiation are additional to the naturally occurring background radiation everyone receives. For both high level and low level radioactive wastes, the form of radiation emitted from the wastes and the half life of the materials are two key factors in deciding how long such wastes must be stored and what kind of protective measures must be applied to ensure that they are safely stored.

### *The legal instruments*

- The Nuclear Safety and Control Act (NSCA) which established the Canadian Nuclear Safety Commission (CNSC).
- The Nuclear Liability Act ensures that nuclear facility operator funds are available to compensate third parties for injuries or damage as a result of a nuclear accident, makes the operator exclusively liable and limits the operator's liability.
- Regulations established by the CNSC covering all aspects of LLRW from site preparation to closing down a facility.
- The Canadian Environmental Assessment Act (CEAA) which may be triggered by the licensing activities of the CNSC and requires the proponent to carry out an environmental assessment (EA) on the proposed undertaking. Where a provincial EA process is involved, the federal and provincial processes are harmonized so that one EA is carried out considering blended requirements
- The Transportation of Dangerous Goods Regulations from Transport Canada are triggered if the LLRW is transported off the owner's site to another facility. The regulation is coordinated with the CNSC regulation relating to packaging of the material for safe transport.
- Various provincial statutes may come into play for the siting and construction of a LLRW facility relating to effects that it may have on activities under provincial jurisdiction such as natural resource management, environmental protection and land use. Normally, provincial officials defer all matters radioactive to the CNSC except for naturally occurring radioactive materials (NORM), as noted below. The provincial officials act in a review capacity to make sure that their mandates are protected.

### *Policy and administrative arrangements*

- Natural Resources Canada (NRCan) establishes policy related to LLRW management, such as the 1996 policy making the owners and producers of ongoing LLRW, including nuclear power station owners, responsible for funding and managing their radioactive wastes. NRCan also provides an oversight role, funding and policy advice for the historic waste cleanup program administered by the LLRW Management Office, located administratively within Atomic Energy of Canada Limited (AECL).
- In 1996, NRCan entered into a 50/50 cost-sharing agreement with the province of Ontario for the decommissioning and long-term maintenance of uranium mine and mill tailings. The agreement recognizes that present and past producers of uranium are responsible for all financial aspects of the decommissioning and long-term maintenance of uranium mine sites, including uranium tailings. In the case of abandoned tailings, where a producer or owner is unable to pay, the agreement outlines how the two parties will share the costs. A similar administrative arrangement is being considered with the province of Saskatchewan,

### *Categories of radioactive wastes*

In Canada, radioactive waste may be divided into four categories based on administrative responsibility for management. The categories are:

- **Used Nuclear Fuel** - high level waste, funded and administered by the producers and owners of the waste such as operators of nuclear power stations under policy established by the

federal government and according to the terms of licenses issued by the Canadian Nuclear Safety Commission.

- **Low Level Radioactive Waste** – further classified into:
  - **historic waste** - funded by the federal government and administered by the Low Level Radioactive Waste Management Office of Atomic Energy of Canada Limited. The Port Hope Initiative includes 95% of historic LLRW in Canada.
  - **on-going waste** - funded and administered by the owners and producers of the wastes such as nuclear power station operators.
- **Mine and mill tailings** - while not included in the official definition of LLRW, they are a category of LLRW and they are administered separately from other LLRW. They are funded and administered by the owners of the waste
- **Naturally occurring radioactive materials (NORM)** - are also a special kind of LLRW. They are not part of the nuclear fuel cycle, but result from certain industrial activities using naturally radioactive materials. They are administered by the provinces and territories and the owners of the material according to guidelines produced by a federal/ provincial committee and published by Health Canada. When these wastes are transported they are subject to CNSC regulations. Note: the CNSC has changed the name of these materials to “naturally occurring nuclear materials”.

The accumulated amount of used nuclear fuel in Canada is small compared to the amount of LLRW and mine tailings. For instance, in 1998 there was 5,580 m<sup>3</sup> of used nuclear fuel stored in Canada. This compares to 571,250 m<sup>3</sup> of on-going waste (mostly from the operation and decommissioning of reactors), 1,200,000 m<sup>3</sup> of historic LLRW (mostly in the Port Hope area, and 210,018,000 tonnes of mine and mill tailings (including operating and inactive mines) in Ontario and Saskatchewan.<sup>4</sup>

#### *The classification of LLRW*

In Canada, Low-level Radioactive Waste (LLRW) is defined by exclusion. If the material is radioactive waste and is not used nuclear fuel or mine and mill tailings, then it is LLRW. The definition in the USA is similar. In France, radioactive waste is defined by radioactivity and half-life based on recommendations of the International Atomic Energy Agency (IAEA). The Canadian definition for LLRW includes a large range of radioactivity and half-lives. Consequently, after excluding used nuclear fuel, nuclear power station managers and AECL have developed management practices for intermediate and low level radioactive waste.

#### *LLRW management*

The three utilities in Canada with nuclear reactors, Ontario Power Generation, Hydro Quebec and New Brunswick Power, manage radioactive waste in four ways: wet storage of used nuclear fuel, dry storage of used nuclear fuel, storage of intermediate level radioactive waste and processing and storage of LLRW. The material is currently stored on their own properties according to the terms of licenses from the CNSC.

- OPG, with 20 reactors, ships intermediate level radioactive waste in specially designed containers to their Western Waste Management Facility at the Bruce Station site where it is

placed below ground for storage. The LLRW is also shipped to the WWMF for incineration and/or compaction and stored in the WWMF.

- Hydro Quebec with one reactor at Gentilly-2 station stores the low and intermediate level radioactive waste on site in their Solid Radioactive Waste Management facility which is currently under study to increase its capacity.
- New Brunswick Power with one reactor at Point Lepreau stores low and intermediate level radioactive waste on site in their Solid Radioactive Waste Management facility. The facility is currently being expanded to provide storage for radioactive waste as part of a refurbishment project, which will extend the life of the power station.
- The AECL research laboratories at Chalk River, Ontario, accept LLRW material from the production and use of radioisotopes in research, industry and medicine. They also store LLRW from some of the historic clean-up projects such as Surrey, British Columbia and Port Hope, Ontario.
- LLRW resulting from the production of radioisotopes, the use of radioisotopes in medical therapy and in industry, also referred to as On-going Waste, is partly managed by these organizations on site. For instance, some radioisotopes used as tracers and for medical therapy in hospitals decay in minutes and can be disposed of down the drain. Wastes that take longer to decay to harmless levels are sent to Chalk River for storage. In 2001, AECL constructed a new modular facility at Chalk River for packaging and storing LLRW, which is monitored and the LLRW can be retrieved for eventual disposal.

#### *Key Elements that may be of Interest to the Used Nuclear Fuel Program*

##### Legal Instruments

- Most of the legal instruments that apply to LLRW management also apply to high-level waste management. The lessons learned may be found not so much in the instruments themselves, but rather in how the legal and administrative arrangements were carried out by the administrators and waste owners together with the involved stakeholders and the public.
- The proposed new CNSC regulatory policy P-290, Managing Radioactive Waste, is currently out for public review. The next step is for the CNSC to prepare the regulatory guide for the management of radioactive waste. In the interim, NWMO should talk to CNSC staff to advise on draft principles and expectations for the long-term management of radioactive waste.

##### Public Perception of Radiation

The Siting Task Force on LLRW management, established to find a solution to the Port Hope situation, and other leading practitioners have recognized that the public tends not to distinguish between different levels of radioactivity. They see exposure as possibly causing health effects, and thus focus on the consequence and not the low probability of a health problem from most LLRW. Thus the perception of risk by many citizens is different than that of the scientific community. There is a need to work closely with all stakeholders to make sure that the facts are clear and the programs of the various players are integrated. For instance, discussion of management options for used nuclear fuel with communities where other initiatives are ongoing

with respect to the long-term management of LLRW need to be highly integrated and coordinated so the message is clear to the community.

### Approval and Licensing Activities

The Canadian Environmental Assessment process and the CNSC licensing process have become more integrated and open in recent years. This is apparent for the EA process regarding the Port Hope Initiative being carried out by the LLRW Management Office in cooperation with the local communities and the Point Lepreau radioactive waste facility expansion project by New Brunswick Power. In the Point Lepreau case, the facility modification project was formally registered to CEAA and the New Brunswick EA program and the two processes were totally harmonized. For the Port Hope Initiative, the provincial EA has been harmonized into the federal EA. Both programs have extensive public and agency consultation, which is now required by legislation. Thus the agencies and the public would expect a similar approach for the used nuclear fuel management approval.

### LLRW Management Technology

Power generating station operators distinguish between different radioactive waste streams based on radioactivity and half-life. These two aspects of the waste are important for deciding the most appropriate waste management technique for storage and long-term management. There is no facility in Canada for long-term management of LLRW. OPG is currently studying, together with Kincardine, the feasibility of a long-term facility at their Bruce Power Site. AECL has proposed an underground facility for long-term storage of LLRW at Chalk River, which is currently on hold. The NWMO should examine these two initiatives and coordinate closely with the agencies involved.

### Facility Siting and Public Consultation

The experience and lessons learned from the historic LLRW management programs for the Port Hope/Clarington area, Ontario may be of interest regarding possible facility siting and public consultation for the used nuclear fuel program. These are discussed briefly in Appendix C.

The concerns expressed by the public to the Siting Process Task Force regarding facility siting were:

- consultation is too little too late;
- citizens want some control over what happens in their own community;
- there is a lack of trust of government and experts;
- inequity exists between those who benefit and those who live near the facility;
- opposition often results from the perceived risks and stigma of an unwanted facility.

The Task Force also learned about the value of listening with understanding, putting sound engineering on a level playing field with social and political realities, and jointly exploring issues and options. Such findings have been shared by others involved in facility siting. Research and experience over the last 10 to 15 years has revealed that facility siting processes often failed for three key reasons:

- efforts to engage the public suffered from poor form and format;

- the progressive narrowing of sites to select a preferred site was inherently flawed in that the “preferred community” was excluded from participating in the very decisions which resulted in their being selected causing a “why us” defensive response;
- the processes were top-down exercises focused almost exclusively on getting through the legal and administrative hurdles at the expense of gaining and sustaining public trust and confidence.

These problems are still much in evidence, a phenomenon indicating that there are more deeply rooted barriers to be addressed.



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## 1. INTRODUCTION

In 1988 the Canadian Government referred Atomic Energy of Canada Limited (AECL) concept of deep geological disposal of used nuclear fuel for public review under the Federal Environmental Assessment Process. In 1989 the Federal Minister of Environment appointed an independent panel to conduct the review. The panel, known as the Seaborn Panel, reported their findings to the Minister in 1998. To paraphrase the key findings of the panel, the deep geological disposal concept was deemed technically acceptable but, from a social perspective, it was not seen to have broad public support.<sup>1</sup> In response to the panel, the Canadian government carried out a number of initiatives including the development of a policy making the producers and owners of radioactive waste responsible for the management of the waste. The government also established the Nuclear Fuel Waste Act (NFWA), which came into effect in November 2002. The NFWA requires the nuclear power utilities in Canada to set up and fund the Nuclear Waste Management Organization (NWMO), which was established in late 2002.

The NFWA requires that the NWMO explore three waste management options at a minimum including:

- deep geologic disposal,
- storage on site at the various power plants, and
- a central facility either above or below ground.

The review of these different waste management options involves diverse issues ranging from the identification of societal, ethical and community implications, to specific issues of safety and security in transportation and storage of the used nuclear fuel. The NWMO is to report its findings to the federal government in 2005 then carry out the course of action chosen by government.

Rennick & Associates has been retained to prepare this background paper which documents the current status of the legal and administrative arrangements for low-level radioactive waste (LLRW) management in Canada. This paper also highlights some of the key elements and related areas that may be relevant to the management of used nuclear fuel.

Why is the NWMO interested in the LLRW management program when its mandate is the management of high-level radioactive wastes, that is, used nuclear fuel? The answer to this question is two-fold. First, the operation of nuclear power plants produces low-level radioactive wastes as well as used nuclear fuel and so it is important to understand the specific requirements that apply to the management of LLRW, especially how these might differ from the requirements for used nuclear fuel. Second, lessons have been learned from the legal and administrative procedures, planning and decision-making processes for the management of LLRW that may be instructive in assessing management options for used nuclear fuel.

Furthermore, the Seaborn Panel in their report provided the following observation: “In the course of our hearings, however, we gleaned much useful information about the general management of low-level radioactive wastes and hazardous waste, and interim storage practices for nuclear fuel waste. A number of the lessons learned and procedures adopted for good

management - safe on-site storage, safe transportation, federal-provincial cooperation, selection of a facility site, postclosure measures, societal aspects and public involvement – should be given close attention when developing policy and procedures for managing nuclear fuel wastes. This information has proven valuable in framing the conclusions and recommendations provided elsewhere in this report.”<sup>2</sup>

The primary purpose of the legal and administrative arrangements governing the management of radioactive waste is to safeguard the health of people and the environment. Thus, before examining the arrangements in place for low-level radioactive waste, a brief primer on radioactivity, ionizing radiation, sources of radiation and dose limits is provided in this introductory chapter to focus attention on the key issues associated with the management of radioactive waste.

Following this discussion, the paper briefly describes:

- low level radioactive waste –how it is defined and classified,
- the management of radioactive wastes by Nuclear Power Stations and Atomic Energy of Canada Limited Chalk River facility,
- the legal and administrative arrangements,
- a brief report on LLRW management in the United States of America and France, and
- conclusions and lessons learned that may be instructive for the used nuclear fuel program.

### *Radioactivity*

Atoms are composed of three kinds of particles: the proton, which has a positive electrical charge; the neutron, which has no electrical charge; and the electron, which carries an electrical charge of the same magnitude as the proton but of the opposite charge. Protons, neutrons and electrons are combined in many different ways to make up the atoms of the elements, from a single proton and single electron of the hydrogen atom to and beyond the 92 protons, 143 neutrons and 92 electrons of the uranium atom. Protons and neutrons are contained in the nucleus of an atom. Electrons move around rapidly in the space surrounding the nucleus and are held in that space by the electrical attraction between the positively charged protons and the negatively charged electrons.

In an ordinary chemical reaction, say the burning of carbon, the electrons of the carbon atoms and those of the oxygen atoms are redistributed as though the nuclei of both atoms were sharing electrons. It is this sharing which creates the chemical bonds between the carbon and oxygen atoms and results in carbon dioxide. During this chemical reaction heat is produced, which is why coal (which contains carbon) can be used as a source of energy to fuel furnaces.

