

Regulatory Challenges in the Age of Nuclear Waste and Decommissioning

A Report by Gordon Edwards, Ph.D.,

Commissioned by the Concerned Citizens of Renfrew County & Area

Funded by the Canadian Nuclear Safety Commission (CNSC)

October 7 2019

Executive Summary

This report was prepared for the Concerned Citizens of Renfrew County and Area (CCRCA) through a grant from the Canadian Nuclear Safety Commission's Participant Funding Program.

The present report is intended to link two documents, the **Integrated Waste Strategy** issuing from Canadian Nuclear Laboratories (CNL) in April 2017 and the **Regulatory Oversight Report for Canadian Nuclear Laboratories' Sites: 2018**, issuing from the Canadian Nuclear Safety Commission (CNSC) in September 2019.

Under the terms of the funding agreement, the participant is instructed to “*review the Regulatory Oversight Report for Canadian Nuclear Laboratories Sites: 2018 and prepare a report on CNL's Integrated Waste Strategy that examines issues such as the consolidation of high, intermediate, and low-level radioactive waste at Chalk River Laboratories, as well as waste characterization and analysis, packaging, labeling, and transport considerations,*” and to “*Summarize the findings and recommendations in a written report to be submitted to the Commission.*”

CNL's Integrated Waste Strategy was first expounded in an April 2017 document entitled Canadian Nuclear Laboratories Integrated Waste Strategy, Summary Document, Company Wide, CW-508600-PLA-006, Revision 0, henceforth referred to as the **Integrated Waste Strategy**. This CNL document, published 19 months after the consortium of private companies that now owns and operates CNL was awarded the contract to manage federal nuclear properties, represents a radical departure from radioactive waste practices and strategies previously espoused by Atomic Energy of Canada (AECL).

Nevertheless, the CNL strategy document has received little discussion, debate or circulation. Most members of the public, including elected representatives, seem to be ignorant of its existence.

Surprisingly, the recently released CNSC Regulatory Oversight Report does not mention “CNL's Integrated Waste Strategy” at all. Nor does the Oversight Report discuss the “*consolidation of high, intermediate, and low-level waste at Chalk River Laboratories*” referred to in the funding agreement, nor does it discuss the extensive transport of radioactive materials of all kinds that has been, is, and will be taking place over public roads and bridges in order to achieve the “consolidation” of radioactive waste at Chalk River Laboratories.

One is tempted to conclude that any attempt to review the Regulatory Oversight Report in the light of the Integrated Waste Strategy would be futile, since the Oversight Report does not cite the Strategy document; however, CNSC has funded the present report explicitly on those terms. Of necessity, then, this report deals with much content that is completely missing from the Regulatory Oversight Report. *A list of recommendations is found on the following three pages.*

Gordon Edwards, Ph.D., October 7, 2019

List of Recommendations

- 1. that CNSC not receive, accept or circulate for public comment any draft proposal for a nuclear waste “disposal” facility or a decommissioning project that is clearly at odds with international guidance;**
- 2. that CNSC reject the proposed entombment of two nuclear reactors at Whiteshell and at Rolphton, unless the proponent can demonstrate that it is not possible to carry out the original and already approved strategy of dismantling the two reactor structures, removing radioactive materials off-site, and returning both sites to “green field” status;**
- 3. that CNSC require that a complete list of radionuclides involved in any waste management, transportation or decommissioning scenario, complete with half-lives, activities (total becquerels as well as becquerels per kilogram or per litre), mode of disintegration, radioactive progeny and target organs, be provided by the proponent;**
- 4. that all information about the radioactive inventory involved in any such scenario be communicated to indigenous peoples and to other members of the Canadian public in plain language stripped of scientific symbols and abbreviations;**
- 5. that CNSC not accept the emplacement of any intermediate-level waste in any surface or near-surface radioactive waste facility;**
- 6. that CNSC not accept the emplacement of any measurable amounts of transuranic waste in any surface or near-surface facility;**
- 7. that CNSC ensure that the necessary laboratory tests are carried out on each batch of decommissioning waste to detect the presence of transuranic contamination;**
- 8. that CNSC not accept the emplacement of any measurable quantities of radioactive carbon-14 in any surface or near-surface facility, given its 5700 year half-life and its exceptional environmental mobility as radioactive carbon dioxide or carbonic acid;**
- 9. that CNSC ensure that no ion-exchange resins be emplaced in any surface or near-surface radioactive waste facility (among other reasons, the fact that carbon-14 contamination is almost always found in such resins);**

10. that CNSC reconsider its opposition to the mandatory environmental assessment of new nuclear reactors and recommend that such assessments be required;
11. that CNSC require any proponent of a facility for permanent storage of radioactive waste to propose and prepare a comprehensive strategy for the transmission of RK&M (Records, Knowledge and Memory on Radioactive Waste) to future generations, including a detailed inventory of specific radionuclides included in the proposed facility along with relevant physical, chemical and biological properties ;
12. that CNSC require any proponent of a facility for permanent storage of radioactive wastes to provide detailed instructions as to how the wastes can be retrieved and repackaged if need be at some future date, and failing the provision of those instructions, approval for the project be withheld.
13. that CNSC require any proponent of a facility for permanent storage of radioactive waste to examine the option of Rolling Stewardship as an alternative to abandonment ;
14. that CNSC request the government of Canada to formulate a socially acceptable policy on the long-term management of radioactive wastes other than used nuclear fuel, based on extensive public consultations with First Nations and other Canadians.
15. that CNSC establish a new set of regulations governing the transport of radioactive waste, including requirements for justification and discussion of alternatives ;
16. that CNSC withhold approval for the transportation of radioactive wastes over public roads unless the proponent of such transport can show a demonstrable improvement in security and environmental protection as a result of such transport;
17. that CNSC send a correction to the Ontario Office of the Fire Marshal and Emergency Management giving the true radioactive inventory of the Chalk River liquid being transported over Ontario roads and clarifying the danger following a potential spill;
18. that CNSC staff recalculate and publish the amount of drinking water that could be ruined if accidentally contaminated with various quantities of high-level radioactive liquid waste currently being trucked from Chalk River to South Carolina;

- 19. that CNSC not permit the transport of irradiated fuel from other CNL sites to the Chalk River site unless CNL presents an irrefutable safety case for doing so;**
- 20. that CNSC initiate a consultation process to develop a new classification scheme for radioactive waste materials based on health and environmental considerations rather than ease of handling;**
- 21. that CNSC require a thorough manifest of radionuclides, complete with half-lives, activity levels in becquerels, and type of radioactive emission, to accompany every shipment of radioactive waste material, easily accessible for use by first responders;**
- 22. that CNSC develop an entire suite of regulations focused exclusively on radioactive wastes, concentrating on questions of waste characterization, hazard analysis, packaging, labeling, and transport requirements.**

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A List of Organizations and Acronyms

CNL = Canadian Nuclear Laboratories, owned and operated by a consortium of multinational corporations (SNC-Lavalin, Fluor and Jacobs), contracted by the Harper government in September 2015 to reduce the federal government's \$7.9 billion radioactive waste liability;

CNL Sites: Since 2015, CNL manages the following federally-owned nuclear sites – CRL (Chalk River Laboratories), WL (Whiteshell Laboratories), DP (Douglas Point Nuclear Reactor), G-1 (Gentilly-1 Nuclear Reactor), NPD (Nuclear Power Demonstration Reactor), PH (Port Hope Legacy Radioactive Wastes), PG (Port Granby Legacy Radioactive Wastes).

AECL = Atomic Energy of Canada Limited, a federal crown corporation to whom CNL reports and from whom CNL is allocated annual federal funding; AECL was previously responsible for all of the sites and radioactive wastes now under the management of CNL;

CNSC = Canadian Nuclear Safety Commission, Canada's nuclear regulatory agency;

CRL = Chalk River Laboratories, Canada's main federal nuclear research centre since its construction was first authorized in Washington DC in December 1944.

WL = Whiteshell Research Laboratories, Canada's second federal nuclear research centre, sited at Pinawa, Manitoba, in operation from 1960 to 1998, now being decommissioned;

HLW = **High-Level Radioactive Waste**, a term reserved for irradiated nuclear fuel, whether in solid form [fuel assemblies or fuel bundles] or liquid form [post-reprocessing high-level waste];

ILW = **Intermediate-Level Radioactive Waste**, radioactive waste that requires shielding or remote manipulation as well as radioactive waste having exceptionally long half-lives;

LLW = **Low-Level Radioactive Waste**, radioactive waste that can be handled without special protection or remote manipulation (but radiotoxic when inhaled or ingested);

ROR = CNSC's **Regulatory Oversight Report for CNL Sites: 2018**, a report by CNSC staff on the agency's activities at CNL sites during the calendar year 2018;

IWS = **Integrated Waste Strategy**, an internal document written by and for CNL staff;

CCRCA = Concerned Citizens of Renfrew County and Area, a public interest organization that asked for and was granted "Participant Funding" by CNSC to comment on ROR & IWS;

EIS = Environmental Impact Study, prepared by the proponent of a project that is undergoing an assessment by the CNSC in accordance with the 2012 Environmental Assessment Act.

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Introduction

The Canadian Nuclear Safety Commission (CNSC) has published a **Regulatory Oversight Report for Canadian Nuclear Laboratory (CNL) Sites: 2018**. The Oversight Report summarizes the activities of CNSC staff at the seven sites where federally-owned radioactive wastes are situated. Since September 2015, the management of Canada's federal radioactive waste liability, estimated at \$7.9 billion by the Auditor General of Canada, has been entrusted to Canadian Nuclear Laboratories (CNL) – a privately-owned company that is contracted and funded by the Canadian government through the Crown Corporation Atomic Energy of Canada Limited (AECL). AECL remains the sole owner of all federal radioactive waste.

CNL is owned and operated by a consortium of multinational corporations, currently comprising SNC-Lavalin, Fluor, and Jacobs. In April 2017, 19 months after being awarded the contract to manage Canada's federally-owned radioactive wastes, the CNL consortium produced an **Integrated Waste Strategy** (IWS) document, of which a summary is publicly available. The full document had to be obtained through Access to Information. The Waste Strategy document delineates CNL's business-like plans to deal with the federal radioactive waste legacy in a “timely” and “cost-effective” manner, as stipulated in the contract it signed with the Harper government shortly before the 2015 federal election.

The main features of the strategy involve: (1) building a gigantic engineered mound containing up to one million cubic metres of radioactive waste, right on the surface, less than one kilometre from the Ottawa River; (2) entombing two defunct nuclear reactors by simply grouting them in place rather than dismantling the radioactive structures, and (3) centralizing most federally-owned radioactive waste at one site, namely Chalk River Laboratories (CRL). The centralization of waste at CRL is considered of great importance, as we read:

“A key constraint and dependency to the CNL strategy is the packaging and transportation of waste. . . . In the near term, this has been identified as of particular importance for transferring radioactive waste from WL [Whiteshell] to CRL [Chalk River] for storage and/or disposal, where stakeholder issues and logistics have not yet been fully developed and agreed.”

Integrated Waste Strategy, p. 3-10

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According to documents obtained through Access to Information, by the end of 2018

- 3000 tonnes of nuclear waste had already been trucked from Whiteshell to Chalk River (CRL);
- 200 tonnes of nuclear waste had already been trucked from Gentilly-1 in Quebec to CRL;
- smaller amounts of nuclear waste had already been trucked to CNL from the Douglas Point Reactor, at Kincardine, Ontario; from the Nuclear Power Demonstration Plant, at Rolphton Ontario; and from Port Hope, Ontario (Legacy Radioactive Wastes from uranium processing).

Surprisingly, the CNSC Oversight Report does not even mention CNL's Integrated Waste Strategy – not even once. Nor does that Report discuss the “consolidation of high, intermediate, and low-level waste at Chalk River Laboratories” referred to in the CNSC funding agreement that led to the present report, nor does it discuss the extensive transport of radioactive materials of all kinds that has been, is, and will be taking place over public roads and bridges in order to achieve the aforementioned “consolidation” of radioactive waste at Chalk River Laboratories. Accordingly, one is tempted to conclude that any attempt to review the Regulatory Oversight Report in the light of the Integrated Waste Strategy would be a hopeless task; however, CNSC funded the present report explicitly on those terms. Of necessity, then, the present report deals with much content that is missing from the Regulatory Oversight Report.

The two documents, the **Regulatory Oversight Report** and the **Integrated Waste Strategy**, are totally different in tone as well as content. The Oversight Report reads like a calm methodical “business as usual” document, in which staff

- (1) uses the “safety and control area framework “ to assess CNL's performance and
- (2) reports on CNSC's own public information and community engagement efforts.

In the Oversight Report, we read that routine inspections are made, existing regulations are enforced, standard reports are prepared, action items are noted, and the overall safety of the ongoing operations is repeatedly emphasized: “CNSC staff confirm that in 2018, CNL sites continued to perform licensed activities safely.” The message is that everything is proceeding as one would expect, and regulatory actions are much the same as they have ever been. Everyone goes about their business as usual without major disruptions.

The Integrated Waste Strategy document has a very different tone. Everything is in motion. Things are being turned upside down and inside out. Nothing remains as it is. Radioactive and non-radioactive toxic waste of all kinds are being prepared for “disposal”.

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Prior to disposal the vast majority of such waste will be packaged and transported to one centralized site: the Chalk River Laboratories (CRL) site, on the Ontario side of the Ottawa River, about 250 kilometres upstream from the nation's capital. Meanwhile, decommissioning activities will be accelerated. In fact, accelerated decommissioning is already well underway at the Whiteshell Laboratories in Manitoba and the Chalk River Laboratories in Ontario..

On the first page of the Integrated Waste Strategy (p. 1-1) we read that CNL's plan *“focuses on the management of wastes using a lifecycle (cradle to grave) approach.”* All CNL managed radioactive and non-radioactive waste streams will be addressed in the context of *“the full waste management lifecycle including pretreatment, treatment, storage, transport and disposal.”* These activities will be integrated and aligned with *“CNL's primary business missions, including lifecycle cost optimization”*. CNL's clearly stated primary objective to cut costs poses a challenge to any regulatory body that says it will *“never compromise safety”*.

In Table I (p. 1-1) of the Integrated Strategy document, we learn that the lifecycle approach will be applied to every waste form at all CNL sites, whether it is radioactive waste (high-level, intermediate-level or low-level), or mixed and hazardous waste (non-radioactive toxic materials mixed or not with radioactive materials). According to the CNL strategy, all high-level waste (irradiated nuclear fuel) will be moved to CRL. All intermediate-level waste will be packaged in “safe, secure, suitable storage facilities” awaiting “disposal”, and either transported to CRL or processed in situ. Solid low-level waste will be managed “to support the CNL mission, including accelerated decommissioning”. This curious phrasing fosters a misleading impression that all decommissioning debris is necessarily “low-level” waste.

Given the dramatic changes occurring at all CNL properties, given CNL's preoccupation with cost reduction, given the extensive transportation requirements envisaged by CNL, and given the fact that all categories of radioactive and non-radioactive toxic wastes are being prepared for “disposal” – a permanent waste management option that ultimately entails abandonment of the radioactive and non-radioactive toxic materials in question – it is surprising that there is no indication in the Integrated Waste Strategy document or the Regulatory Oversight Report that these activities require or are subject to any specific set of regulatory actions or approvals. In particular, it is unclear what authorization was sought or granted for the truckloads of radioactive waste already delivered.

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It appears that CNSC is simply not focussing on the new reality laid out in the Integrated Waste Strategy document, which cries out for a whole new set of regulatory mechanisms regarding the classification, segregation, packaging, labelling, and transport of radioactive wastes, including the radioactive waste arising from dismantling contaminated buildings and decommissioning nuclear reactors, and the permanent emplacement and ultimate abandonment of such waste. Lack of adequate attention to these issues in the Oversight Report suggests that a thorough rethinking and expansion of the existing CNSC regulatory framework is needed for the regulator to confront these formidable changes and challenges.