The nucleus of atoms can also be changed. Such nuclear reactions happen naturally and they can now be technologically generated. They occur naturally when nuclei of certain atoms, known as “radionuclides” or radioisotopes, are energetically unstable; that is, they have too much energy. Radioisotopes become more stable by giving up some of this extra radiation energy in the form of particles (alpha and beta particles) or rays (gamma rays) through the process of “radioactive

decay.” Man-made radioisotopes are produced in nuclear reactors to generate electrical power or in cyclotrons for scientific and medical research.

Each of the more than 1,800 known radioisotopes has a unique characteristic rate of decay expressed as its “half-life”, or the time it takes for half the original number of nuclei to decay. The half-life of radioisotopes ranges from microseconds to billions of years.

### *Ionizing Radiation*

In the process of radioactive decay, energy is emitted. This energy has been named “ionizing radiation” because it can cause ions to be formed in the matter with which it reacts. An ion is an atom that has gained or lost one or more electrons and thus becomes electrically charged. Ionizing radiation that passes directly through matter, including human tissue, has no effect on it. However, if it is arrested in the matter, it gives up its energy to that matter and affects it. So, for example, ultra-violet radiation penetrates skin and causes it to tan, burn or undergo cancerous changes. However, the transmission of ionizing radiation can be interrupted by placing a barrier between the source of the radiation and the receiving matter (e.g., lead aprons to protect tissue from X-rays, sunscreen lotion or clothing to prevent ultra-violet rays from burning the skin).

### *Sources of Ionizing Radiation*

All life on earth is exposed to a continuing bombardment of ionizing radiation. It is given off, not only in the decay of naturally occurring minerals (principally uranium, thorium, radium and potassium), but also by the universe (cosmic rays), the sun (ultraviolet rays) and even through processes within our own bodies. A common example of terrestrial radiation is radon gas, which comes from uranium in the soil and can accumulate in buildings.

There is also man-made radiation that humans are exposed to on a regular basis and which could also be considered part of “background” doses. For instance, medical applications, such as X-rays, medical diagnosis and therapy for cancer treatment account for most of the manufactured sources of low level radiation. A small amount of fallout from past nuclear weapons testing, and consumer goods such as colour television sets, adds to human exposure to radiation.

### *Measuring Radiation*

Radiation is measured in two different ways: the quantity of radiation present or “activity”, and the effective dose received, which relate to the biological effect. The two measures are termed:

Becquerel, which is the measure of activity. The becquerel (Bq) measures the quantity of radioactivity present without consideration for what kind of radiation is emitted.  $1\text{Bq} = 1$  nuclear disintegration per second.

Sievert, which is the measure of effective dose and biological effect.

### *Dose Assessment and Limits*

Different types of radiation have different penetrating power and different parts of the body have different sensitivities to radiation. Dose assessment therefore requires knowledge of the type and amount of radiation and the biological sensitivity of the body part exposed<sup>3</sup>. Also geographic location needs to be taken into account. Some parts of Canada have higher levels of background radiation than others. A Canadian may receive a range of annual doses of natural background radiation from 1.2 millisieverts per year (mSv/a) to 3.2 mSv/a based on geographic location. Another factor is altitude. Plants, animals and people living at higher altitudes receive more cosmic radiation from outer space than those at sea level.

According to Health Canada, the average Canadian receives a typical annual dose of approximately 2.0 mSv from background radiation<sup>3</sup>. This provides a useful basis of comparison with man-made radiation.

The following table provides the radiation dose limits used by Health Canada and the Canadian Regulatory Safety Commission as recommended by international organizations such as the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).

Table 1.1  
Radiation Dose Limits

Affected Group	Annual Effective Dose Limit (mSv) <sup>a</sup>	Five Year Cumulative Dose Limit (mSv)
Occupationally Exposed Workers <sup>b</sup>	20 <sup>c</sup>	100
Incidentally Exposed Workers & Members Of the Public	1	5

Notes:

- (a) These limits are exclusive of natural background and medical exposures.
- (b) For the balance of a known pregnancy, the effective dose to an occupationally exposed worker must be limited to 4 mSv as stipulated in the “Radiation Protection Regulations”, Canadian Nuclear Safety Act. This limit may differ from corresponding dose limits specified in current provincial legislation applicable for exposure to sources of X-rays.
- (c) For occupationally exposed workers, a maximum dose of 50 mSv in one year is allowed, provided that the total effective dose of 100 mSv over a five-year period is maintained. This translates into an average limit of 20mSv/a.<sup>3</sup>

There is no general agreement on the threshold of radiation below which human health is not at risk. Thus, regulatory agencies use the “As Low As Is Reasonably Achievable” (ALARA)

principle when licensing facilities. Basic standards, or dose limits have to be met first and then, as an extra precaution, the ALARA principle has to be applied. This involves doing a cost-benefit analysis. If the benefits of an additional protection measure exceed the costs of the measure, then the measure is used. Thus, the ALARA principle in radiation protection encourages facility managers to reduce dose levels as much as possible, social and economic factors to be taken into account, even if they are already meeting allowable levels.

#### *Key Issues for LLRW Management*

There are many forms of ionizing radiation, each with its own level of activity and potential to affect matter. Exposures from man-made sources of ionizing radiation are additional to the naturally occurring background radiation everyone receives. The biological effects of ionizing radiation, however, depend upon the extent of exposure of living tissue to ionizing radiation and the degree of interaction of the radiation energy with the living tissue. Although there is no agreed-upon threshold of radiation below which there is no risk of effect, measures can be taken to reduce the risk of exposure and limit the interaction, whether the source is natural or man-made. Sometimes protective measures are a simple matter. In the case of radioactive waste, this issue is a complex and challenging one.

For both high level and low level radioactive wastes, the form of radiation emitted from the wastes and the half life of the materials are two key factors in deciding how long such wastes must be stored and what kind of protective measures must be applied to ensure that they are safely stored. As will be discussed in Chapter 2, what distinguishes low level radioactive waste from high level radioactive waste is the varied nature of low level wastes, which offers a wider range of management options.

## 2. RADIOACTIVE WASTE

“Radioactive waste” may be defined as material which is a product of deliberate processing and which contains radioactive elements in a greater concentration than that considered safe for uncontrolled release into the environment and for which no further use is foreseen. Accordingly, naturally occurring uranium is not radioactive waste, but uranium mine and mill tailings are.<sup>4</sup>

Radioactive waste in Canada may be divided into four categories based on administrative responsibility for its management. The categories include, Used Nuclear Fuel, Low Level Radioactive Wastes, Mine and Mill Tailings, and Naturally Occurring Radioactive Materials. Each of these is discussed below.

### 2.1 *Category 1: Used Nuclear Fuel*

Used Nuclear Fuel is high-level waste and the producers and owners of the waste such as operators of nuclear power stations are responsible for its management under policy established by the federal government and according to the terms of licenses issued by the Canadian Nuclear Safety Commission.

Nuclear fuel waste results from the irradiation of nuclear fuel bundles and rods in:

- CANDU power reactors
- Prototype and power demonstration reactors
- Research and isotope production

There are 22 power reactors in Canada, owned by the provincial utilities – 20 in Ontario, some of which are in a temporary shutdown (“lay-up”) mode, 1 in Quebec and 1 in New Brunswick. The used nuclear fuel is stored at the reactor sites according to the terms of licenses from the CNSC, while waiting for a solution for long term management. Currently, the NWMO is conducting a study and will be making a recommendation to the Government of Canada, which will decide on an approach for the long term management of used nuclear fuel.

There are 3 prototype or power demonstration reactors, owned by Atomic Energy of Canada Limited (AECL), located at Douglas Point and Rolphoton, Ontario and Gentilly-1, Quebec. All of these have been defueled and the used nuclear fuel is either being stored on site or shipped to Atomic Energy of Canada Limited waste management facilities at Chalk River Laboratories, Ontario and Pinawa, Manitoba, for storage.

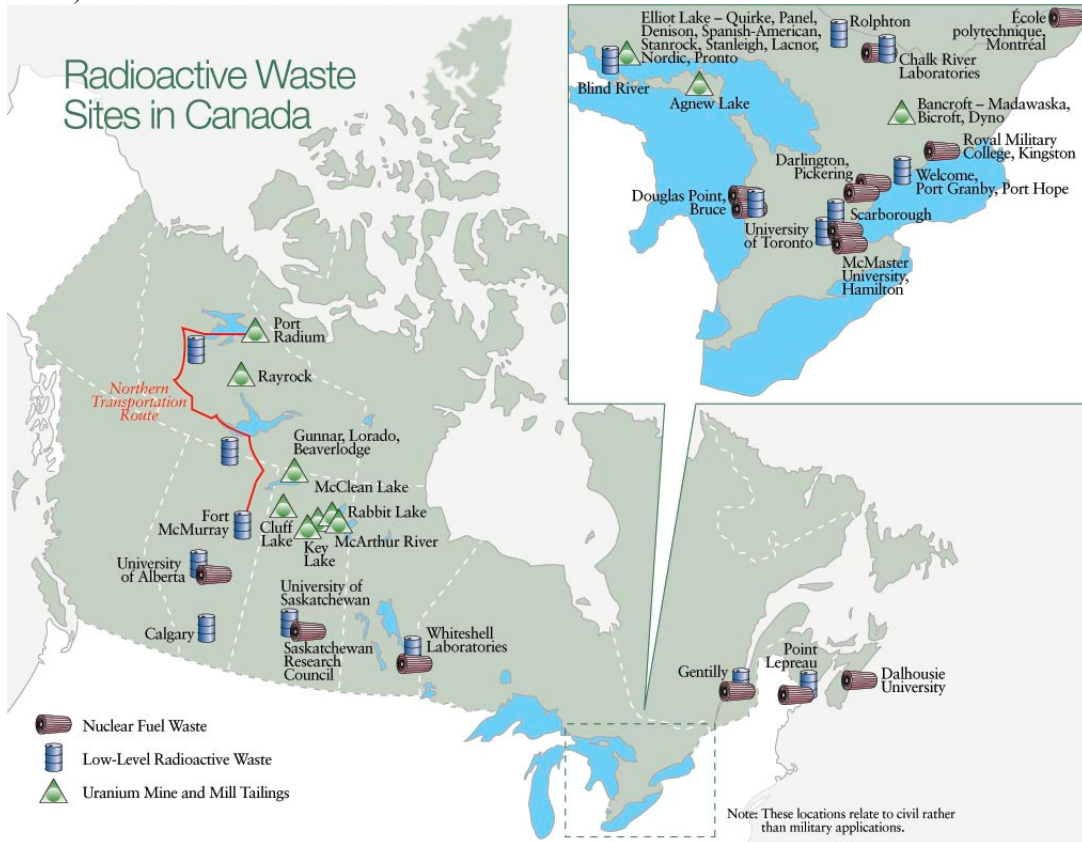
There is also a small amount of nuclear fuel waste produced by research and radioisotope production reactors at AECL facilities and universities, which is stored according to the terms of CNSC licenses.

Map 1 shows the location of radioactive waste sites in Canada.



While nuclear fuel waste is not the subject of this paper, the operation and maintenance of nuclear reactors for the generation of electricity also produces LLRW.

It is noteworthy that the accumulated volume of used nuclear fuel in Canada is small compared to the volume of LLRW and mine tailings. For instance, in 1999 there was 5,580 m<sup>3</sup> of used nuclear fuel stored in Canada. This compares to 571,250 m<sup>3</sup> of on-going waste (mostly from the operation and maintenance of reactors), 1,200,000 m<sup>3</sup> of historic LLRW (mostly in the Port Hope area, and 210,018,000 tonnes of mine and mill tailings (including operating and inactive mines) in Ontario and Saskatchewan.<sup>5</sup>



Map 1  
Source: Map courtesy of the Low Level Radioactive Waste Management Office, AECL

## 2.2 Category 2: Low Level Radioactive Waste

In Canada, low-level radioactive waste (LLRW) is defined by exclusion. If a waste is radioactive, but is neither used nuclear fuel nor uranium mine and mill tailings, then it is classified as LLRW. As note previously, LLRW includes intermediate level wastes. Canada’s approach to classifying low-level radioactive waste is described in more detail in the following section. Here, emphasis is given to describing the types of LLRW present in Canada, along with

a brief discussion of how these wastes have been managed to date. LLRW is divided into two classes: historic waste and on-going waste.

### *Historic Waste*

Historic Waste is LLRW waste that was managed in the past in a manner no longer considered acceptable but for which the original producer cannot reasonably be held responsible. The Canadian government has accepted responsibility for the management of this waste. The government established the Low-Level Radioactive Waste Management Office within AECL for administrative purposes in 1982 to carry out this responsibility. According to its 2001-2002 Annual Report, the Office is operated by a cost-recovery agreement with Natural Resources Canada, the federal department that provides the funding and establishes national policy for LLRW management. In essence, the LLRW Management Office prepares an annual business plan, which is approved by NRCan and funded accordingly.

The main historic LLRW sites in Canada, in order of volume of waste materials, are located in the Port Hope Area of Ontario, the Northern Transportation Route in the Northwest Territories and Alberta, in Scarborough, Ontario and in Surrey, British Columbia. The low-level radioactive waste in each of these areas is being cleaned up by the Low Level Radioactive Waste Management Office in collaboration with the local communities and provincial agencies. Long-term management facilities will be licensed by the Canadian Nuclear Safety Commission. A brief description of each initiative is provided below.

- The municipality of Port Hope and adjacent municipality of Clarington, Ontario, contains 95% of the historic wastes in Canada. This waste resulted from radium and uranium refining that began in the 1930's by Eldorado Resources Limited and its predecessor Eldorado Nuclear at the Port Hope refinery now owned by Cameco Corporation. This mixed waste is largely soil contaminated with low levels of radium-226, uranium and hazardous contaminants such as arsenic, which requires long-term management. The Low-Level Radioactive Waste Management Office has been cleaning up old deposits in the town of Port Hope and storing the material in licensed above ground mounds waiting for the long term solution, which is being explored by the Port Hope Initiative discussed below. Two large deposits also exist in the area, both of which are owned by Cameco. These are the Welcome Waste Management facility (in the former township of Hope now part of Port Hope), which was closed in 1955, and the Port Granby Waste Management facility in the municipality of Clarington, which was closed in 1988. Both of these waste deposits have been included in the Port Hope Area Initiative which, as of 2002, amounts to approximately 1 to 1.5m<sup>3</sup> of waste material.