But such action is not indicated. The lack of initiative, imagination, or even interest on the part of CNSC seems out of keeping with the regulator's legislated mandate to protect the health and safety of Canadians and the environment, and to disseminate objective information to the public about the nature of radiological risks from CNSC licensed facilities.

Accelerated decommissioning, for example, is projected by CNL to launch two thousand additional truckloads of radioactive wastes en route to Chalk River, passing through hundreds of communities along the way. About 500 of these truckloads will be so intensely radioactive that the surfaces of the truck will have to be shielded to provide some radiation protection for the driver, passengers in other vehicles, and bystanders along the route. But transport of radioactive waste is not a topic that is discussed or detailed in the CNSC Oversight Report.

The abandonment of long-lived human-made radioactive wastes is being planned for the first time at several sites (CRL, WL and NPD), but the Oversight Report makes no comment on these developments. One wonders what efforts, if any, have been made by CNSC to provide objective scientific information to the public on the contents, implications and challenges of the Integrated Waste Strategy, or the degree of regulatory involvement, or the nature of the wastes being shipped, or any of the other ambitious plans that are afoot.

We are at the dawn of a new era, the Age of Nuclear Waste and Decommissioning, and it behooves CNSC to act accordingly. Never before in Canada has permission been sought to permanently abandon post-fission radioactive wastes in an engineered repository of any kind. Radioactive waste materials cannot be eliminated or destroyed by any conventional means. Yet abandonment of such wastes ultimately entails a transference of responsibility from the nuclear establishment to society at large. For this reason, the Canadian public will want to become involved in nuclear decisions more than ever before.

Radioactivity is a form of nuclear energy that cannot be turned off. Although the ionizing energy emitted by a given radioactive element will diminish over time, the potential danger can endure for thousands or millions of years depending on the half-life of the material.

Example: In-situ decommissioning of WR-1 and NPD

Consider, for example, the radioactive remains of the Whiteshell WR-1 reactor (in Manitoba) and the NPD reactor (at Rolphton, Ontario). Before the CNL contract came into force in 2015, decommissioning plans for WR-1 and NPD had already been approved by CNSC. These plans involved carefully dismantling the radioactive structures, packaging all radioactive and non-radioactive toxic materials in robust containers and removing them from the reactor sites, then decontaminating those sites and returning them to “green field” status.

But in the Integrated Waste Strategy, CNL changes direction abruptly, declaring its intention to opt for “in-situ decommissioning” for both of these federally-owned reactors. CNL's plan involves the permanent grouting of these radioactive remains using cement, after dumping all the dangerous above-ground materials into the subterranean basement of the building.

While the CNSC's Oversight Report acknowledges CNL's intent to change the WR-1 and NPD decommissioning plans from dismantlement to the less costly “in-situ decommissioning” (i.e. entombment), the Report makes no mention of the fact that the International Atomic Energy Agency (IAEA) has explicitly warned that such an approach is not acceptable except under extreme circumstances; for example, the aftermath of a major reactor accident might make dismantling of the structure extraordinarily difficult or impossible.

Entombment. The encasing of part or all of a facility in a structure of long lived material for the purposes of decommissioning. Entombment is not considered an acceptable strategy for decommissioning a facility following planned permanent shutdown. Entombment may be considered acceptable only under exceptional circumstances (e.g. following a severe accident). In this case, the entombment structure is maintained and surveillance is continued...

from the IAEA Glossary, under “Decommissioning”

The question arises, how long will the entombed structure remain dangerous? In the draft Environmental Impact Statement (EIS) for the proposed WR-1 entombment, after searching in vain for some type of definitive radioactive inventory data, we encountered the following table:

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Table 7.2.1-1: Radionuclides Associated with Main Systems and Components of WR-1

| <u>System/Component</u> | <u>Radionuclide</u> |
|-----------------------------|--|
| Reactor Core | Carbon-14, Iron-55, Cobalt-60, Nickel-59, Nickel-63, Niobium-94 |
| Primary Heat Transport | Cesium-137, Strontium-90, Cobalt-60, (small amounts of Niobium-94, Zirconium-95, Antimony-125, Europium-152, Radon-226, Americium-241, Isotopic Plutonium, Technetium-99, Iodine-129, Curium-244 |
| Biological Shield | Carbon-14, Chlorine-36, Calcium-41, Nickel-63, Cobalt-60, Europium-152 |
| Heavy Water & Helium System | Tritium, Carbon-14 |
| Corrosion products | Carbon-14, Chlorine-36, Iron-55, Nickel-63, Nickel-59, Cobalt-60, Niobium-94 |
| Surface contamination | Cesium-137, Strontium-90, Isotopic Plutonium, Americium-241 |

The WR-1 draft Environmental Impact Statement fails to display the total inventory of radionuclides that will be interred if CNL has its way, although Table 7.2.1-1 provides at least a partial listing. However, in this table there is no information about half-life, total activity in becquerels, mode of radioactive disintegration, radioactive progeny, target organs, or other pertinent data about any of these radionuclides.

There is one obvious error in the table, as Radon-226 does not exist; presumably the radionuclide intended is Radium-226, with a half-life of 1600 years. The phrase “Isotopic Plutonium” presumably indicates a mixture of Plutonium-239, Plutonium-240, and Plutonium-241, with half-lives of 24,100 years, 6,560 years, and 14.4 years.

The draft EIS does not specify the half-lives of the radionuclides mentioned in Table 7.2.1-1. Here they are:

| <u>Radionuclide</u> | <u>Half-Life</u> | |
|-----------------------|-------------------|------------------|
| | <u>< 100 y</u> | <u>>100 y</u> |
| Hydrogen-3 (Tritium), | 12.3 years | |
| Carbon-14, | | 5 730 years |
| Chlorine-36, | | 301 000 years |
| Calcium-41, | | 102 000 years |
| Iron-55, | 2.73 years | |
| Nickel-59, | | 76 000 years |
| Nickel-63, | | 101 years |
| Cobalt-60, | 5.26 years | |

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| <u>Radionuclide</u> | <u>Half-Life</u> | |
|----------------------------|--------------------------|-------------------------|
| | <u>< 100 y</u> | <u>>100 y</u> |
| Strontium-90, | 28.8 years | |
| Niobium-94 | | 20 300 years |
| Zirconium-95, | 64.0 days | |
| Technetium-99, | | 120 000 years |
| Antimony-125, | 2.76 years | |
| Iodine-129, | | 15 700 000 years |
| Cesium-137, | 30.2 years | |
| Europium-152, | 13.5 years | |
| “Radon-226” (Radium-226), | | 1 600 years |
| Plutonium-239, | | 24 100 years |
| Plutonium-240, | | 6 560 years |
| Plutonium-241, | 14.4 years | |
| Americium-241, | | 432 years |
| Curium-244, | 18.1 years | |

From these data we can see that, of the 22 radionuclides indicated in Table 7.2.1-1 (WR-1 EIS), eleven of them have half-lives of over 100 years, nine of them have half-lives over 1,500 years, seven of them have half-lives over 15,000 years, four of them have half-lives over 100,000 years, and one of them has a half-life over 15 million years.

The Regulatory Oversight Report does not call attention to the fact that many radioactive contaminants in the structural components of defunct reactors have exceedingly long half-lives, far exceeding the expected lifetime of the concrete mausoleum planned by the CNL consortium to house these wastes.

Let's follow this line of thought a bit further. The half-life of a radioactive element is the time required for half of the radioactive atoms to disintegrate. If one doubles that period of time, only one quarter of the original number of radioactive atoms will remain. If one triples that time period, only one eighth of the original number of radioactive atoms will remain. It will take ten half-lives for 99.9 percent of the original radioactive atoms to be gone ; at that point, only one thousandth of the original amount remains.

Multiplying by 10 all the figures listed above (as half-lives), one can see how long that takes!

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| <u>Radionuclide</u> | <u>Half-Life</u> | | <u>Ten Half-Lives</u> |
|---------------------|------------------|--------|-----------------------|
| Nickel-59, | 76,000 years | x 10 = | 760,000 years |
| Nickel-63, | 101,000 years | x 10 = | 1,010,000 years |
| Niobium-94, | 20,300 years | x 10 = | 203,000 years |
| Plutonium-239, | 24,000 years | x 10 = | 240,000 years |
| Technetium-99, | 120,000 years | x 10 = | 1,200,000 years |
| Iodine-129, | 15,700,000 years | x 10 = | 157,000,000 years |
| Chlorine-36, | 301,000 years. | x 10 = | 3,010,000 years |
| Calcium-41, | 102,000 years | x 10 = | 1,020,000 years |

Similarly incomplete information can be found in the draft EIS for the proposed NPD in-situ decommissioning, in Table 4.4-1. Once again, half-lives are not specified. Here they are:

| <u>Radionuclide</u> | <u>Half-Life</u> |
|-----------------------|-----------------------|
| Hydrogen-3 (Tritium), | 12.3 years |
| Carbon-14, | 5 730 years |
| Chlorine-36, | 301 thousand years |
| Calcium-41, | 102 thousand years |
| Nickel-59, | 76 thousand years |
| Nickel-63, | 100 years |
| Cobalt-60, | 5.26 years |
| Selenium-79 | 295 thousand years |
| Strontium-90, | 28.8 years |
| Niobium-93m | 16.1 years |
| Niobium-94 | 20 thousand years |
| Zirconium-93 | 1 530 thousand years |
| Technetium-99, | 211 thousand years |
| Silver-108m | 418 years |
| Tin-121m | 43.9 years |
| Tin-126 | 230 thousand years |
| Antimony-125, | 2.76 years |
| Iodine-129, | 15 700 thousand years |
| Cesium-135 | 2 300 thousand years |
| Cesium-137, | 30.2 years |
| Samarium-151 | 90.0 years |
| Europium-152, | 13.5 years |
| Uranium-234 | 246 thousand years |

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| <u>Radionuclide</u> | <u>Half-Life</u> |
|----------------------------|-------------------------|
| Uranium-235 | 704 million years |
| Uranium-236 | 23 400 thousand years |
| Uranium-238 | 4 470 million years |
| Neptunium-237 | 2 140 thousand years |
| Plutonium-239, | 24 thousand years |
| Plutonium-240, | 6 560 years |
| Plutonium-241, | 14.4 years |
| Plutonium-242 | 375 thousand years |
| Americium-241, | 432 years |
| Curium-243, | 29.1 years |
| Curium-244, | 18.1 years |

Of the 34 radionuclides indicated in Table 4.4-1 (from the NPD EIS), twenty-two of them have half-lives over 100 years, eighteen of them have half-lives over 5 thousand years, fourteen of them have half-lives over 100 thousand years, five of them have half-lives over one million years, and one of them has a half-life over one billion years.

Multiplying the figures listed above (as half-lives) by a factor of 10, one sees just how long it takes to reduce the activity by a factor of a thousand! One can also see just how much radioactivity will be left after hundreds of thousands or even millions of years of abandonment. (One becquerel indicates that one atomic disintegration is taking place every second. So one million becquerels is a significant amount.)

| <u>Radionuclide</u> | <u>Ten Half-Lives</u> | <u>Remaining Activity</u> |
|----------------------------|------------------------------|----------------------------------|
| Chlorine-36, | 3 million years | 40 million becquerels |
| Calcium-41, | 1 million years | 7.6 million becquerels |
| Nickel-59, | 760 thousand years | 48 million becquerels |
| Zirconium-93 | 15 million years | 20 million becquerels |
| Niobium-94, | 203 thousand years | 70 thousand becquerels |
| Technetium-99, | 1.2 million years | 18.9 thousand becquerels |
| Plutonium-239, | 240 thousand years | 507 thousand becquerels |
| Plutonium-242, | 3.75 million years | 1 thousand becquerels |

As before, we see that the longevity of these radioactive materials is measured not just in hundreds of thousands of years, but in millions of years. Many ordinary citizens would regard

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it as folly to abandon such long-lived radiotoxic materials right beside a major river in a subterranean grouted mausoleum – a structure that was never intended to outlast the Egyptian pyramids by hundreds or thousands of millennia. There is no information offered in the draft EIS regarding how long it might take for CNL's grout to break down and disintegrate.

The fact that CNSC would entertain such a proposal at all is a mystery. By law, the CNSC has a duty to the Canadian public, but not to the nuclear industry, and certainly not to private companies seeking to cut costs. CNSC also has a legislated obligation to disseminate objective scientific information about the nature of all licensed undertakings and the associated radiological risks. In addition, CNSC has a mandate “*to achieve conformity with measures of control and international obligations to which Canada has agreed*”.

Several questions arise. Why would the CNSC even entertain a draft EIS for in-situ decommissioning that runs counter to IAEA recommendations? Why would CNSC circulate a draft EIS for public comment that has such an inadequate description of the radioactive inventory? In its meetings and discussions with indigenous groups and others, has CNSC taken steps to disseminate any objective scientific information at all about the diversity and especially the longevity of the radioactive species involved? If not, why not?

It is recommended

- **that CNSC not receive, accept or circulate for public comment any draft proposal for a nuclear waste “disposal” facility or a decommissioning project that is clearly at odds with international guidance;**
- **that CNSC reject the proposed entombment of two nuclear reactors at Whiteshell and at Rolphton, unless the proponent can demonstrate that it is not possible to carry out the original and already approved strategy of dismantling the two reactor structures, removing radioactive materials off-site, and returning both sites to “green field” status;**
- **that CNSC require that a complete list of radionuclides involved in any waste management, transportation or decommissioning scenario, complete with half-lives, activities (in becquerels per kilogram or per litre), mode of disintegration, radioactive progeny and target organs, be provided by the proponent;**

- **that all information about the radioactive inventory involved in any such scenario be communicated to indigenous peoples and to other members of the Canadian public in plain language stripped of scientific symbols and abbreviations;**

Long-Term Management of Radioactive Wastes

“Disposal” is not a scientific term and does not have a scientific definition. CNSC Regdoc 3-6 defines radioactive waste disposal as “The placement of radioactive waste without the intention of retrieval.” That is a political definition, not a scientific one. It is based on intention rather than scientific evidence or proof. According to the definition as stated, emplacing radioactive waste in any given repository or waste storage facility can be called “disposal” as long as it is *intended* to be permanent (i.e. with no intention of retrieval).

But circumstances often change, and intentions may be overturned or belied by events. Mistakes and miscalculations can and do occur. We have seen that happen with the fiasco of the Asse-II geological repository in Germany, where low-level and intermediate-level wastes that were “disposed of” must now be removed from the underground workings, at great peril and at an estimated cost of two billion dollars, over a period of 30 years or more, due to extensive and persistent leakage of radioactive materials into ground and surface waters.

Nobody knows how to eliminate radioactive wastes, or even to reduce the radioactive burden in a substantial or permanent way. True, the waste can be compacted into a smaller volume, but the radioactivity is not reduced, it is simply more concentrated. The waste can be moved from point A to point B, whereupon it is still present, albeit in a different location, one that may or may not be more secure than the original location. One can also package the waste so that it is less easily accessible to the environment, and in that way one can reduce the risk, at least temporarily – but have we reduced the long-term liability? As in the case of the Asse-II facility, the liability may become even greater, tomorrow, if wrong decisions are made today.

But CNL is a privately-run profit-oriented organization that has been hired to do a job – that is, to reduce the multibillion dollar federal liability associated with the Canadian government's radioactive waste legacy. From a simplistic point of view, “reducing the liability” is largely a matter of “fixing the books” so that the multibillion-dollar radioactive liability does not have to

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be reported as part of Canada's national debt. Presumably, this can be accomplished if one can make a credible claim (complete with regulatory certification) that the radioactive waste has been permanently “disposed” of. The waste itself is not gone, but the liability is no longer recorded on the books because the waste has been “dealt with” in a permanently “satisfactory” fashion. Of course, financial concerns are not the direct responsibility of CNSC (except for decommissioning guarantees), but resisting the temptation to approve questionable projects based on political or corporate pressure that may be brought to bear – pressure that may well be inspired by financial or political considerations – is very much a CNSC responsibility.