The citizens of Port Hope/Clarington have undergone a long struggle since the early 1980's to have their community cleaned up in a socially responsible and technically safe manner. Initially, they demanded that the LLRW material be removed far away from their communities. A Siting Task Force was established by the federal government in December 1986 to design a cooperative approach to facility siting. It proposed a five-phase process that was accepted by the Federal Government and in 1987 the Task Force was given the mandate

to implement Phases 1–4, leading to the identification of a volunteer community. Phase 5 was to involve detailed environmental assessment studies to confirm the acceptability of the proposed site and facility design. Nearly two dozen communities participated in the Cooperative Process, with four expressing strong interest in the proposed facility. At the end of Phase 4, the Deep River community was identified as a potential volunteer for the facility. However, subsequent negotiations between the federal government and the Town of Deep River failed to secure a mutually satisfying legal agreement on the terms and conditions under which the facility would be built and the Cooperative Process came to an unhappy end.

This result prompted the Port Hope area communities involved to find a local solution to the long-term management of LLRW. In 2001, the communities entered into a legal agreement with the federal government to clean up the LLRW and place it in above ground mounds licensed by the CNSC. An environmental assessment began in 2002 for this Port Hope Area Initiative, which if approved will result in a preferred waste management option, followed by facility design, licensing and clean-up expected to be completed by 2011<sup>6</sup>. The above ground facilities planned for each community would be engineered to remain safe for over 500 years<sup>7</sup>.

- The Northern Transportation Route area has about 4% of the historic LLRW in Canada. This accumulation of mostly contaminated soils occurred when uranium was first mined and concentrated in the Northwest Territories and shipped south to Port Hope for refining. Mildly contaminated soil from several sites in Fort McMurray, Alberta was moved to a local landfill and placed in an engineered containment cell. Other more northern sites in the Northwest Territories have been located and they are scheduled for clean up over the next few years.
- Scarborough, Ontario, has about 1% of the LLRW in Canada. The historic wastes in Scarborough, which contain the naturally radioactive element radium, arose from radium recovery operations and other activities that took place on a farm in the mid-1940s. The McClure Crescent area was developed in the mid-1970s without knowledge of the history of the site. In 1980, radium contamination was discovered on McClure Crescent and in 1990 on nearby McLevin Avenue.

A joint Canada-Ontario project, in cooperation with the local community was established to complete the clean up in 1995. The mildly contaminated soils, about 9,000 cubic metres, are stored in an above ground mound located in an industrial section of Scarborough on Passmore Avenue. The mound is landscaped to blend in with the surrounding land and monitoring has indicated no effect on the local environment. The licensable portion of the LLRW was transferred to a storage building at Chalk River, Ontario.

- Surrey, British Columbia contained less than 1% of the historic LLRW in Canada. The waste has been successfully cleaned up. The mildly contaminated material has been safely stored in an Oregon, USA site and the material considered radioactive according to the Transportation of Dangerous Goods Regulation was sent to Chalk River, Ontario for storage.

During the 1970's, imported niobium ore, containing naturally radioactive thorium, was smelted and thorium remained in the slag. Some of the slag was inadvertently mixed with sand and gravel and used for fill on the Anvil Way site and some material was moved to what is now part of Canadian National Railway's Thornton Yard site, also in Surrey. In 1984, the federal government took responsibility for the removal and disposal of the waste and entered into an arrangement with the province of British Columbia, the site owners, and the local community to clean up the area. By 1986, the LLRW Office placed the Anvil Way waste in a storage bunker and the CNR built a similar interim storage bunker for the Thornton Yard waste.

In 1989, the federal government appointed the Surrey Siting Task Force, which carried out a cooperative siting process. After local communities declined to accept a LLRW management facility for the waste, the task force widened their search to the USA and successfully negotiated disposal of the Anvil Way waste at a commercial facility in Oregon. In 1999 and 2000, 350 securely covered trucks moved 5,000 cubic metres of mildly contaminated thorium soil and slag to the Oregon facility. This material was not considered radioactive under the federal Transportation of Dangerous Goods Regulations.

The Thornton Yard waste, which was considered radioactive under the federal Transportation of Dangerous Goods Regulation, was placed in 83 one-cubic metre metal boxes, and then into six containers and shipped by rail to Toronto, Ontario. The containers were then trucked to the licensed storage facility at Chalk River, Ontario.

This project involved an environmental assessment under the Canadian Environmental Assessment Act in cooperation with provincial requirements, extensive consultation with the property owners, neighbouring industries, U.S border officials, federal and provincial officials, local citizens and local Members of Parliament. The LLRW Management Office also established the Surrey Project Public Affairs Office to conduct media relations, including monitoring news coverage in British Columbia and Oregon.

The cooperative facility siting exercise carried out by the Siting Task Force and the failed negotiation effort of the federal government offers some potentially important lessons. Similarly, the more positive outcomes in the Scarborough and Surrey cases may also offer some important lessons for any siting exercise that may be undertaken for the management of used nuclear fuel. For the Port Hope story and lessons learned by the Siting Task Force see Appendix C and D and the last chapter in this paper.



Map 2

Source: Map courtesy of the Low Level Radioactive Waste Management Office, AECL.

### *On-going Waste*

Ongoing Waste is LLRW generated from continuous activities by companies that are currently in business, such as nuclear power producers and users of radioisotopes for medical diagnosis. The owners and producers of the waste are responsible for its management according to government policy and according to the terms of licenses issued by the Canadian Nuclear Safety Commission.

Ongoing LLRW result from the operation and maintenance of facilities related to the nuclear fuel cycle, nuclear research and development, the production and use of radioisotopes and the decommissioning of nuclear facilities.

The nuclear fuel cycle begins with uranium refining and conversion followed by fuel fabrication and nuclear power reactor operations. Each of these steps produces LLRW. The LLRW resulting from the mining and milling of uranium ore is administered separately and is not included in this description. The following table lists the types of LLRW material produced during the fuel cycle not including mining and milling.

**Table 2.1 - LLRW Produced from Uranium Refining, Conversion, Fuel Fabrication, Bundle Production and Reactor Operations<sup>5</sup>**

1. Process	2. LLRW
<p>Refining: Uranium ore concentrate (yellow cake) is refined producing Uranium Trioxide and various waste products.</p> <p>Conversion: Natural Uranium Trioxide Powder is converted into Ceramic Grade Uranium Dioxide Powder resulting in various LLRW.</p>	<ul style="list-style-type: none"> <li>• Combustible wastes including uncontaminated and contaminated scrap lumber, pallets, rags, paper, cardboard, rubber and plastic</li> <li>• Organic liquid wastes</li> <li>• Non-combustible wastes including uncontaminated insulation pipe racks, light bulbs, metal turnings, paint cans, cell gaskets, concrete and glass</li> <li>• Contaminated air filters, fiberglass, PVC ductwork, floor sweepings, sandblast sand, insulation, sample bottles, scrap metal anodes</li> <li>• Recyclable scrap metal</li> <li>• Contaminated soils</li> </ul>
<p>Fuel Fabrication: Ceramic Grade Uranium Dioxide Powder is fabricated into fuel pellets with associated LLRW</p> <p>Fuel Bundle Production: Fuel Pellets are combined into Fuel Bundles with associated LLRW</p>	<ul style="list-style-type: none"> <li>• Contaminated Soils</li> <li>• Contaminated rags, paper, gloves</li> <li>• Contaminated oils and oil sludge</li> <li>• Contaminated equipment and construction materials</li> <li>• Contaminated filters and dust collectors</li> </ul>
<p>CANDU Reactors: Operation and maintenance of the reactors produces high-level, intermediate level and low-level wastes</p>	<ul style="list-style-type: none"> <li>• Combustible wastes including paper, plastic, rubber, cotton, wood, organic liquids</li> <li>• Compactible wastes including paper, plastic PVC suits, rubber, fiberglass, metal pieces, empty drums</li> <li>• Non-Processible waste including filters, light bulbs, cable, used equipment, metals, construction debris, absorbents (sand, vermiculite, sweeping compound), ion exchange resins, reactor core components, retube wastes</li> <li>• Processible liquids including active drain wastes, chemical cleaning solutions</li> </ul>

**Note: Some of these are intermediate level wastes such as filter and ion exchange resins. The management of these wastes is discussed in the next chapter.**

Atomic Energy of Canada Limited has nuclear research and development facilities at Chalk River, Ontario and Pinawa, Manitoba, which are licensed by the Canadian Nuclear Safety Commission. LLRW produced are stored in waste management facilities at each site. Research

and development activities at Chalk River include the application of nuclear science, reactor development, environmental science, and LLRW management. The Chalk River facility also produces radioisotopes for MDS Nordion. Some of AECL’s waste management sites will require decommissioning and long-term storage in the future. (See Chapter 3 for more details on the Chalk River facility.)

In Canada, radioisotopes are processed, packaged, distributed and marketed by MDS Nordion, the world’s leading producer and exporter of these products, located at Kanata, Ontario. They are used for industrial, medical and educational purposes. The low-level radioactive wastes resulting from the production and use of the radioisotopes are managed by the producers and users of the products, such as hospitals. Some radioisotopes lose their radioactivity in minutes and can be disposed of on site into the municipal waste disposal system. Others have a long half-life and are shipped to Chalk River for management.

Significant quantities of nuclear wastes will be generated from the decommissioning of nuclear reactors and supporting facilities. Current plans of reactor operators call for decommissioning in 3 phases. The purpose of phase 1 is to isolate and dispose of the wastes that can be dealt with immediately. In phase 2, the remaining wastes will be stored for 25 to 30 years until they have decayed sufficiently so they can be moved to a long-term management or disposal facility. Phase 3 involves the final dismantling and clean up for future land use. The following table summarizes the wastes expected to be involved at each stage. Specific protective measures will have to be identified and put in place at each phase to prevent or minimize potential risks.

**Table 2.2**  
**Nuclear Wastes Involved from CANDU Reactor Decommissioning**

Reactor Shutdown – Phase 1 – 2 to 3 years	<ul style="list-style-type: none"> <li>• Incinerable wastes including paper, plastic, rubber, cotton, wood</li> <li>• Compactible wastes such as paper, plastic PVC suits, rubber, fiberglass, metal pieces</li> <li>• Non-processible wastes such as filters, used equipment, absorbents (sand, vermiculite, sweeping compound), ion exchange resins</li> <li>• Processible liquids such as active drain wastes, decontamination solutions</li> </ul>
Reactor Shutdown – Phase 2 – 25 to 30 years	Material is stored until decayed sufficiently for disposal – additional waste is not produced during this period.
Reactor Shutdown – Phase 3 – 5 to 7 years	Same as Phase 1, plus: <ul style="list-style-type: none"> <li>• Active systems such as fuel channel components, reactor and shield tanks, piping, boilers</li> <li>• Active structures such as biological shield, fuel bay</li> </ul>

### **2.3 Category 3: Waste from Uranium Mine and Mill Tailings**

Tailings resulting from the mining and milling of uranium ore and the production of concentrate comprise LLRW and hazardous contaminants such as heavy metals. There are large volumes of acid tailings and they are managed and decommissioned in place. It would be very costly to do otherwise. According to the *Inventory of Radioactive Waste in Canada, 1999*, management usually involves improvement or construction of dams to provide long-term containment, followed by flooding or covering of the tailings to reduce acid generation and the release of gamma radiation and radon gas, and then monitoring to maintain materials on site.<sup>5</sup>

With respect to the decommissioning of abandoned tailings, the federal government has entered into a 50/50 cost share agreement with Ontario to clean up the situation. A similar agreement is being considered with the province of Saskatchewan. This is discussed under the legal and administrative arrangement section of this report.

### **2.4 Category 4: Naturally Occurring Radioactive Materials (NORM)**

Long-lived radioactive elements such as uranium, thorium and potassium and their radioactive decay products, such as radium and radon, have always been present in the earth's crust and within the tissue of all living beings.

Although the concentration of NORM in most natural substances is low, higher concentrations may arise due to human industrial activities. For example, calcium scale precipitated from oil recovery brine may contain radium at much greater concentrations than the water source itself.

Thus NORM, according to Health Canada Guideline, results from the processing of raw materials by many resource-based industries that may increase the concentration of radioactive substances. Radioactivity may be concentrated such that the materials require special precautions for handling, storing, transporting, and disposal, including by-products, end products or process equipment<sup>3</sup>.

The Canadian Nuclear Safety Commission, which regulates radioactive materials associated with the nuclear fuel cycle and artificially produced radioisotopes, does not regulate NORM wastes except for transportation purposes. NORM activities are the responsibility of the provinces and the territories.

Industries with NORM radiation include:

- Mineral Extraction and Processing such as in the phosphate fertilizer and abrasive and refractory industries.
- Oil and Gas Production such as radioactivity found in the liquids and gases from hydrocarbon-bearing geological formations
- Metal Recycling where NORM contaminated materials can be redistributed to other industries
- Forest Products and Thermal-Electric Production where mineral ashes left from combustion may concentrate small amounts of NORM present naturally in the plant and coal material



- Water Treatment Facilities (geothermal sources and fish hatcheries) where fresh water or wastewater is treated through sorptive media or ion exchange resins to remove minerals and other impurities and may release radon.
- Tunneling and Underground Workings where small amounts of indigenous radioactive minerals or gases may be present, such as in underground caverns, electrical vaults, tunnels or sewer systems<sup>3</sup>.

Further discussion of NORM guidelines is included in the section on Legal and Administrative Arrangements

## 2.5 How LLRW is Classified?

In Canada, as noted above, LLRW is classified by exclusion, that is, if it is radioactive waste and is not used nuclear fuel or mine and mill tailings, and then it is LLRW. Furthermore, LLRW is classified based on administrative responsibility. The management of *historic waste*, which is funded by the federal government, is delegated to the Low Level Radioactive Waste Management Office for clean up in cooperation with the local communities and the provincial agencies. It should be noted that “clean up” essentially means consolidating the wastes in a few locations and creating facilities for their long-term storage and management. Presumably this storage will last until the radioactive decay process is completed, a timeline which will vary for each LLRW facility due to differences in the nature of the wastes at each location, an issue that has great interest for the communities involved.

*On-going waste* management is the responsibility of the producers and owners of the wastes such as the operators of nuclear reactors. In addition, NORM wastes are not regulated by the CNSC except for transportation, and they are the responsibility of the provinces and territories.

The classification of LLRW does not distinguish between very low-level waste with low hazard that can be managed in above ground mounds and material that is very hazardous over a long time and that requires a much more secure facility for long term management. Management is decided by those responsible for the LLRW and the CNSC during the licensing process.

The classification of LLRW is similar in the United States of America (USA), where it is also defined by exclusion. In the USA, LLRW is any radioactive waste not classified as spent fuel, high-level waste, transuranic waste or uranium or thorium mill tailings. The problem with the exclusion approach is that one has to understand all the other radioactive waste classifications to understand what LLRW is. As stated by the National Council on Radiation Protection and Measurement (NCRP), “there is no definition of what LLRW is, only a definition of what it is not. As a result, in contrast to the earliest descriptions of low-level waste prior to the establishment of definitions in law, this class is not restricted to waste that contains relatively low concentrations of radionuclides compared with high-level waste. Rather low-level waste can range from virtually innocuous to highly hazardous over long time frames.”<sup>8</sup>

Consequently, in the USA, sub-classifications of fuel-cycle LLRW have been developed that are licensed by the U.S. Nuclear Regulatory Commission or an Agreement State. An Agreement

State is a state to which the NRC has relinquished part or all of its authority to regulate radioactive materials.

As stated in the NCRP report, waste designated as Class A, B, or C is generally acceptable for near-surface disposal in accordance with requirements for each subclass specified by the NRC or compatible Agreement State requirements. Greater-than-Class C waste, which contains the highest concentrations of radionuclides with half-lives of about 30 years or greater, requires disposal in geologic repositories, unless disposal elsewhere is approved.

The International Atomic Energy Agency (IAEA) has recommended a classification system based on radiological properties rather than source. France, who generally follows the IAEA system, classifies radioactive waste based on radioactive level and half-life. This is discussed in Chapter Five.

Not surprisingly, nuclear power station managers in Canada have also developed their own sub-classification system in cooperation with the CNSC. These are discussed in the next chapter.

### **3. THE MANAGEMENT OF LOW AND INTERMEDIATE LEVEL RADIOACTIVE WASTES BY NUCLEAR POWER STATION OPERATORS AND BY AECL, CHALK RIVER**

Nuclear Power Station operators and Atomic Energy of Canada Limited (AECL) have developed their own low level radioactive waste classification and management system. It is based on the Canadian government policy and international standards while considering the activity and half-life of their own radioactive waste material. This chapter summarizes LLRW management for Ontario Power Generation, Hydro Quebec and New Brunswick Power, and AECL at the Chalk River Laboratories in Ontario.

#### **Ontario Power Generation (OPG)**

Ontario has three nuclear power sites (Note: Bruce A & B are considered to be separate generating stations), two east of Toronto on the shores of Lake Ontario and one in the Municipality of Kincardine on the eastern shores of Lake Huron, including a total of 20 nuclear reactors, (See Map 1). All 20 reactors are owned and operated by OPG, except the 8 reactors of the Bruce A and B generating stations which are leased and operated by Bruce Power. However, OPG manages the radioactive wastes from all 20 reactors. OPG has four means of managing radioactive waste based on activity, half-life and hazard of the material. These are wet storage of used nuclear fuel, dry storage of used nuclear fuel, storage of intermediate-level waste (having elevated levels of radioactivity and/or long half-lives) and processing and storage of low-level radioactive wastes. Wet and dry storage of used nuclear fuel is discussed in another background paper.

Intermediate and low level radioactive waste produced from the operation and maintenance of the nuclear reactors at Pickering, Darlington and the Bruce Power Site generating stations ARE packaged and shipped to the Western Waste Management Facility (WWMF) at the Bruce Power Site.

#### *Intermediate Level Radioactive Waste*

A small amount of the radioactive waste produced by the operation of the OPG reactors has elevated levels of radioactivity and longer half-lives and thus requires special treatment. The most radioactive of these wastes consist primarily of used reactor components, and resins and filters used to keep the reactor water system clean. These items make up about 3 percent of the total volume of non-fuel waste. The resins and filters are loaded into specially reinforced and shielded transportation packages and shipped to the WWMF, where the intermediate level waste is stored in steel lined concrete containers placed in the ground.<sup>9</sup>

### *Low Level Radioactive Waste*

About 97 percent of the total non-used fuel waste volume is made up of radioactive material such as mop-heads, rags, paper towels, floor sweepings and protective clothing. After being packaged in plastic bags and placed in special containers, these LLRW are sent to WWMF for processing and storage. Most of this material is compacted or incinerated to reduce the volume, placed in containers or bailed and stored in concrete buildings.

### *LLRW Management Steps at OPG*

Low and intermediate level radioactive waste management at OPG is carried out as follows:

Collection and handling at Ontario generating stations

- low-level radioactive waste is collected, sorted, bagged and placed in containers ready for shipment to WWMF
- intermediate level radioactive waste is placed in specially designed containers ready for shipment to WWMF

Transportation to the WWMF

- Different containers are built depending on the hazard of the radioactive waste. For example the intermediate radioactive waste containers are designed to withstand possible transportation accidents. The material is shipped by truck from the Pickering, Darlington and Bruce Power stations to the WWMF located at the Bruce Power site. According to OPG, there have only been five traffic accidents during the over 30 years of nuclear operation in Ontario, resulting in no damage to the specially designed containers and no releases of radioactivity.

Processing and Storage at the WWMF

- The LLRW is processed by incineration or compacted and bailed and placed in warehouse-like concrete buildings.
- The intermediate level waste is not processed for volume reduction at this time. It is currently placed in in-ground steel lined, concrete containers. Above ground structures are also used.
- All the low and intermediate-level radioactive waste can be retrieved at some future date for long term management.

Long-Term Management of Low and Intermediate Level Radioactive Waste

- At the present time, there is no facility in Canada for long term disposal or management of radioactive waste. OPG's current plan for long term disposal/management is to have a LLRW facility in place by 2015 and an intermediate level radioactive waste facility in place by 2035. The plan also indicates that intermediate wastes could be co-managed with used nuclear fuel pending review of the long-term management of used nuclear fuel by the NWMO and Government of Canada<sup>9</sup>.
- In addition to the above plan, OPG is currently collaborating with the Municipality of Kincardine to explore possible options for the long-term management of low and intermediate waste at the WWMF. A joint steering committee has been established and an independent study has been contracted that will provide a technical comparison of the options and include the results of consultation with stakeholders and the community, to be completed early in 2004. Kincardine and OPG will develop a "community offsets and benefit

plan” and seek community agreement for the facility through a referendum. If the referendum is positive, the undertaking will be submitted for an environmental assessment and if accepted, site preparation and construction approvals will be requested from the Canadian Nuclear Safety Commission followed by an operating license<sup>10</sup>.

### **Hydro Quebec Gentilly-2 Nuclear Generating Station**

The Gentilly-2 nuclear power station is located on the south shore of the Saint Lawrence River near the city of Trois-Rivieres. Similar to OPG, Hydro Quebec recognizes an intermediate level of radioactive waste based on activity and half-life of the material.

The Gentilly-2 station has four methods of managing radioactive waste including used nuclear fuel water storage, used nuclear fuel dry storage, intermediate level radioactive waste storage and LLRW storage. Hydro Quebec intends to store used nuclear fuel at the Gentilly-2 site until a final disposal site is available in Canada. The low and intermediate wastes are stored on site in the Solid Radioactive Waste Management Facility (SRWMF).

#### *Intermediate Level Radioactive Waste*

Intermediate radioactive waste consists mainly of filters from the purification systems and some equipment parts. Conventional filters used to trap impurities in the stations various systems become radioactive. They are dried and stored in specially designed vaults in the SRWMF. Contaminated equipment parts are also placed in containers and placed in the SRWMF. Chemical filters, called ion exchange resins filters, are used in the moderator coolant system. When replaced, the contaminated resins are placed in two special tanks at the station. All the waste material is retrievable for long term management.

#### *Low Level Radioactive Waste*

LLRW such as cloths, gloves, protective clothing, vinyl film and covering sheets are compressed and wrapped in vinyl. The packages are numbered and labeled so that they may be retrieved if necessary. The packages are then stocked in vaults in the SRWMF. Unlike OPG, LLRW is not incinerated at Gentilly-2.

The SRWMF has 7 vaults for Gentilly-2 wastes and 19 vaults for waste from the now decommissioned Gentilly-1, which stopped operating in 1979. Currently, the waste management facility is being examined for modifications to extend its capacity and an environmental assessment is being carried out according to the Quebec EA process which is coordinated with the federal EA process. Hydro Quebec is also considering refurbishment of the reactor but no firm decision has been made in that regard. The CNSC is involved in this exercise to make sure their licensing requirements will be met.<sup>11</sup>.

## **New Brunswick Power – Point Lepreau Generating Station**

The Point Lepreau Generating Station (PLGS) is located on the south coast of New Brunswick, near the city of Saint John. (see Map 1) The PLGS has three facilities for storing radioactive wastes on site including used nuclear fuel water storage in “spent fuel bays”, above-ground dry fuel storage containers made of concrete and steel and a solid radioactive waste management facility for storage of low and intermediate level radioactive waste.

### *Low Level and Intermediate Level Radioactive Wastes*

The PLGS has a solid waste management facility, licensed by the CNSC. PLGS does not incinerate LLRW. They are compacted and stored in above ground concrete vaults. Intermediate wastes such as ion exchange resins are stored in underground containers. A program has been implemented to reduce the amount of waste stored in the facility. A solid waste segregation program outlines procedures to monitor the amount of waste generated by the station. In conjunction with this program, a waste minimization program is being developed to raise general awareness on the handling, storage and disposal of waste. All wastes are retrievable, if necessary, for long term management<sup>12</sup>.

### *The Point Lepreau Generating Station Refurbishment Project*

NB Power is in the planning stages of a project to refurbish the PLGS. If approved, NB Power will proceed with detailed engineering and an 18-month shut down starting in the spring of 2007. To store the radioactive material being removed from the reactor as part of the refurbishment program, additional storage structures would be constructed beginning in 2005 at the existing licensed solid radioactive waste management facility. In addition to these new structures, additional vaults would be constructed to house the LLRW that would be generated over the extended plant life.

The modification of the waste facility license to allow construction of these additional radioactive waste management structures triggered an Environment Assessment under the Canadian Environmental Assessment Act. The project has also been registered under the provincial Environment Impact Assessment Regulation. Thus a harmonized CEAA/Provincial EA is currently taking place. A decision on the EA is expected in July of 2003. If approved and the refurbishing completed and licensed by the CNSC by the planned start up date of the fall of 2008, the reactor would be operating for another 25 to 30 years<sup>13</sup>.

### *AECL, Chalk River Laboratories, Ontario*

AECL provides a facility for storing LLRW produced from its own research activities and from other companies, hospitals and universities across Canada. The facility also stores LLRW from the production of radioisotopes used for industrial and medical purposes. AECL also administers

the historic LLRW program through it's the LLRW Management Office as discussed earlier in this report.

In 2001, after a public consultation process, AECL constructed a new facility for packaging and storing solid LLRW at its Chalk River Laboratories site. Modular, aboveground storage (MAGS) buildings are used to store LLRW. According to AECL, the MAGS facilities will store LLRW that have been sorted and compacted into tagged steel containers. Each building is designed to hold up to two years' worth of wastes. The waste can be monitored and easily retrieved for long-term management.

AECL, in discussion with the CNSC, has plans to license a prototype below ground concrete vault known as IRUS (Intrusion-Resistant Underground Structure) for relatively short-lived wastes. The future application of IRUS technology is currently being reassessed by AECL. Until this, or another disposal facility is available, AECL will continue to store its on-going LLRW in below ground and above ground structures.

#### **4. THE STATUS OF THE LEGAL AND ADMINISTRATIVE ARRANGEMENTS**

While electricity and natural resources are under provincial jurisdiction, the Government of Canada established its clear jurisdiction and regulatory power over nuclear energy by enacting the Atomic Energy Control Act of 1946 and has maintained its jurisdiction ever since. Thus, the Government of Canada is responsible for ensuring that the long-term management of radioactive waste is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner. The producers and owners of the radioactive wastes are responsible for the funding, organization, management and operation of all facilities related to their wastes.

Natural Resources Canada (NRCAN) develops policies related to radioactive waste management resulting from the nuclear fuel cycle to ensure that the waste producers and owners meet their operational and funding responsibilities.

Guidelines related to manage Naturally Occurring Radioactive Material (NORM) arising from industrial processes not related specifically to the nuclear fuel cycle or the production of radioactive material, are developed by Health Canada in cooperation with the provinces. Carrying out the guidelines is the responsibility of the provinces and territories and the corporations producing the wastes. This is discussed further below under the role of the Provinces.

Following is a listing and summary of the purpose of the major legal and regulatory instruments related to LLRW management in Canada.

##### **4.1 Federal Legal and Administrative Arrangements**

Natural Resources Canada (NRCAN) is responsible for policy on radioactive waste management in Canada that relates to the used nuclear fuel cycle including:

- Used nuclear fuel
- Low-level radioactive waste, and
- Mine and mill tailings.

NRCAN is also responsible for policy related to the production and use of radioisotopes for industry and medicine. While there is no specific policy at present, it is understood that the owners and producers of these wastes are responsible for its management according to general federal policy on radioactive waste management.

##### *The Nuclear Safety and Control Act (NSCA)*

The NSCA received Royal Assent on March 20, 1997 and was proclaimed on May 30, 2000. The NSCA replaced the Atomic Energy and Control Act of 1946 to more effectively regulate the activities of the Canadian nuclear industry. The purpose of the NSCA is to provide for:



- (a) the limitation, to a reasonable level and in a manner that is consistent with Canada's international obligations, of the risks to national security, the health and safety of persons and the environment that are associated with the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information; and
- (b) the implementation in Canada of measures to which Canada has agreed respecting international control of the development, production and use of nuclear energy, including the non-proliferation of nuclear weapons and nuclear explosive devices<sup>14</sup>.

The NSCA establishes the Canadian Nuclear Safety Commission (CNSC) which replaced the Atomic Energy Control Board. The CNSC is responsible for the administration of the NSCA and much of the act deals with the establishment of the Commission, its objects, the role of Commission members and technical staff, powers of the CNSC, role of inspectors, procedures for decisions and orders, etc.

Section 44 deals with regulations that the Commission may establish including regulations for the management, storage, transportation and disposal of LLRW.

*An Act Respecting Civil Liability for Nuclear Damage. The short title is The Nuclear Liability Act (NLA)*

The NLA was proclaimed on October 11, 1976. In essence the NLA ensures that funds are available from the operator of a nuclear facility to provide financial compensation to third parties for injuries or damage suffered as a result of a nuclear incident, and places on the operator the obligation of strict liability regardless of fault. The NLA also establishes a regime of nuclear liability that encourages nuclear development by channeling all third party liabilities to the operator and by limiting the operator's liability.

In other words, the operator of a nuclear facility is "absolutely liable" for third-party injury and damage. This means that victims do not need to prove negligence to claim for injury or damages. Another important feature of the Act is the "exclusive liability of the operator". This means that the operator alone is liable, regardless of the acts or omissions that were the actual cause of the accident.