Here is an excerpt from a memorandum dated January 30, 2013, addressed to the Minister of Natural Resources (obtained by Access to Information) entitled “Review of the Legacy Waste and Decommissioning Liabilities at Atomic Energy of Canada Limited's Sites”:

“While it is too early to assess the outcome in the UK, US experience demonstrates that private-sector involvement has brought financial and scheduling benefits to some waste management and decommissioning sites – getting the work done cheaper and faster. For example, in 2000 the US DOE expected the clean up of the Rocky Flats site, which was a former nuclear weapons facility in Colorado, to cost \$4 billion over six years. A private sector contractor completed the work 14 months ahead of schedule, at a cost saving of more than \$550 million.”

ATIP7040-19-068 Final Release Package.pdf , page 11

In fact the Rocky Flats clean-up was incomplete, and problematic levels of plutonium contamination remain. Mark Lesinski, the current CNL President, was in charge of this clean-up. His bio on the Canadian Nuclear Association website inflates the magnitude of his success in this regard: *“Mr. Lesinski’s experience includes 17 years of successful hands-on management of major commercial nuclear power plant retrofits.... At Rocky Flats, his innovative safety and regulatory approaches and use of high-performance teams supported site closure 60 years earlier and US \$30 billion lower than the original estimate.”*

Lesinski then moved to the U.K. to become chief operating officer of the U.K. Nuclear Decommissioning Authority, which also tried to use private companies to clean up nuclear weapons facilities such as Sellafield. There were a number of scandals and the U.K. government finally had to take back control of those clean-up operations. Lesinski left that job in December 2013 and went back to the U.S. Then, less than two years later, he became the leader of the Canadian contract-winning consortium of SNC Lavalin, Fluor and others.

Chalk River Near Surface Disposal Facility

In order to achieve rapid progress towards reducing the federal radioactive waste liability, CNL's Integrated Waste Strategy proposes a gigantic engineered mound on the surface at Chalk River, dubbed the Near Surface Disposal Facility (NSDF). NSDF is designed to hold up to a million cubic metres of Low-Level Waste (LLW) and some Intermediate Level Waste (ILW), including a large volume of decommissioning waste (radioactive debris from demolished buildings) and contaminated soil.

The strategy document states that NSDF *“will provide near term disposition for stored legacy waste, enable accelerated decommissioning at CRL and closure of WL, achieve the immediate reduction of the estimated cleanup liability, and demonstrate a cost-effective disposal method for LLW.”* (p. 8-1) However, the International Atomic Energy Agency (IAEA) has advised that such a surface “landfill” operation for radioactive wastes is only suitable for Very Low-Level Waste (VLLW), e.g. for soil that is very lightly contaminated with radioactive pollutants, and for some types of low-level wastes.

More problematic types of low-level waste, however, will have to be stored at greater depths, up to 30 metres below the surface. Future human intervention, activities ranging from excavation for a homesite to drilling for valuable minerals, must be anticipated. The disruptive actions of burrowing animals and the intrusive root systems of plants must also be taken into account, as well as earthquakes and tornados which the region has experienced with growing frequency.

Originally, CNL representatives informed concerned citizens in the Ottawa Valley area that a small amount of Intermediate-Level Waste (ILW) would be included in the NSDF, less than 10 percent by volume. This, despite the fact that IAEA specifically recommends excluding all intermediate-level wastes from disposal in any surface or near surface facility.

Moreover, 10 percent of one million cubic metres is 10,000 cubic metres, which is not such a small volume after all. These ILW wastes would be gamma-emitting and even heat-generating in some cases, putting extra stresses on the “impermeable membranes” required to prevent leakage, causing them to fail even sooner than otherwise. Much of the Intermediate Level Waste destined for NSDF calls for remote handling because of gamma radiation levels that would preclude direct handling.

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The Integrated Waste Strategy states that Near Surface Disposal Facility is supposed to “enable accelerated decommissioning of CRL and closure of WL”, suggesting that large quantities of highly diverse radioactively contaminated structural materials from both Chalk River and Whiteshell will be emplaced in the NSDF from many dozens of demolished buildings and laboratories.

Some of those structures are contaminated with plutonium, americium and other highly toxic and very long-lived transuranic actinides, as well as unusually long-lived fission products and activation products such as iodine-129 (half-life 16 million years), carbon-14 (half-life 5,700 years), technetium-99 (half-life 210,000 years), nickel-59 (half-life 76,000 years) and others. The radioactivity of such materials will not change appreciably for many centuries or millennia, during which time their radiotoxicity will remain undiminished.

Whereas Naturally-Occurring Radioactive Materials (NORM) are chemically different from the vast majority of non-radioactive materials all around us in soil, food and water, most of the fission products and activation products are chemically identical to non-radioactive species. Once those human-made radioactive varieties are allowed to contaminate the environment, they will blend with their non-radioactive counterparts and will subsequently be virtually impossible to separate again by any standard chemical process or filtration method.

Consequently putting such radioactive waste materials on the surface, in an earthen mound 5 to 7 stories high, covering 11 hectares of land, situated between a wetland and a major river that provides drinking water for millions of people, including Ottawa and Montreal, offers little assurance that the environment and the food chain will be adequately protected from contamination – especially over such exceedingly long time periods.

Under these circumstances, the Canadian public needs to have confidence that there is a strong, principled and independent regulator that is ready and willing to stand up for the public interest – a regulator that is not afraid to speak truth to power and to remain principled through it all. Like the Auditor General of Canada, who never seems to hesitate “to tell it like it is”, or the previous Attorney General of Canada, who courageously insisted on protecting the independence of the judiciary, or Linda Keen, who was determined to demonstrate that CNSC licence conditions must be enforceable, today's CNSC must be trusted not to flinch when it comes to representing the best interests of present and future generations of Canadians.

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The public has to have confidence that CNSC will stick to its guns and keep its promise never to compromise public safety by yielding to corporate or government pressure. It is difficult to generate such confidence when CNSC spends more time negotiating with proponents than interacting with the public on an equal footing.

There are 140 municipalities whose town councils have passed resolutions against the proposed NSDF. There are more than a dozen ex-AECL employees, some having served for many years in positions of responsibility, who have expressed serious objections to the siting of the NSDF and to the project itself. Despite the fact that CNL has assured people for more than a year now that ONLY low-level nuclear wastes will be included in the NSDF mound, there are clear indications that this is not true. For example, in its comments to the CNSC earlier this year (2019) regarding REGDOC-2.11.1, Volume I, "Waste Management: Management of Radioactive Waste", CNL made the following observation:

"Industry Issue - The 4th bullet is a potentially misleading or biasing statement.

There are current plans to place ILW in aboveground mounds. *[emphasis added]*

"Suggested Change - Amend 4th bullet to read, 'Due to its long-lived radionuclides ILW generally **may** require a higher level of containment and isolation than can be provided in near surface repositories.'"

CNL's comments are posted on-line at <http://www.nuclearsafety.gc.ca/eng/pdfs/REGDOC-comments-received/Comments-REGDOC-2-11-1-v1-CNL.pdf>.

The only thing that makes nuclear power a potential menace to society is the fantastic inventory of radioactive wastes that are created in the core of the reactor – wastes that can cause great harm if released into the environment by any means whatsoever. When those wastes are being transported by the thousands of truckloads over public roads and through countless communities, and when those wastes are being prepared for eventual abandonment beside major bodies of water, the Canadian public is understandably concerned.

It is deeply distressing when the one body that is legally charged with the job of protecting the health and safety of Canadians and the environment, and of disseminating objective

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scientific information, seems to be “missing in action”. In this regard, the absence of all these issues from the Regulatory Oversight Report is Exhibit A. There is considerable public apprehension that Canadian Nuclear Laboratories is calling the shots and CNSC is struggling to oblige, even to the point of recasting the definition of Low-Level Radioactive Waste so as to justify the consortium's plan for emplacing Intermediate Level Waste in the NSDF.