As a result of the NLA, liability in Canada is limited to \$75 million and coverage is provided by the Nuclear Insurance Association of Canada, the only insurer. The Government of Canada re-insures some risks and provides supplementary insurance to the amount of \$600 million contingent liability. The most recent installation designated under the NLA is OPG's Western Waste Management Facility at the Bruce Power site. The CNSC is responsible for administering the NLA.

Natural Resources Canada is currently carrying out a review of the NLA to update and improve it<sup>15</sup>.

### *The Transportation of Dangerous Goods Act, 1992, and Regulations (TDG)*

The transportation of such products by air, marine, rail and road is regulated under the federal Transportation of Dangerous Goods Act, 1992. The Transportation of Dangerous Goods Regulations, adopted by all provinces and territories, establishes the safety requirements for the transportation of dangerous goods.

Federal and provincial legislation provides for the regulation of an extensive list of products, substances or organisms classified as dangerous. The products fall into one of nine classes (Class 7 deals with radioactive materials). The Transportation of Dangerous Goods Act divides dangerous goods into nine classes according to the type of danger they present. Some of the nine classes are subdivided into divisions. The nine classes, as well as their divisions, are described in The Marks of Safety handout. For further detail on classification, Part 2 of the Regulations should be consulted.

Class 7 deals with radioactive materials. Products, substances or articles containing a product or substance with activity greater than 74kBq/kg are radioactive materials and are included.

It is the consignor's responsibility to classify a substance, product or organism to determine if it is dangerous goods. A consignor must do all the preparation work before the carrier takes possession of the dangerous goods. Preparing the dangerous goods for transport includes: classifying the dangerous goods, completing the documentation, affixing the dangerous goods safety marks on the means of containment, selecting a means of containment, etc.

The packaging of the radioactive waste material ready for transport is controlled by the Canadian Nuclear Safety Commission according to the Packaging and Transport of Nuclear Substances Regulations.

### *The Canadian Nuclear Safety Commission (CNSC)*

The task of the CNSC is to regulate the use of nuclear energy and materials and to respect Canada's international commitments on the peaceful use of nuclear energy. The CNSC operates according to the Nuclear Safety and Control Act, its Regulations and other legal instruments such as licenses and orders. The Commission functions as a tribunal making independent decisions on the licensing of nuclear-related activities in Canada. The Commission's mandate involves four major areas:

- Regulation on the development, production and use of nuclear energy in Canada;
- Regulation of the production, possession and use of nuclear substances, prescribed equipment and prescribed information;
- Implementation of measures respecting international control of the use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons; and
- Dissemination of scientific, technical and regulatory information concerning the activities of the CNSC

The Commission takes into account the views, concerns and opinions of interested parties and intervenors when establishing regulatory policy, making licensing decisions and implementing programs. Staff prepares recommendations on licensing decisions, present them to the Commission for consideration during public hearings and then administer the decisions once they are made by the Commission. Throughout the stages of the licensing process for a LLRW management facility, from site preparation through to closing down a facility, applicants must provide detailed information to show their ability to meet required health, environmental and safety standards. The Commission bases its standards on internationally accepted rules of good practice, dose limits, emission limits and other safeguards.

Prior to making a decision on a particular licensing matter, the Commission generally holds a 2 day hearing (day one is often separated from day two by a number of weeks) where the applicant, Commission staff, and members of the public can present relevant information.

The legal framework within which the CNSC operates is supported by regulatory documents issued by the Commission, the main classes of which are:

- Regulatory Policy (RP): A document that describes the philosophy, principles or fundamental factors, which underlie the Commission's approach to its regulatory mission. It is issued for the guidance of Commission staff and for the information of stakeholders
- Regulatory Standard (RS): A document that describes CNSC requirements. It imposes obligations on the regulated party, once it is referenced in a license or other legally enforceable instrument.
- Regulatory Guide (RG): A document that indicates acceptable ways of meeting the Commission's requirements, as expressed in the Act, Regulations, regulatory standard or other legally enforceable instruments. It is issued for the guidance of licensees and other stakeholders
- Regulatory Notice (RN): A document that provides licensees and other stakeholders with information about significant matters that warrant timely action.

Under the NSCA, the Commission has put into place a number of regulations and bylaws. These are all available on the CNSC web site. All of these documents may apply to the management of LLRW. It should be noted that the NSCA and Regulations do not prescribe how LLRW material is to be managed. Rather, the owners and operators (the licensees) detail how they propose to meet the regulations such as the regulated limits for radioactivity and potential hazard to workers and the public.

- General Nuclear Safety and Control Regulations
- Radiation Protection Regulations
- Class 1 Nuclear Facilities Regulations
- Class 11 Nuclear Facilities and Prescribed Equipment Regulations
- Nuclear Substances and Radiation Devices Regulations
- Packaging and Transport of Nuclear Substances Regulations
- Uranium Mining and Mills Regulations
- Nuclear Security Regulations
- Non-Proliferation Import and Export Control Regulations
- CNSC Cost Recovery Fees Regulations

The CNSC generally follows international standards set by the International Atomic Energy Agency (IAEA) and International Commission on Radiological Protection (ICRP) when preparing regulations considering the local Canadian situation.

It should be noted that the regulatory policy statement, R-104 relating to the disposal of nuclear waste has been withdrawn. A new regulatory policy is being prepared called P-290, Managing Radioactive Waste, and has been issued for public comment. Comments are required in writing by August 1, 2003<sup>16</sup>. In its draft regulatory policy statement P-290, six key principles are listed as follows:

- The generation of radioactive waste should be minimized to the extent practicable by the implementation of design measures and operating and decommissioning practices;
- Radioactive waste should be managed in a manner that is commensurate with its radiological, chemical and biological hazards to the environment and to the health and safety of persons;
- The anticipated impacts on the environment, and on the health and safety of persons, from the future management of the radioactive waste should not be greater than those that are currently permissible in Canada;
- The establishment of arrangements to fund any measures needed to protect the environment and persons from the radioactive waste, and the implementation of such measures, should not be deferred unduly so as to impose a burden on future generations;
- The period over which the future impacts of radioactive waste on the environment and the health and safety of persons are assessed should include the period over which the maximum impacts are anticipated; and
- The trans-border effects on the health and safety of persons and on the environment that could result from the management of radioactive waste in Canada should not be greater than the effects experienced in Canada.

The next step for the CNSC is to prepare the regulatory guide for the management of radioactive waste. This is expected in 2004. In the interim, interested parties should talk to CNSC staff for draft principles and expectations for the management of radioactive waste.

#### *The Canadian Environmental Assessment Act (CEAA)*

The CEAA came into force in 1996 and replaced the former Environmental Assessment Review Process Guidelines Order. Simply stated, the purposes of CEAA are:

- to ensure that environmental effects of a project are carefully considered
- to promote sustainable development
- to ensure that projects within Canada or on federal lands do not cause significant adverse environmental effects on outside jurisdictions, and
- to ensure public participation in the EA process.

CEAA applies to a federal authority when there is a project, which is defined as a physical work or an activity in relation to a physical work. CEAA is triggered if a federal authority is contemplating an action that will enable a project to proceed such as:

- proposes a project,
- grants money to a project,

- grants an interest in land to a project,
- exercises a regulatory duty in relation to a project.

CEAA is a self-assessment process. The legislation establishes certain things that must be included in an EA and decisions the responsible authority must take. However, it also leaves a great deal of discretion in carrying out the EA. A federal authority is a Minister of the Crown, any federal Department, an agency or body of the federal government and any body prescribed in a regulation under CEAA. Thus Natural Resources Canada and the Canadian Nuclear Safety Commission are federal authorities under CEAA.

For LLRW management, various licenses are required from the CNSC for activities ranging from site preparation and construction, waste handling, transportation and storage to decommissioning. These actions may trigger an EA under the CEAA. Furthermore, the Inclusion List Regulation under CEAA, Part 111: Nuclear and Related Facilities, requires an EA depending on the amount and activity of the radioactive material. For LLRW, the preferred approach is for the EA to cover all steps in the LLRW management process.

A 5-year review of CEAA has been completed and the amendments to CEAA received Royal Assent on June 11, 2003. It is expected that the revised act will come into force in November of 2003. According to the Ontario Regional Director, the revisions to CEAA build on the fundamentals and core principles EA included in the original act, which have not changed. What has changed is an increased coordination role for the Regional Offices of CEAA. Regional staff of CEAA will be promoting better EA and harmonization with provincial processes, earlier application of CEAA in the planning process and improved coordination and communications among the stakeholders<sup>17</sup>.

#### *A Policy Framework for Radioactive Waste*

In 1996, Natural Resources Canada, on behalf of the Government of Canada, issued a policy statement called the Policy Framework for Radioactive Waste. This policy makes the producers and owners of ongoing LLRW responsible for its safe management. The principles are:

- The federal government will ensure that radioactive 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 waste producers and owners for ensuring that they comply with legal requirements and meet their funding and operational responsibilities
- The waste producers and owners are responsible for the funding, organization, management and operation of disposal and other facilities for their waste.

#### *Administrative Arrangements.*

Administrative arrangements for the management of historic LLRW were delegated to the Low Level Radioactive Waste Management Office in 1982, which is administratively part of AECL.

NRCan is responsible for oversight of the LLRWM Office, funding and policy advice according to a business plan prepared by the LLRWM Office. Where dollars are limited, NRCan makes the choice on how the money should be spent. AECL provides day-to-day administration.

In 1996, NRCan entered into a 50/50 cost-sharing agreement with the province of Ontario for the decommissioning and long-term maintenance of uranium mine and mill tailings. The agreement recognizes that present and past producers of uranium are responsible for all financial aspects of the decommissioning and long-term maintenance of uranium mine sites, including uranium tailings. In the case of abandoned tailings, where a producer or owner is unable to pay, the agreement outlines how the two parties will share the costs. Currently in Ontario, all abandoned mines have identified owners.

A similar administrative arrangement is being considered for the province of Saskatchewan, the only other province with uranium mines.

#### **4.2 Provincial Legal and Administrative Arrangements**

In general, the provinces and territories defer all radioactive waste management related to the nuclear fuel cycle to the federal government and the CNSC. This includes policy development for LLRW management, environmental assessment and the licensing activities. However, the provincial agencies responsible for environmental assessment, solid and hazardous waste management normally participate in the licensing process. For example where the LLRW material is mixed waste, including radioactive material mixed with hazardous contaminants such as heavy metals, (such as the Port Hope Initiative), the provinces normally defer to the CNSC regulatory processes and participate in a review role to make sure that their mandated interests are protected.

Also, once CEAA is triggered, the federal and provincial EA administrators endeavour to harmonize their respective EA requirements. Presently, there are harmonization agreements between the federal CEA Agency and the provinces of British Columbia, Alberta, Saskatchewan and Manitoba. CEAA is currently negotiating with the other provinces to harmonize the EA processes. This coordination of federal and provincial EA processes brings in those provincial and municipal interests dealing with the natural resources, environmental issues, land use and other interests that may be impacted by a proposed LLRW management facility. Furthermore, both CEAA and most provincial EA's require consultation with stakeholders and the public.

As previously noted, naturally occurring radioactive material (NORM) that is a by-product of some industrial process and not part of the nuclear fuel cycle is the responsibility of the provinces and the companies owning the material. A Canadian intergovernmental committee, the Federal Provincial Territorial Radiation Protection Committee, established a Canadian NORM Working Group which has recently (October 2000) produced the Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM), published by Health Canada. The guidelines are an extension of the work done by the Western Canadian Committee on NORM in 1996.

The basic principle of these guidelines is that where workers or the public are exposed to additional sources of radiation exposure because of activities involving NORM, the same radiation protection standards should be applied as for CNSC activities. It should be noted that the transportation of NORM materials requires a license from the CNSC.

Note: The CNSC now refers to these materials as “naturally occurring nuclear materials”.

## 5. THE LEGAL AND ADMINISTRATIVE ARRANGEMENTS IN THE UNITED STATES OF AMERICA AND FRANCE

### *The United States of America (USA)*

Unlike Canada, much of the nuclear wastes in the USA come from weapons manufacturing and testing. These are referred to as “defense wastes”. Both high level-waste and low-level wastes are produced by weapons manufacturing and currently stored at government facilities.

Similar to Canada, the balance of non-defense nuclear waste in the USA, referred to as “commercial” waste comes from:

- nuclear power plants in the form of used nuclear fuel referred to as “spent fuel” and low-level nuclear waste such as contaminated clothing, ion exchange resins, contaminated concrete and metal from decommissioned facilities, etc. Also similar to Canada, no reprocessing of spent fuel rods from commercial reactors (and recently, from defense reactors) is taking place and the spent fuel is stored on site waiting the approval and construction of a permanent disposal facility.
- the production and use of radioisotopes for medical diagnosis and treatment, resulting in low-level nuclear wastes such as work gloves, wipes, used needles, etc managed on site or shipped to approved low-level facilities.
- uranium mine tailings including large volumes of low-level nuclear wastes managed on site.
- the clean up of historic sites including both low-level and intermediate-level nuclear wastes.

All rules and regulations for US federal LLRW stem from the Atomic Energy Act (AEA), which has been amended a number of times since its establishment in the late 1940's. Similar to the NSCA in Canada, the AEA provides for the management and regulation of radioactive materials that are “source materials” and “by-products of materials” including LLRW.

The AEA established the Nuclear Regulatory Commission (NRC), which regulates and licenses commercial radioactive waste resulting from the nuclear fuel cycle. On the other hand, the Department of Energy (DOE) is given the authority under the AEA to set policy for defense wastes using a self-regulatory process. In circumstances where defense wastes are to be treated or disposed of in a NRC-licensed commercial facility, then the DOE wastes must meet NRC requirements.

The Environmental Protection Agency, under the authority of the Resources Conservation and Recovery Act, is responsible for the regulation of hazardous chemical wastes. Thus mixed waste with both radioactive and hazardous material would trigger both the EPA, the NRC and possibly DOE. The EPA also regulates radiation exposure to workers and the public and this responsibility could also involve the EPA with the NRC regulatory process.

The states become involved in radioactive waste management in two ways. First, and similar to Canada, NORM waste is not subject to the AEA. Rather, it is a state responsibility. Second, the U.S. Low Level Waste Policy Act of 1980 (and 1985 amendments) requires every state to



provide for disposal of its own LLW, either alone or in cooperation with other states. This led to the formation of 10 state “Compacts”, which include most states. Currently, however, there are only three LLW disposal facilities. For the most part, these facilities, located in South Carolina, Washington and Utah, are still receiving waste from outside their Compact. Because the facilities are in NRC Agreement States, each facility is licensed by its host state. As previously noted in Section 2.5, an Agreement State is a state to which the NRC has relinquished part or all of its authority to regulate radioactive materials. Section 274 of the 1954 AEA, as amended, provides a statutory basis under which the NRC may relinquish to the states portions of its regulatory authority to license and regulate byproduct materials, source materials, and certain quantities of special nuclear materials. The mechanism for the transfer of NRC’s authority to a state is an agreement signed by the Governor of the State and the Chairman of the Commission. Currently there are 32 Agreement States.<sup>18</sup>

Similar to Canada, the management of these wastes received little attention from policymakers in the first 3 decades of the nuclear era (1945 –1975). During that time, wastes were treated, stored or disposed of with an eye toward convenient, short-term solutions. It was not until the late 1970’s that the federal government allocated substantial funds and personnel to develop a plan for the long-term management of nuclear wastes.

By 1980 the critical necessity to find a permanent solution became apparent for the following reasons<sup>19</sup>:

- There were only three commercial operating low-level disposal sites at Barnwell, South Carolina; Beatty, Nevada; and Hanford, Washington, to serve nuclear power plants, medical and research facilities and other industries. Governors in these States had given notice that they were going to cut back on accepting nuclear waste from outside the State.
- Used nuclear fuel (spent fuel rods) were not being reprocessed and the inventory of spent fuel kept in pools at nuclear power plants was growing and some power plants were running out of capacity, facing possible shut down.
- The future of nuclear power was at stake. The public was increasingly skeptical that methods and materials to contain radioactive waste could endure over the very long time required for nuclear waste to decay. Several states passed laws prohibiting further nuclear power plants until the federal government developed a long term solution to nuclear waste management. Some states restricted or prohibited the storage and disposal of radioactive wastes of any radioactive level within their borders.
- Radioactive wastes leaking from government storage tanks and the dispersal of abandoned uranium mill tailings in the environment added to the public’s fears and distrust of the federal government’s ability to develop and carry out a waste management system that would provide adequate safeguards for both public and environmental health. The public began asking questions such as, “What kind of institutional mechanisms are needed to assure the total isolation of radioactive waste? How much safety is required in the transportation, handling and storage of nuclear waste? Will the federal government deal fairly with the states in site selection? How can the federal government overcome the past legacy of distrust and problems that feed the “not-in-my-backyard” syndrome?”<sup>19</sup>

As a result of these issues in the USA, Congress passed the two major pieces of legislation the Low-level Radioactive Waste Policy Act of 1980 and the Nuclear Waste Policy Act of 1982. Both of these laws stem from the AEA. Together these two laws provided a framework, in

principle, for resolving the above issues related to both low-level and high-level nuclear wastes. However, these laws did not provide answers to the entire range of scientific and technical questions nor did they resolve the more troublesome social, political and institutional issues. The laws did acknowledge the important part that states, local governments, policymakers and citizens must play in resolving the nuclear waste management issue. As noted by the Nuclear Waste Primer, “The challenge to our society is to find ways within the framework of our federal form of government to develop a nuclear waste disposal system that is technically sound and politically and socially acceptable.”<sup>19</sup>

Since the mid 1980’s, the USA has been struggling to obtain approval and to construct new LLRW management facilities. Many states, singly and in combinations referred to as “compacts”, have attempted to site new LLRW management facilities with limited success to date.

After the Low Level Waste Policy Act made states responsible for disposal of their low-level wastes and directed the formation of interstate compacts, the states and compacts spent almost \$600 million in siting efforts. However, no new commercial disposal facilities have been opened in the U.S. since the Envirocare of Utah site opened in 1988. A site in Ward Valley, California was licensed by U.S. Ecology but land transfer issues from the federal to state government effectively blocked that site’s start up. This year (2003) the Texas legislature has recently approved bills to allow commercial waste disposals in that state.

Although the specific reasons for the lack of success vary among compacts and states, there are several common threads. One thread is the controversial nature of nuclear waste disposal, which often manifests itself in the form of skepticism about and/or opposition to disposal facilities by members of the public and political leaders at all levels of government. Also in recent years, the declining volume of NRC Class B and C wastes, the high cost of developing new disposal facilities, and the continued availability of disposal services to most waste generators caused waste generators, compacts, and states to reassess their need for disposal facilities and to defer the development of facilities<sup>20</sup>.

**Comment:** GAO 1999 N/Background/States and compacts

In Canada, radioactive waste is classified according to administrative responsibility. In the USA, radioactive waste is classified on the basis of origin rather than radioactivity or hazard. Generally, the origin of the wastes identifies the administrative responsibility (DOE, NRC, or state). According to the Board on Radioactive Waste Management, of the National Academy of Sciences in Washington, the current systems for regulating this waste lacks overall consistency and as a consequence, waste streams having similar physical, chemical and radiological characteristics may be regulated by different authorities and managed in disparate ways. For instance, some types of naturally occurring radioactive materials (NORM wastes) are not regulated in some states, even though these materials may be more hazardous than some regulated waste streams. Furthermore, current policies have also created significant disparities in options and costs for managing civilian LLRW which have led to uncertainties in future disposal capacity, access to capacity and a significant increase in cost. The picture for defense LLRW, much of which is similar to civilian waste, is very different: there is more than adequate disposal capacity and disposal costs are only a fraction of civilian costs.

For these and other reasons, the Board of Radioactive Waste Management in the USA, which makes recommendations to government, is currently carrying out a study called, “Improving Practices for Regulating and Managing Low-Activity Radioactive Waste”, an interim report that evaluates the current situation due in September of 2003<sup>18</sup>. A final report that assesses and recommends options for improving the system, with emphasis on better risk-informed regulatory and management practices is expected in about one year.

### *France*

In France, radioactive waste is classified according to two criteria:

- Radioactive level. This determines the level of protection required for efficient waste management
- Radioactive half-life. This defines the period of time during which the radioactive waste continues to represent a potential hazard.

Four types of radioactive wastes are recognized in France.

1. Long-lived and high-level waste
2. Short-lived low level and intermediate-level waste
3. Very low-level waste
4. Radiferous and graphite waste

The cut off between short and long-lived radioactive waste is 30 years.

The National Radioactive Waste Management Agency (ANDRA) is responsible for the Aube Center which is the facility for long-term management of low and intermediate-level radioactive waste. ANDRA is financed by the waste generators according to the “polluter pay” principle.

Low and intermediate radioactive waste is placed in surface disposal at the Aube Center Disposal Facility, which houses 90% of the low and intermediate-level waste in France. These wastes are processed into:

- Metallic drums for the least radioactive such as gloves, rags, etc
- Concrete containers for average radioactive wastes
- Concrete boxes containing a metal drum for compacted material and nuclear power plant filters
- Metal boxes for the most voluminous waste such as tubing, scrap metal, etc

Studies for the management of high-level radioactive waste and other material are currently taking place according to the Ongoing Studies Law of 1991.

### *The International Atomic Energy Agency (IAEA)*

IAEA is an independent intergovernmental, science and technology based organization, in the United Nations family that serves as the global focal point for nuclear cooperation.

IAEA assists UN member states, in the context of social and economic goals, in the planning for and using nuclear science and technology for various peaceful purposes including the generation of electricity. The IAEA develop standards and promotes the achievement of a high level of safety in the application of nuclear energy, as well as the protection of human health and the environment against ionizing radiation. The IAEA also verifies through its inspection system that States comply with their commitments under the Non-Proliferation Treaty to use nuclear material and facilities only for peaceful purposes.

The Waste Technology Section is responsible for fostering technology transfer, promoting information exchange and cooperative research and building capacity of member states to manage radioactive waste. The current radioactive waste classification system recommended by IAEA has the following features:

- The basic waste classification system includes a general class of exempt waste, which is defined in terms of a dose to an individual member of the public, resulting from waste disposal, that is regarded as negligible.
- The basic waste classification system does not distinguish between radioactive waste associated with the nuclear fuel cycle and other wastes that is, the fuel cycle and NORM wastes are included in the system.
- High-level radioactive waste is defined in terms of its radiological properties, rather than its source.
- Concentrations of shorter-lived radionuclides in low and intermediate level waste are limited by the criterion on thermal power density (decay heat).
- Some of the definitions are linked to disposal technology.

For a summary of the IAEA radioactive waste classification see Appendix E.

#### *The International Commission on Radiological Protection (ICRP)*

ICRP is an independent registered charity, established to advance for the public benefit the science of radiological protection especially by providing recommendations and guidance on all aspects of protecting against ionizing radiation. The ICRP depends on the scientific prestige of its members and its publications to maintain its status as an internationally recognized authority on radiation protection. In preparing its recommendations, ICRP considers the fundamental principles and quantitative bases upon which appropriate radiation protection measures can be established. It leaves to the various national protection bodies, such as the CNSC and Health Canada, the responsibility of formulating the specific advice, codes of practice or regulations that are best suited to the needs of their individual countries.

While ICRP has no formal power to impose its proposals on anyone, in fact legislation in most countries, including Canada, adheres closely to ICRP recommendations. For instance, the radiation dose limits used by Health Canada and the CNSC for power plant workers of 20 mSv per year and a five year cumulative dose limit of 100 mSv are based on ICRP recommendations.

According to the ICRP web site, a number of reports are currently being prepared and near publication. One may be of interest to NWMO. It deals with “the management of low and

intermediate level radioactive wastes with regards to their chemical toxicity”. The objective of this report is to provide member states with reasonable understanding of the potential for chemically toxic components in radioactive waste and the role that waste treatment and conditioning options can play for safe disposal.

## 6. CONCLUSIONS AND SUMMARY OF KEY ELEMENTS THAT MAY RELATE TO THE MANAGEMENT OF USED NUCLEAR FUEL

### *Conclusions*

In Canada, LLRW is defined by exclusion. If it is not used nuclear fuel or mine and mill tailings, then it is LLRW. Nuclear power station operators also recognized an intermediate level radioactive waste. The definition in the USA is similar. In France, radioactive waste is defined by radioactivity and half-life based on recommendations of the IAEA

The principal legal instruments for LLRW management are:

- The Nuclear Safety and Control Act (NSCA) which established the Canadian Nuclear Safety Commission (CNSC).
- The Nuclear Liability Act which ensures that funds are available to compensate third parties for injuries or damage as a result of a nuclear accident, makes operators absolutely and exclusively liable but limits their liability.
- Regulations established by the CNSC covering all aspects of LLRW from site preparation to decommissioning including the handling, processing, packaging, transporting, storing and long-term management of the waste.
- The Canadian Environmental Assessment Act (CEAA) which may be triggered by the licensing activities of the CNSC, requires the proponent to carry out an EA on the proposed undertaking. The CEA Agency, through its Regional Offices, and the CNSC encourages proponents to carry out the EA early in the planning process. Where a provincial EA process is involved, the federal and provincial processes are harmonized so that one EA is carried out considering blended requirements.
- The Transportation of Dangerous Goods Act and Regulations from Transport Canada is triggered if the LLRW is transported off the owner's site to another facility. The regulation is coordinated with the CNSC regulation relating to packaging of the material for safe transport.
- Various provincial statutes may come into play for the siting and construction of a LLRW facility relating to effects that the facility may have on provincial jurisdiction such as natural resource management, environmental protection and land use. Normally, provincial officials defer all matters radioactive to the CNSC (except NORM) and act in a review capacity to make sure that their mandates are protected.

In Canada, radioactive waste may be divided into four categories based on administrative responsibility for management. The categories are:

- **Used Nuclear Fuel** - high level waste, funded and administered by the producers and owners of the waste such as operators of nuclear power stations under policy established by the federal government and according to the terms of licenses issued by the Canadian Nuclear Safety Commission.
- **Low Level Radioactive Waste** – further classified into:

- **historic waste** - funded by the federal government and administered by the Low Level Radioactive Waste Management Office of Atomic Energy of Canada Limited. The Port Hope Initiative includes 95% of historic LLRW in Canada.
- **on-going waste** - funded and administered by the owners and producers of the wastes such as nuclear power station operators.
- **mine and mill tailings** - while not included in the official definition of LLRW, are a category of LLRW and they are administered separately from other LLRW. They are funded and administered by the owners of the waste. In the case of abandoned tailings in Ontario, where the owners are not available or unable to pay, funding for decommissioning is shared 50/50 between the federal and provincial governments. A similar arrangement is being negotiated with Saskatchewan.
- **Naturally occurring radioactive materials (NORM)** - are also a special kind of LLRW. They are not part of the nuclear fuel cycle, but result from certain industrial activities using naturally radioactive materials. They are administered by the provinces and territories and the owners of the material according to guidelines produced by a federal/ provincial committee and published by Health Canada. When these wastes are transported they are subject to CNSC regulations. Note: the CNSC has changed the name of these materials to “naturally occurring nuclear materials”.

Natural Resources Canada (NRCan) establishes policy related to LLRW management, such as the 1996 policy making the owners and producers of ongoing LLRW, including nuclear power station owners, responsible for funding and managing their radioactive wastes. NRCan also provides an oversight role, funding and policy advice for the historic waste program administered by AECL.

Nuclear Power Station managers have developed their own sub-classification system for the management of LLRW based on radioactivity and half-life according to federal policy and international standards. Specific management practices are carried out for used nuclear fuel, intermediate-level waste and low-level waste. The material is currently stored on their own properties according to the terms of licenses from the CNSC.

The AECL research station at Chalk River, Ontario, accepts LLRW material from the production and use of radioisotopes in research, industry and medicine. They also store LLRW from some of the historic clean-up projects such as Surrey, British Columbia and Port Hope, Ontario.

#### *Key Elements and Lesson Learned from LLRW Management for the Used Nuclear Fuel Program*

Following are some of the key elements and lessons learned that may be helpful to the used nuclear fuel program. These are presented from different perspectives such as legal, radioactivity, approval and licensing activities, LLRW management technology, and facility siting and public consultation.

## Legal Instruments

- Apart from the Nuclear Fuel Waste Act specifically designed to deal with used nuclear fuel (and not discussed in this paper), most of the other legal instruments that apply to LLRW management also apply to high-level waste management. The lessons learned may not be found in the instruments themselves, rather in how the legal and administrative arrangements were carried out by the administrators and waste owners together with the involved stakeholders and the public. This paper has addressed the factual legal and administrative arrangements and noted only a few realities related to their application.
- The preparation of the new regulatory policy, P-290 Managing Radioactive Waste, is currently out for public review. The next step is for the CNSC to prepare the regulatory guide for the management of radioactive waste. In the interim, the NWMO should talk to CNSC staff for advice on the draft principles and expectations for long term management of radioactive waste

## Public Perception of Radiation

- The Siting Task Force recognized that the public tends not to distinguish between different levels of radioactivity. They see exposure as possibly causing health effects, and thus focus on the consequence and not the low probability of a health problem from most LLRW. This may be due to confusion over the classification system, lack of trust in the managers or indifference. The key issue here is the need to work closely with all stakeholders to make sure that facts are clear and the waste management programs and initiatives of the various players are at least coordinated, if not integrated. For instance, discussion of management options for used nuclear fuel with communities where other initiatives are ongoing with respect to the long-term management of LLRW (or even hazardous wastes) can create unnecessary confusion and conflict.