It is not reassuring to learn of the many hours of closed door consultations between CNL and CNSC staff, completely out of the public eye. It is alarming to read about CNSC's reported advocacy for eliminating the requirement for public environmental assessments for so-called “Small Modular Nuclear Reactors” (SMNRs) below a certain thermal power rating (200 megawatts of heat), even though these new reactors are highly diverse in design, unbuilt and untested, employing unorthodox High Assay enriched fuels, novel coolants (for Canada) such as helium gas, liquid sodium, and molten salt, as well as other technologies (e.g. graphite moderators) that have never before been used in Canada's commercial nuclear power sector.

Small Modular Nuclear Reactors (SMNRs) constitute a new fleet of nuclear reactors that is being championed by CNL as an entrepreneurial endeavour, using the CRL (Chalk River) and WL (Whiteshell) sites for this purpose. The multinational corporate partners running CNL want to make Canada an international hub for building and testing a variety of SMNR designs. This ambitious undertaking enjoys the full participation and active support of the Minister of Natural Resources – the same Minister to whom CNSC reports.

Many Canadians, including First Nations, are dismayed by the perceived conflict of interest when CNSC – mandated to protect the public, not the industry – urges the government to exempt most SMNRs from the formal environmental assessment process laid out in the 2019 Impact Assessment Act. Eliminating environmental assessments effectively eliminates public participation in decision making. People wonder: is meaningful public participation a thing of the past? or was there any meaningful public participation to begin with?

It is recommended

- **that CNSC not accept the emplacement of any intermediate-level waste in any surface or near-surface radioactive waste facility;**
- **that CNSC not accept the emplacement of any measurable amounts of transuranic waste in any surface or near-surface facility;**
- **that CNSC ensure that the necessary laboratory tests are carried out on each batch of decommissioning waste to detect the presence of transuranic contamination;**
- **that CNSC not accept the emplacement of any measurable quantities of radioactive carbon-14 in any surface or near-surface facility, given its 5700 year half-life and its exceptional environmental mobility as radioactive carbon dioxide or carbonic acid;**
- * **that CNSC ensure that no ion-exchange resins be emplaced in any surface or near-surface radioactive waste facility (among other reasons is that carbon-14 contamination is almost always found in such resins);**
- **that CNSC reconsider its opposition to the mandatory environmental assessment of new nuclear reactors and recommend to the federal government that such assessments be required;**

Communicating with future generations

There is no scientific principle that can be used to guarantee that long-lived radioactive waste will remain in one designated place forever, considering the unpredictable and uncontrollable powers of natural forces and the ever-present possibility of human intrusion. In recognition of this reality, Swedish nuclear authorities sponsored a three day international workshop from 21-23 May, 2019, in Stockholm – attendance by invitation only – to discuss the responsibility that we all share to communicate to future societies the essential facts about the radioactive legacy that we are leaving them; i.e. to transmit, to the best of our abilities, RK&M (Records, Knowledge and Memory) about radioactive waste.

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The RK&M initiative on the “Preservation of Records, Knowledge and Memory (RK&M) Across Generations” was launched by the Radioactive Waste Management Committee of OECD's Nuclear Energy Agency. It ran from March 2011 to April 2018. Twenty-one organizations from 14 countries, representing implementing agencies, regulators, policy makers, R&D institutions, and international archiving agencies, plus the International Atomic Energy Agency, contributed to the work.

The 2019 Swedish workshop, which I was invited to attend, was co-hosted by the Swedish National Council for Nuclear Waste (Kärnavfallsrådet), Linnaeus University, the National Archives of Sweden (Riksarkivet), and the Swedish Radiation Safety Authority (SSM). SSM is the Swedish counterpart of CNSC – it is the Swedish nuclear regulatory agency.

The event was chaired and organized, and the Proceedings were edited, by Claudio Pescatore, Ph.D., a nuclear physicist who obtained his doctorate from the Massachusetts Institute of Technology (MIT). Dr. Pescatore, a Professor in the Department of Cultural Sciences at Linnaeus University, occupies the United Nations Chair on Heritage Futures under UNESCO – the United Nations Educational, Scientific and Cultural Organization.

The Stockholm workshop focused on the fact that we are now entering the Age of Nuclear Waste and Decommissioning in a serious way, in the sense that permanent “solutions” are being sought for the vexing problem of keeping dangerous long-lived radioactive poisons out of the environment of living things for periods of time that dwarf the span of recorded human history. But our radioactive waste legacy is ultimately an everlasting societal problem, not just a temporary industrial problem. That legacy will remain a matter of concern for countless generations, since there is no incontrovertible scientific proof that a permanent solution exists.

“The present text serves as a vision document helping start a broad-based reflection in Sweden and elsewhere on how to aid future generations maintain or regain awareness of some of the most relevant environmental legacies that they will inherit – notably nuclear waste. . . . In 2007 the UNESCO Member States signed a joint declaration on the Responsibilities of the Present Generations Towards Future Generations. This declaration emphasizes that 'The present generations have the responsibility of ensuring that the needs and interests of present and future generations are fully safeguarded.' But how can this be done? Today you are all here to discuss one important aspect of this, namely how we manage, explain and communicate the risks and proper management of nuclear and other wastes to future generations.”

Claudio Pescatore, Welcome Address, Workshop Proceedings, pp.1-2

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The CNSC was explicitly created to ensure that the health and safety of persons and the integrity of the environment are protected, presumably both now and in the future. One of the most essential tools that people need to protect themselves from any peril or environmental hazard is knowledge – knowledge of the nature of the danger.

How are future generations going to know what these radioactive wastes are, what dangers they may pose, and what protective measures must be taken to keep them out of the environment of living things? Who is going to ensure the preservation and transmission of such vital information if not the CNSC – the only government agency that has been charged with the statutory responsibility of disseminating objective scientific information to the public on matters related to nuclear energy and radioactive hazards?

It is recommended

- **that CNSC require any proponent of a facility for permanent storage of radioactive waste to propose a comprehensive strategy for the transmission of RK&M (Records, Knowledge and Memory on Radioactive Waste) to future generations, including a detailed inventory of specific radionuclides included in the proposed facility along with relevant physical, chemical and biological properties ;**
- **that CNSC require any proponent of a facility for permanent storage of radioactive wastes to provide detailed instructions as to how the wastes can be retrieved and repackaged if need be at some future date, and failing the provision of those instructions, approval for the project be withheld.**

Rolling Stewardship as an Alternative to Abandonment

The concept of Rolling Stewardship was discussed during the Stockholm Workshop as an alternative to the abandonment of radioactive waste in permanent facilities that may well prove to be ultimately inadequate (as in the case of the Asse-II facility).

Once the gigantic mound of radioactive waste known as the Near Surface Disposal Facility (NSDF) is completed, it will be virtually impossible for anyone to disaggregate the radioactive

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waste materials emplaced in the mound in order to provide superior containment at some future time. Should we be in such a hurry to commit society to a permanent and irreversible “solution” that is to last over a thousand years and yet remains unproven and unprovable?

Rolling Stewardship provides an alternative. This concept was originally advanced by the US National Academy of Sciences in the 1980s in the context of managing persistent chemical wastes such as heavy metals. Rolling Stewardship is an intergenerational containment strategy for managing toxic waste, equally applicable to radioactive waste. It requires that the waste be segregated and stored in robust state-of-the-art licensed containers, each one fully documented as to contents and well-labelled. These containers, designed to prevent dissemination of radionuclides into the environment, are to be maintained in a monitored and retrievable condition at all times, providing future generations with the necessary knowledge to allow for prompt corrective action to be taken when containment shows signs of failing.

One of the advantages of Rolling Stewardship is that it facilitates the preservation and transmission of Records, Knowledge and Memory. It is easier to pass information along from one generation to the next, at 10 or 20 year intervals, than it is to attempt communicating with unknown civilizations in the far distant future that may not even speak the same languages that we use today.