## Approval and Licensing Activities

The Canadian Environmental Assessment process and the CNSC licensing process have become more integrated and open in recent years. This is apparent for the EA processes regarding the Port Hope Initiative being carried out by the LLRW Management Office, in cooperation with the local communities and the Point Lepreau waste facility modification exercise. In the Point Lepreau case, the modification of the waste facility licenses to allow construction of the addition structures triggered an EA under CEAA. The project has also been registered under the New Brunswick EA program, and is totally integrated. For the Port Hope Initiative the provincial EA has been harmonized into the federal EA. Both programs have extensive public and agency consultation, which is now required by legislation. In addition, a number of other nuclear projects, not directly related to LLRW management, have recently gone through or are going through EA processes with extensive public and agency consultation (e.g. Pickering A restart, Bruce A restart, and a series of projects for new construction or expansion of used fuel dry storage facilities at the Pickering, Bruce and Darlington nuclear sites). Thus the agencies and the public would expect a similar approach for the used nuclear fuel management approval process.



## LLRW Management Technology

- Power generating station operators distinguish between different radioactive waste streams based on radioactivity and half-life. These two aspects of the waste are important for deciding on the most appropriate waste management technique for storage and long-term management. At the present time, there is no facility in Canada for long term management of LLRW. OPG has indicated that one option for the long-term management of intermediate level waste (such as ion exchange resins) is co-management with used nuclear fuel pending the NWMO study. However, OPG is currently studying, together with Kincardine, the feasibility of a long-term facility at their Western Waste Management Facility within the Bruce Power Site. Another initiative for long-term management of LLRW is also being considered by AECL. They have proposed an underground facility (IRUS) at Chalk River, which is currently on hold. The NWMO should examine these two initiatives and coordinate closely with the agencies involved when discussing used nuclear fuel, which is also located in the same communities.

## Facility Siting and Public Consultation

The experience and lessons learned from the historic LLRW management programs for the Port Hope/Clarington area, Ontario may be of interest regarding possible facility siting and public consultation for the used nuclear fuel program. These are discussed briefly in Appendix C.

The concerns expressed by the public to the Siting Process Task Force regarding facility siting were:

- consultation is too little too late;
- citizens want some control over what happens in their own community;
- there is a lack of trust of government and experts;
- inequity exists between those who benefit and those who live near the facility;
- opposition often results from the perceived risks and stigma of an unwanted facility.

The Task Force also learned about the value of listening with understanding, putting sound engineering on a level playing field with social and political realities, and jointly exploring issues and options. Such findings have been shared by others involved in facility siting. Research and experience over the last 10 to 15 years has revealed that facility siting processes often failed for three key reasons:

- efforts to engage the public suffered from poor form and format;
- the progressive narrowing of sites to select a preferred site was inherently flawed in that the “preferred community” was excluded from participating in the very decisions which resulted in their being selected causing a “why us” defensive response;
- the processes were top-down exercises focused almost exclusively on getting through the legal and administrative hurdles at the expense of gaining and sustaining public trust and confidence.

These problems are still much in evidence, a phenomenon indicating that there are more deeply rooted barriers to be addressed.

The NWMO would be advised to explore these issues first hand to see if they still apply so that facility siting options can be put forward to the government of Canada that have support of the current stakeholders and interested public.

## APPENDIX A

### GLOSSARY

**Activity (Radioactivity):** The number of nuclear transformations that occur in a quantity of material per unit of time. Unit: becquerel (Bq), 1Bq = 1 disintegration per second.

**ALARA:** A principal of risk management according to which exposures are kept as low as reasonably achievable, economic and social factors being taken into consideration. A guiding principle of radiation protection.

**Alpha Radiation (Alpha Decay):** A high-energy positively charged particle ejected from the nucleus of an unstable (radioactive) atom, consisting of two protons and two neutrons. An alpha particle is a helium nucleus.

**Atom:** The building block of nature, an atom is composed of a nucleus containing protons and neutrons surrounded by orbiting electrons.

**Atomic Number:** The number of protons contained in the nucleus of an atom. This number gives each atom its distinct chemical identity.

**Background Radiation:** The radiation to which an individual is exposed arising from natural radiation sources such as terrestrial radiation from radionuclides in the soil, cosmic radiation from space, and naturally occurring radionuclides deposited in the body from foods, etc.

**Becquerel (Bq):** A SI unit of radioactivity, equivalent to 1 nuclear transformation per second. Used as a measurement of the quantity of a radionuclide since the number of radioactive transformations (disintegration) is directly proportional to the number of atoms of the radionuclide present. Replaces an earlier unit, the curie (Ci).

**Beta Radiation (Beta Decay):** The ejection of a high-energy negatively charged subatomic particle from the nucleus of an unstable atom. A beta particle is identical in mass and charge to an electron.

**Contamination (Radioactive Contamination):** Radioactive material present in excess of natural background quantities in a place where it is not wanted.

**Decay (Radioactive Decay):** A process followed by an unstable nucleus to gain stability by the release of energy in the form of particles and/or electromagnetic radiation. Naturally occurring radioactive materials decay with the release of alpha particles, beta particles and/or gamma photons.

**Decay Series (Radioactive Decay Series):** A succession of radionuclides, each member of which transforms by radioactive decay into the next member until a stable nuclide results. The first member is called the “parent”, the intermediate members are called “progeny” and the final stable member is called the “end product”. For the uranium and thorium series, uranium-238 and thorium-232 are the “parents”, and lead-206 and lead-208 are the “end products”.

**Diffuse NORM:** NORM-contaminated material in which the radioactive concentration is uniformly dispersed. It is generally low in radioactive concentration, and relatively large in volume.

**Discrete NORM:** NORM-contaminated material in which radioactive substances are concentrated, or not uniformly dispersed throughout the material. It generally has much higher levels of radioactive concentration in a localized volume than diffuse NORM.

**Disposal:** The permanent and secure containment of radioactive wastes, with no intention to retrieve them.

**Dose Coefficient (DC):** A factor that relates the amount of radiation dose (Sv) delivered to the body per unit of activity (Becquerel) taken into the body. Unit: (Sv/Bq).

**Dose Constraint:** An upper bound on the annual dose that members of the public or incidentally exposed workers should receive from a planned operation or single source.

**Gamma Radiation (Gamma Rays or Gamma Photons):** Electromagnetic radiation or photon energy emitted from an unstable nucleus in the process of ridding itself of excess energy. Highly penetrating, gamma rays lose energy as they pass through atoms of matter.

**Half-life, Biological:** The time required for the body to eliminate half the quantity of a substance taken into the body. A major factor in determining a radionuclide’s Dose Coefficient.

**Half-life, Radioactive:** The time required for a radioactive material to lose half of its activity through radioactive decay.

**Hazardous waste:** General term describing waste that is deemed to be a hazard to the health of humans or other organisms, due to the presence of radionuclides or hazardous chemicals, to the extent that it must be regulated. Hazardous waste does not include biological, medical, or infectious wastes.

**High-Level Radioactive Waste:** Used nuclear fuel or spent reactor fuel or the highly radioactive liquid which is separated during chemical reprocessing of spent reactor fuel. In Canada reprocessing is not conducted.

**Intermediate-Level Waste:** Waste of a lower activity level and heat output than high-level waste, but which still requires shielding during handling and transportation. In Canada intermediate-level waste is generally included as part of low-level radioactive waste.

**Ion:** An atom that has gained or lost one or more electrons and which thus becomes electrically charged.

**Ionizing Radiation:** Radiation which can deliver energy to matter in a form capable of creating ions.

**Isotope:** Different forms of a single element having identical chemical properties but different masses. Nuclei contain identical numbers of protons but different numbers of neutrons.

**Low Level Radioactive Waste:** Radioactive waste, which is not used nuclear (high-level waste) nor mine tailings.

**Mine Tailings:** Finely ground residues from the processing of ore from uranium mining. Also known as mill tailings.

**Mixed Waste:** Radioactive wastes that also contain components that are regulated as chemical or biological hazards.

**NORM (Naturally Occurring Radioactive Materials):** NORM is an acronym for naturally occurring radioactive materials comprising radioactive elements found in the environment. Long-lived radioactive elements of interest include uranium, thorium and potassium and any of their respective radioactive decay products, such as radium and radon. Some of these elements have always been present in the earth's crust and within the tissues of all living beings. Although the concentration of NORM in most natural substances is low, high concentrations may arise as the result of human activities.

**Nuclear Energy:** The energy liberated by a nuclear reaction. In large-scale nuclear reactors it is created by the fissioning of nuclei of Uranium 235.

**Radioactive Waste:** Any material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than the 'exempt quantities' established by the competent authorities and for which no use is foreseen.

**Radioactivity:** Process in which nuclei spontaneously undergo decay and emit radiation.

**Radionuclide or Radioisotope:** A particular form of an element, characterized by a specific atomic mass and atomic number, whose atomic nucleus is unstable and decays or disintegrates with a statistical probability characterized by its physical half-life.

**Radium-226:** A radioactive element with a half-life of 1600 years. It is a particularly hazardous decay product of natural uranium, and is frequently the dominant NORM nuclide. It decays into the radioactive gas Radon-222.

**Radon:** The only radioactive gas generated during natural radioactive decay processes. Two

radioisotopes of radon are present – radon and thoron – each a decay product of radium. Radon (Rn-222) is found in the uranium decay series while thoron (Rn-220) is found in the thorium decay series.

**Scoping:** An exercise of identification and ranking of the key issues associated with a proposed undertaking.

**Shielding:** The reduction of radiation beam intensity by interposing, between the source and an object or person that might be exposed, a substance that absorbs radiation energy, either by collision, in the case of particulate radiation, or by absorption of waveform energy, in the case of gamma photons.

**Sievert (Sv):** The sievert is the unit of radiation equivalent dose, H that is used for radiation protection purposes, for engineering design criteria and for legal and administrative purposes. The sievert is the SI unit of absorbed radiation dose in living organisms modified by radiation type and tissue weighting factors. The unit of dose for the terms “equivalent dose” and “effective dose”.

**Specific Activity (Radioactive Concentration):** The number of becquerels per unit of mass of a material. Units: Bq/g and kBq/kg.

**Spent Fuel/Used Nuclear Fuel:** Irradiated fuel units not intended for further reactor service.

**Storage or Interim Storage:** Storage of a waste such that isolation, monitoring, environmental protection and human control are provided and subsequent action involving treatment, transport and/or disposal are expected.

## APPENDIX B

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**APPENDIX C - Chronological Events Related to Historic LLRW Management in the Port Hope Area**

Event	LLRW Consequence
1930-32 Mining of Uranium & Thorium Ore & production of concentrate or “yellow cake” begins at Port Radium, Great Bear Lake, Northwest Territories, Canada. Shipped to Port Hope, Ontario to extract radium	Low Level Radioactive material escaped along this Northern Transportation route contaminating local deposits of soil in Northwest Territories and Alberta. Clean up was carried out between 1993 to 1996 by the Low Level Radioactive Waste Management office in cooperation with the local communities. Material is disposed as industrial wastes (has both radioactive and hazardous materials) in designated landfill in Fort McMurray, Alberta, Canada
1932 Eldorado Gold Mines Ltd. opens in Port Hope, Ontario, Canada to refine “yellow cake” concentrate from Port Radium mine to produce radium	At that time, radium was more valuable than gold. During the early years, the process residue was stored on the plant site.
1939 to 1948 Eldorado changes from the recovering of radium to the refining of uranium for nuclear reactors	Eldorado began disposing of process residue in municipal landfill sites and vacant land within the town of Port Hope. The residue contained radioactive and hazardous materials and some radioactive wastes were “intermediate” in activity
1946 the Atomic Energy Control Act was passed	The Atomic Energy Control Board (AECB) was established as a result of the Act to regulate the activities of the Canadian nuclear industry.
1948 to 1954 Eldorado stores residue at company owned site in Hope Township called Welcome Disposal Area.	The residue contains both radioactive and hazardous materials. In 1955, the site was closed by the company following arsenic contamination of a pasture (some cattle died) and a stream adjacent to the property
1955 to 1988 Eldorado disposes of residue at a new site at Port Granby on shore of Lake Ontario	Site is locate on bluffs above Lake Ontario and residents concerned that material leaching into lake
1975 the AECB begins to regulate LLRW	Up to this time, the AECB (now the CNSC) was not involved in any of the above events because it did not begin to regulate LLRW facilities until 1975
1977 the AECB issues the first license to Eldorado for the Port Granby site	In the license, the Board ordered the Company to control ground and surface water and to construct a water treatment facility to help control leachate from the site.

1979 the AECB issues license to Eldorado for Welcome site	The company was given instructions for remedial action at Welcome site, Hope Twp. Ontario.
1980 the AECB directs Eldorado to decommission Port Granby site by 1986	The Board was concerned for the long-term stability of the bluffs, which were eroding, a situation, which would ultimately result in the waste slipping into Lake Ontario.
1982 Low Level Radioactive Waste Management Office is formed	The Canadian Government established the LLRWM Office to cleanup and dispose of the Historic LLRW in Canada 95% of which was in the Port Hope area.
1982 to 1984 Eldorado proposes new sites for LLRW in the Port Hope area	Local citizens become increasingly unhappy with proposed sites by Eldorado for long-term storage of the LLRW.
1984 the Eldorado siting process becomes a federal election campaign issue	Brian Mulroney, then leader of the opposition wrote a letter to a local citizen suggesting that the proposed sites were unacceptable and raised the hopes of the people that the LLRW would be moved well away from their area.
1986 the Canadian Federal Government releases a policy on LLRW management	The policy stated that LLRW would be dealt with so that human health and the environment would be protected now and in the future and that social and economic factors would be taken into account. The policy also detailed a series of corollaries on siting and licensing aspects and on the division of responsibilities between the producers of the wastes and the federal government. At the same time, the government announced that Eldorado would drop from consideration the proposed sites near the Lake Ontario and would seek another site further from the lake.
1986 the federal Minister of the Environment announces Panel to Review the plans for clean up and disposal of LLRW in Port Hope Area.	The Panel was to carry out a public review of both Eldorado's siting proposals to move and dispose of the Welcome and Port Granby deposits and that of the LLRWM Office for clean-up and disposal of the contaminated soils in Port Hope.
1986 Eldorado announces that had taken options on two sites	The new sites were more than 10 km from the Lake and on Class 1 Agricultural land. The neighbours were so upset and their opposition so vehement that the federal government was forced to reconsider the issue. Because of the ill-will generated in the Port Hope area, a decision was made to widen the area of search for an acceptable site and to

	change the siting process.
1986 the Canadian Government stops Environmental Assessment and orders Eldorado to stop assessment work on the proposed sites	As well as stop plans for long-term disposal of the LLRW in the area, the government announced that they would set up a task force to advise the government on a less confrontational and more cooperative siting process.
1986 the Canadian Government announces the appointment of a 7 member independent Siting Process Task Force	The Siting Process Task Force was charged with assessing the most suitable technologies for LLRW disposal, the areas in the provinces with the best potential to use these technologies and the most promising approaches to site selection.
1987 the Siting Process Task Force delivers its report to the federal government entitled "Opting for Cooperation"	After 8 months of intensive public consultation and round table discussions with a wide range of stakeholders, municipal officials, interest groups and concerned citizens, the Task Force published the cooperative siting process which was publicly derived and featured 5 principle and 5 safeguards. Throughout its work the Task Force recognized that "social and political issues involved in siting activities can be pivotal and are often more difficult to resolve than technical issues."
1988 the Canadian Government announces the appointment of a second Siting Task Force to carry out the first 3 phases of the 5 phase cooperative process	Five of the members of the original Siting Process Task Force were re-appointed together with one new member.
1990 the Siting Task Force delivers report on the first three phases of the cooperative siting process	After intensive public and community consultation throughout Ontario, the Task Force recommends that 3 Volunteer Communities and 3 Source Communities continue with balance of siting process. The Task Force saw this as a positive step. Previously the LLRW source communities of Port Hope, Hope Township and Newcastle had been demanding that the LLRW be removed from their communities. After participating in the cooperative process they now indicated a willingness to continue with the next steps. They had not volunteered for a local solution but the door was now open for that possibility.
1991-92 the Canadian Government appointed a third Siting Task Force to continue with the final stages of the cooperative siting process	A new Task Force was appointed to continue with the cooperative siting process with the 6 communities interested in proceeding to phase 4 concerning project assessment.

<p>1996 the Task Force terminates further implementation of the cooperative siting process</p>	<p>From 1992 to 1996 each of the volunteer communities opted out of the process with Deep River the last one to leave. Attempts to have a community volunteer to accept a LLRW facility to dispose of the Port Hope Area wastes were terminated. It was clear that no community was willing to accept the waste thus a local solution began to emerge.</p>
<p>1997 Hope Township initiates a community proposal to construct a long-term waste management facility</p>	<p>Hope Township (now part of Port Hope) recognized the need to carry out remedial work on the Welcome site which could become the long-term facility for that material</p>
<p>1998 the municipalities of Port Hope and Clarington initiate community proposals to construct a long-term waste management facility in their respective communities</p>	<p>Port Hope and Clarington follows Hope Township lead and offer to develop a local solution. Each of the 3 communities agreed to deal with their own wastes but not a central facility that would take all the LLRW in the Port Hope area</p>
<p>2000 the Principles of understanding among the Canadian government, the LLRWM Office and the Port Hope Area communities initiated</p>	<p>The LLRWM Office sets up an office in Port Hope to collaborate with the communities during the process.</p>
<p>2001 the Legal Agreement between the federal government and the communities</p>	<p>The Port Hope Area initiative begins. The agreement includes 260 million dollars for the project and 30 million is taken out and given to communities equally as “host community fee”. A property value protection program is also provided.</p>
<p>2002 the Environmental Assessment begins</p>	<p>Currently the environmental assessment stage has begun and if approved, the facilities will be constructed and clean up estimated to be completed by 2011.</p>

## **APPENDIX D - The Siting Task Force on Low-level Radioactive Waste Management-1987 to 1990**

Note: The following observations are summarized from two papers. The first paper was prepared by Mr. Paul Rennick, Chair of the Siting Task Force and Dr. Audrey Armour, member of the Siting Task Force in 1990 and presented by Mr. Rennick at the Radioactive Waste Management Conference in Tucson, Arizona. The second paper was prepared by the same authors in 1992 and presented by Mr. Rennick at the Third Annual International High Level Radioactive Waste Management Conference in Las Vegas, Nevada.

Throughout its work, the Task Force recognized that social and political issues involved in siting activities can be pivotal and are often more difficult to resolve than technical issues. For this reason, members made it one of their primary objectives to better understand the perspectives of those concerned with or affected by siting processes. In preparation for designing a less confrontational and more cooperative process, one-on-one discussions, workshops and site visits were carried out with a broad range of citizens, municipal officials, regulators, experts and public interest groups. Here is what the Task Force heard:

- Consultation is too, little too late
- Citizens want some control over what happens in their own community
- There is a lack of trust of government and experts
- Inequity exists between those who benefit and from those who live near the facility
- Opposition often results from the perceived risks and stigma of an unwanted facility

The Task Force also discovered that public involvement in the assessment and management of environmental impacts and socio-economic concerns was often relegated to a secondary level of importance. Typically, proponents conducted feasibility studies with limited public involvement, decided on a course of action and then made a public announcement. Proponents who follow this approach found themselves in a position of having to defend the decision in the face of public hostility. This approach has been suitably characterized as the “decide, announce, defend” (DAD) syndrome.

In designing a new, more cooperative siting process, the Task Force recognized the need to move away from top-down technocratic decision making and to give interested communities more control over facility planning and decision-making so their needs and concerns have priority in the siting process. The cooperative process was publicly designed by the Task Force and differs from the conventional siting process in that socio-economic issues were addressed from the beginning, before expensive site characterization began, and were resolved jointly through a consensus building approach with the community.

In December of 1987, the Task Force published its report, entitled “Opting for Cooperation”. The cooperative siting process consisted of five phases, including:

1. Establish Task Force and Basic Guidelines
2. Regional Information Sessions and Expression of Continuing Interest
3. Community Information & Consultation and Council Resolution for Continued Interest
4. Project Assessment and Community Acceptance Poll

## 5. Negotiations & Agreements for Implementation, Council Endorsement, Cabinet Decision leading to Design, Construction and Operations

It defined five principles and five safeguards as the cornerstones of the cooperative process as follows:

### Principles

- **The community should volunteer and have the right to opt out of the process at any time, rather than be selected by the project sponsor at its discretion.** This principle aimed to move the process away from the approach of imposing a technical decision on a community and the DAD syndrome, which was seen by the Task Force as inherently confrontational.
- **The community should be a partner in problem solving and decision-making throughout the process.** The aim of the Task Force was to ensure that any community that expressed an interest in participating in the process maintained a strong element of control in the process.
- **The community should receive compensation to offset residual impacts and to enhance local benefits.** The Task Force believed that it was fair to compensate the community for inequities in the distribution of costs and benefits.
- **The community should have the right to select, from given technical options and impact management measures, the ones that are acceptable to it.** The Task Force wanted to ensure that technical and impact management decisions were fully responsive to the community's needs and preferences.
- **The Siting Task Force responsible for the implementation of the process must ensure that the safety of the environment and human health are not compromised for any reason.** The overall aim of the process was to make the facility siting more cooperative but not at any cost.

### Safeguards

- **An explicit, up-front impact management policy will be used to ensure that all communities are aware of the range of options available to them.** This safeguard was intended to ensure from the outset that all communities interested in participating for the facility are equally and fully informed about the kinds of compensation and other impact management measures available to them
- **Community-selected advisors will be employed to ensure that local interests are protected in the process of joint fact-finding and problem solving.** The Task Force held that no community should be disadvantaged due to lack of sufficient advice nor should they be compelled to use consultants whom they felt may not represent their interests
- **Thorough site and technology assessment designed jointly by the community, the Siting Task Force and technical experts, will be carried out to ensure that decisions are based on full information.** The Task Force wanted to ensure that decisions were based on "informed consent" and full information about positive and negative implications of the facility.
- **A broad-based Community Liaison Group will be established to work with the Siting Task Force and local officials.** The Task Force determined that, while

Municipal Council is the decision-maker of record for the community, a Community Liaison Group, independent of Council, should be established and funded by the STF to facilitate information sharing, consultation and to determine consensus.

- **Funding will be provided to allow for community participation in the process.** Funds were provided for such things as a local office, secretarial support, photo copying and mailing.

Needless to say, the selection of a Community Liaison Group was a sensitive issue. It was argued that if it were independent of the elected Municipal Council, questions of legitimacy (who speaks for the community?) would arise. But by the same token, if it is selected by the Council, which is often elected by a minority of the eligible electorate, it can be seen as the voice of the establishment. The Task Force's approach to this issue was to make sure that the CLG's gave regular reports to their municipal councils, held all of their meetings in a public forum, and kept full records (including video tapes) of all meetings.

These principles and safeguards were reported in "Opting for Cooperation" and approved by Federal Cabinet in the summer of 1988. On September 30, 1988, the Minister of the then Energy, Mines and Resources (now Natural Resources Canada) announced the establishment of a second Task Force to initiate the first three phases of the cooperative process. In the news release the Minister said:

"I believe that such a socially responsible approach to facility siting will encourage communities to participate in the process. Since the process is entirely voluntary and no community will be selected against its wishes, I believe communities will want to be informed about the siting process, its principles and safeguards, and the role which they could have in the solution."

In August of 1990, the second Siting Task Force (5 of the original members were re-appointed and one new member added) reported their findings at the end of Phase Three of the five-phase process. They recommended that 3 volunteer communities remain in the process and reported that the LLRW source communities of Port Hope, Hope Township and Newcastle (now Port Hope and Clarington) had also passed resolutions of council to remain in the process. The Task Force considered the continued participation of the LLRW source communities in the process as a positive achievement. Prior to the implementation of the cooperative process, these communities had been demanding that the LLRW be cleaned up and taken far away from their communities. There now appeared to be some interest in a local solution.

However, the federal government chose to give emphasis to the three potential volunteer communities. It appointed a third Task Force, with all new members, to continue with the Phase Four of the process. In the end, the Deep River community chose to enter into negotiations with the Federal Government on terms and conditions under which it would volunteer. Unfortunately, a mutually satisfactory agreement could not be reached and Deep River opted out of the process in 1996.

Faced with this outcome, the LLRW source communities fell back on their only option, which was to find a local solution.

The citizens of Port Hope/Clarington had undergone a long struggle since the early 1980's to have their community cleaned up in a socially responsible and technically safe manner. In 2001, the communities entered into a Legal Agreement with the federal government to clean up the LLRW and place it in above ground mounds licensed by the CNSC in an environmentally safe manner. An environmental assessment, which began in 2002, is currently taking place, and if approved, will result in a preferred waste management option, followed by facility design, licensing and clean-up by 2011.

In 1992, Mr. Rennick, who had served as Chairperson of the Siting Task Force during Phase 3, presented a plenary address at the Third Annual International High Level Radioactive Waste Management Conference, in Las Vegas, Nevada, USA. Some of the lessons learned by the Siting Task Force, which he discussed at that time, may still be relevant for the siting of a used nuclear fuel facility. These are listed as follows:

- If the cooperative approach to facility siting is to be successful, we must all learn to listen to each other with understanding and then act accordingly.
- The cooperative approach does not replace sound engineering and environmental assessment. On the contrary, the cooperative approach demands superb engineering and science and assurances that health and safety will not be compromised
- What the cooperative approach does, however, is turn the traditional technically driven approach upside down and place it on a level playing field with social and political realities
- It replaces top-down decision making with joint exploration and shared decision making

The so-called NIMBY (not-in-my-back-yard) syndrome is too simple a characterization of public opposition to facility siting. It is out there but for the most part the NIMBY characterization of public reactions is based on simplistic assumptions about the nature of public response. The most common reasons for public opposition can be grouped as (a) flawed process, (b) substantive technical concerns, and (c) hidden agendas and old scores to settle.

With respect to "flawed process" following are some of the process problems experienced over the last 15 years from a wide range of facility siting processes:

- It's our agenda – rather than mutually exploring the issues
- It's the big picture that counts – greatest good for the greatest number ethic – personal effect on ones family and property count for nothing
- Going to the public too late – gives the appearance that decision already made (and it usually has been)
- Poor form – unwillingness to treat public with courtesy and with integrity
- Poor format – lack of skill by the proponent to facilitate productive discussion and use basic conflict resolution skills
- It's just a requirement – only do the minimum public involvement – tokenism - a public relations event
- The bunker mentality – defend against attack – the legal approach
- The hard sell – lack of public feedback and action - undermines credibility
- Leave it to the Hearing – rather than resolve conflicts as they arise



**APPENDIX E - Summary of characteristics of radioactive wastes and disposal options in waste system currently recommended by IAEA.**

<b>Class</b>	<b>Waste Characteristics</b>	<b>Disposal Options</b>
Exempt Waste	Concentrations of radionuclides at or below levels corresponding to annual dose to members of the public from waste disposal of 10 $\mu$ Sv	No radiological restrictions
Low- and intermediate-level waste	Concentrations of radionuclides above exempt levels and thermal power density less than about 2kW m <sup>-3</sup>	
Short-lived waste <sup>a</sup>	Concentrations of long-lived, alpha-emitting radionuclides restricted to 4kBq g <sup>-1</sup> in individual waste packages and average of 0.4 kBq g <sup>-1</sup> over all waste packages	Near-surface disposal system or geologic repository <sup>b</sup>
Long-lived waste	Concentrations of long-lived, alpha-emitting radionuclides that exceed restrictions for short-lived waste	Geologic repository
High-level waste	Thermal power density greater than about 2 kW m <sup>-3</sup> and concentrations of long-lived, alpha-emitting radionuclides that exceed restrictions for short-lived waste	Geologic repository
Waste that contains long-lived, naturally occurring radionuclides <sup>c</sup>	Contains uranium, thorium, or radium; generated in mining and milling of ores or similar activities, or decommissioning of nuclear facilities <sup>d</sup>	No radiological restrictions or systems similar to those for short-lived waste <sup>e</sup>

- a Distinction between short- and long-lived radionuclides is half-life of about 30 y.
- b Range of disposal options may be acceptable, due to variety of radionuclides and wide range of concentrations that may be present.
- c Waste is not part of basic waste classification system, but large volumes of waste that contains long-lived, naturally occurring radionuclides are given additional consideration.
- d Waste from decommissioning also may contain man-made radionuclides.
- e Disposal option would depend on results of safety assessments for particular wastes.