Abandonment leads to amnesia; Rolling Stewardship keeps memory alive.

“The main point behind the concept is that we should not plan now to abandon these wastes, but that they should be stored in such a way as to allow for the monitoring, retrieval, repair, and repackaging of the waste if and when that is considered necessary.”

“Rolling Stewardship requires that some institutional body should be in charge of knowing the facts, assessing the needs, and taking action. Thus, society has to grant authority and resources to a body of people, without a conflict of interest, with the necessary resources and authority to carry out these tasks on behalf of society at large, just as we have fire departments and police departments and such.”

“Rolling Stewardship is not the same as talking about a rolling present [i.e. status quo]. The concept of Rolling Stewardship is proactive and aims at continual improvement of the situation.”

Workshop Proceedings, p. 12

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As the age of large nuclear power reactors is drawing to a close, the age of nuclear waste is just beginning. We feel Canada must be prepared with policies and regulations that will guarantee that good governance prevails. Future generations of Canadians will depend on our performance today, and the world will look to Canada to set an example for responsible radioactive waste handling, packaging, transport, and long-term management.

As the Honourable Jim Carr observed when he was Minister of Natural Resources: “Canada does not yet have a federal policy for the long-term management of non-fuel radioactive waste.” The existence of such a glaring policy vacuum at the federal level provides an additional argument against any permanent or irreversible action on radioactive wastes that is predicated on inevitable abandonment.

It is recommended

- **that CNSC require any proponent of a facility for permanent storage of radioactive waste to examine the option of Rolling Stewardship as an alternative to abandonment ;**
- **that CNSC request the government of Canada to formulate a socially acceptable policy on the long-term management of radioactive wastes other than used nuclear fuel, based on extensive public consultations with First Nations and other Canadians.**

Transporting Radioactive Waste on Public Roads

There are no federal government policies or regulations explicitly related to the transportation of radioactive wastes. In their stead, policies and regulations developed for the transportation of radioactive commodities – such as medical or industrial isotopes from Nordion, or uranium concentrates from Saskatchewan (yellowcake), or uranium hexafluoride from Port Hope (for export to enrichment plants) – are utilized, sometimes resulting in mislabelling, or highly misleading, or seriously incomplete documentation.

There are important differences between radioactive wastes and radioactive commodities. First and foremost is the question of justification. Radioactive commodities are transported

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because there is a customer at the receiving end that will use the contents for some useful purpose. Radioactive wastes are most often transported to suit the convenience of the owner of the waste. However, transport of radioactive wastes inevitably increases the risk of accidental spills resulting in radioactive exposure to members of the public or radioactive contamination of the environment. Consequently, radioactive wastes should not be transported without a careful consideration of the justification for and alternatives to transport.

Radioactive commodities are normally much easier to describe and characterize than radioactive wastes, as they involve only one or a very small number of radionuclides. Thus accidents can be more easily dealt with by first responders and clean-up crews as they can quickly ascertain the nature of the precise radioactive hazard and the physical and chemical properties of the specific radioactive commodity. Radioactive wastes, on the other hand, may involve a bewildering variety of radioactive materials, including alpha emitters, beta emitters, gamma emitters, and sometimes neutron emitters, and having a wide variety of physical and chemical properties. For the sake of properly informing first responders and clean-up crews, much more information must be communicated and clean-up is that much more difficult.

Any mischaracterization of the contents of a radioactive waste transport is a disservice to drivers, first responders, the public, and all those who are concerned about the environmental and health hazards of radioactive wastes, especially in the event of a severe accident. If the waste is to be emplaced in a disposal facility, such mischaracterization also establishes an inaccurate record for the contents of the repository.

It is recommended

- **that CNSC establish a new set of regulations governing the transport of radioactive waste, including requirements for justification and discussion of alternatives ;**
- **that CNSC withhold approval for the transportation of radioactive wastes over public roads unless the proponent of such transport can show a demonstrable improvement in security and environmental protection as a result of such transport.**

Example: Transport of Liquid Radioactive Target Material to South Carolina

A well-documented case in point, not involving emplacement in a repository, is the CNSC's mischaracterization of a series of currently on-going shipments of highly radioactive liquid waste from Chalk River to the US Department of Energy's Savannah River Site in South Carolina. There were 100 to 150 shipments of this liquid waste scheduled, of which about 70 percent have been completed to this date.

For some reason, CNSC staff has consistently mischaracterized this liquid waste as “Highly Enriched Uranyl Nitrate Liquid” (HEUNL). Uranyl nitrate is a chemical compound having only one radioactive constituent – uranium. But the radioactivity of the Chalk River liquid is 16,500 times greater than would be the case if the liquid were just uranyl nitrate.

The Chalk River liquid contains a great many other radioactive elements besides uranium – unstable isotopes of niobium, zirconium, rhodium, ruthenium, iodine, xenon, tellurium, barium, cesium, lanthanum, cerium, praseodymium, neodymium, europium, neptunium and plutonium, and more. Most of these are intense gamma emitters, unlike uranium. Each and every one of them is far more radiotoxic than uranium.

The Canadian Nuclear Laboratories' Integrated Waste Strategy is more forthright about the extremely dangerous nature of this liquid, calling it “Target Residue Material” (TRM) and listing it under the heading “High Level Waste” in section 6.1.1 of the CNL strategy document.

CNL has got it right. The Chalk River liquid is an intensely radioactive heat-generating nitric acid solution of fission products and actinides from irradiation of enriched uranium “targets”. The liquid was stored for many years in the Fissile Solution Storage Tank (FISST) at Chalk River, where it was regarded as the most problematic batch of radioactive waste on site.

The Chalk River liquid is similar in nature to the millions of gallons of post-reprocessing liquid high-level waste stored in huge tanks at the US Department of Energy's Hanford site, left over from the extraction of weapons-grade plutonium needed to build up the US nuclear arsenal.

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The Chalk River liquid certainly does contain residual amounts of highly enriched weapons-grade uranium, a primary nuclear explosive material that was originally purchased from the US and is now being “repatriated” under an agreement between the two governments.

So “highly enriched uranyl nitrate” is undoubtedly contained in the liquid waste, but it's a relatively small fraction of the total 23,000 litres of waste and does not pose the greatest risk to the health and safety of Canadians or the environment in case of accidental spillage.

These data are taken from Table 2 of the 2014 CNSC document, “Technical Assessment Report: NAC-LWT Package Design for Transport of Highly Enriched Uranyl Nitrate Liquid”.

Data from CNSC’s Table 2 in layman’s language
Concentrations (per litre) of radioactive materials in the Chalk River liquid

| Isotope | Activity in Becquerels per Litre | Isotope | Activity in Becquerels per Litre | Isotope | Activity in Becquerels per Litre |
|---------------|----------------------------------|-------------------|----------------------------------|---------------|----------------------------------|
| Niobium-95 | 6.63 billion | Barium-137m | 70.19 billion | Europium-155 | 195 million |
| Niobium-95m | 25.35 billion | Cesium-137 | 70.19 billion | Uranium-234 | 28.4 million |
| Zirconium-95 | 23.35 billion | Barium-140 | 58.50 billion | Uranium-235 | 559 thousand |
| Rhodium-103m | 18.13 billion | Lanthanum-140 | 58.50 billion | Uranium-236 | 366 thousand |
| Ruthenium-103 | 18.13 billion | Cerium-141 | 42.88 billion | Uranium-238 | 5.59 thousand |
| Rhodium-106 | 546 million | Cerium-144 | 8.19 billion | Neptunium-237 | 4.51 thousand |
| Ruthenium-106 | 546 million | Praseodymium-144 | 8.19 billion | Plutonium-239 | 1.3 million |
| Iodine-131 | 19.50 billion | Praseodymium-144m | 8.19 billion | Plutonium-240 | 89.9 thousand |
| Xenon-131m | 19.50 billion | Neodymium-147 | 15.80 billion | | |
| Tellurium-132 | 10.33 billion | Europium-154 | 84 million | | |

(table shows only materials giving off penetrating gamma radiation and those heavier than uranium)

The total radioactivity of all the uranium isotopes in each litre of liquid, as reported in this table, is just 29 million becquerels, whereas the total of all the radioactivity in that same litre is more than 485 billion becquerels. That is a factor of 16,500 greater in the level of radioactivity.

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By far, one of the most dangerous radionuclides listed in the table is cesium-137, a long-lived radioactive poison that concentrates in the food chain and accumulates in the flesh of animals. It is an intense emitter of gamma radiation, unlike uranium. It is a far greater hazard to drivers, first responders, the public, and the environment, than all of the uranyl nitrate,

Cesium-137 soil contamination levels are customarily used as markers for evacuation zones following a severe reactor accident. For example, the evacuation zone around the destroyed Chernobyl reactor was defined by over 550,000 becquerels of cesium-137 per square metre.

As noted in Table 2 cited above, each litre of Chalk River liquid contains 70 billion becquerels of cesium-137. Thus each truckload, carrying a total of 232.4 litres of liquid, contains about 16.2 trillion becquerels of cesium-137. That is enough cesium-137 to create a radioactively contaminated evacuation zone of 30 square kilometres using Chernobyl's evacuation criterion.

The previous paragraph focuses on soil contamination. Equally concerning, or perhaps even more concerning, is the potential for water contamination, especially since the radioactive cargo is in liquid form.

In the Guidelines for Canadian Drinking Water Quality published by Health Canada, the maximum allowable concentration of cesium-137 in drinking water is 10 becquerels per litre. Thus the 70 billion becquerels of cesium-137 in just one litre of this Chalk River liquid waste would be enough to render seven billion litres of drinking water unfit for human consumption. That is about 1.2 percent of the annual drinking water consumption for the entire Island of Montreal in 2017 (reported as 567 billion litres): about 5 days worth of drinking water.

The total amount of cesium-137 in a single truckload of Chalk River liquid – 232.4 litres in all – is enough, in principle, to ruin a three-years' worth supply of Montreal's drinking water.

But CNSC refuses to consider such a large spill, even though the post-Fukushima philosophy should be that anything is possible. In the previously cited 2014 CNSC document, staff states

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that up to 0.033 percent of the contents of a given liquid waste shipment may be assumed to escape into the environment. That corresponds to 76 cubic centimetres of radioactive liquid waste. Would that small amount of high-level radioactive liquid waste be reason for concern?

Simple arithmetic shows that such a liquid spill would involve 5,320 million becquerels of cesium-137. That is enough cesium-137 to contaminate 532 million litres of drinking water using the current Water Quality Guidelines for Canada. That much contaminated water would fill 2128 Olympic swimming pools. Given the level of radiotoxicity and the intense gamma radiation of cesium-137, such a spill would hardly be inconsequential – yet that is what CNSC seems to imply in its 2014 document.

By the way, the foregoing discussion completely ignores the fact that a great many other radionuclides, including isotopes of plutonium, would also be released in such a spill.

One might also wonder why, if 76 cc of liquid can leak out under adverse circumstances, what would prevent much greater quantities to escape simply by following the exact same escape route?

The Chalk River liquid is undoubtedly among the most toxic materials ever transported over public roads. It is shocking to find that CNSC spends more effort in downplaying or hiding this fact rather than being straightforward about it. This kind of liquid high-level waste has never previously been allowed to be transported over public roads anywhere in North America.

Regrettably, the Government of Ontario was fooled into disseminating false information to its own first responders, by repeating uncritically the misleading information provided by CNSC. Three documents were dispatched to Emergency Management Officials throughout Ontario, describing the liquid being trucked over Ontario roads as Highly Enriched Uranyl Nitrate Liquid. Nowhere in these documents is there any mention of the preponderance of other far more dangerous radionuclides such as cesium-137.

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The 3 Ontario government documents sent to all Emergency Management officials throughout the province are linked below:

1. http://ccnr.org/TRM_Transport_Ontario_ltr.pdf
2. http://ccnr.org/TRM_Transport_Ontario.pdf
3. http://ccnr.org/HEU_Fact_Sheet.pdf

None of these three documents provides a remotely accurate characterization of the great danger that would arise in the event of a spill of radioactive liquid following a severe accident.

CNSC maintains that the packaging of the Chalk River liquid is robust and the probability of a spill is quite small. However spills are entirely possible in a variety of severe traffic accident circumstances, as described in a paper authored by Gordon Edwards and Marvin Resnikoff - see http://www.ccnr.org/MR-GE_2017_rev2.pdf .

It is recommended

- **that CNSC send a correction to the Ontario Office of the Fire Marshal and Emergency Management giving the true radioactive inventory of Chalk River liquid being transported over Ontario roads and clarifying the danger following a potential spill;**
- **that CNSC staff recalculate and publish the amount of drinking water that could be ruined if accidentally contaminated with various quantities of high level radioactive liquid waste currently being trucked from Chalk River to South Carolina.**

Counterproductive Transport of High-Level Radioactive Wastes

Transportation of high level nuclear waste (HLW), i.e. irradiated nuclear fuel, is a particularly demanding undertaking. Even small quantities of HLW often require shipping casks that weigh from 70 to 100 tonnes. The gamma radiation and neutrons from a fully loaded shipping

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flask cannot be totally blocked, but only attenuated by suitable shielding. Accordingly, the transport of HLW irradiates the driver of the transport truck, the drivers and passengers in vehicles travelling the same roads, and bystanders living, working, or lounging along the way.

Yet the Integrated Waste Strategy states that all irradiated nuclear fuel at CNL sites will be transported to Chalk River Laboratories – from Whiteshell (the WR-1 reactor) in Manitoba, from the Douglas Point reactor at Kincardine, Ontario, and from the federally-owned Gentilly-1 reactor at Bécancour in Quebec.

Such unnecessary and redundant movement of high-level radioactive waste is not justified on safety grounds. Everyone knows that Chalk River cannot be the final destination for used nuclear fuel. NWMO (the Nuclear Waste Management Organization, authorized under the Nuclear Fuel Waste Act) is currently searching for a willing host community to accept all of Canada's used nuclear fuel for emplacement in a deep geological repository. Currently the candidate sites are five in number, three of them north of Lake Superior and the other two quite close to Kincardine.

It is counterproductive to move high-level radioactive waste twice when it could be moved only once, directly from the site of the reactor where it was produced to the site where it will be permanently stored.

No argument has been made to show that the high-level waste will be any safer at Chalk River than it is now. There is no justification for the transport. Moreover it is a longstanding principle of radiation protection that unnecessary exposures to ionizing radiation be avoided.

It is recommended that CNSC not allow the transport of irradiated fuel from other CNL sites to the Chalk River site unless CNL presents an irrefutable safety case for doing so.

Concluding Comments

Returning to the larger question of radioactive waste transport, we are now learning of thousands of shipments of federally-owned radioactive wastes of all kinds, ranging from low-level contaminated soil to highly dangerous intermediate level waste, including radioactive tubes, pipes, bulky equipment, structural components, and ion exchange resins, to the most highly radioactive material on earth – irradiated nuclear fuel – all headed to Chalk River Laboratories, right beside the mighty Ottawa River.

The existing simplistic classification of radioactive waste into “low-level, intermediate-level and high-level” is woefully inadequate to deal with the enormously complicated mix of radiotoxic materials resulting from the existence of hundreds of human-made radioactive isotopes, most of which were never found in nature prior to 1939. The risk analysis associated with such material must be multidimensional, as each individual radionuclide has its own unique properties, and follows its own distinctive pathways through the environment and through the human body.

The three broad classes of radioactive waste mentioned above are based on the relative safety of workers handling various kinds of radioactive materials that are for the most part well-packaged. Different categories of radioactive waste require different precautions. Should exposure time be limited? Is direct handling permissible? Is shielding necessary? Should remote handling tools be used? Is robotic equipment needed?

Some radioactive materials, such as strontium-90, polonium-210, or plutonium-239, are quite safe to handle without shielding when sealed in a suitable container, but are extraordinarily radiotoxic and environmentally hazardous when released in a form where they can be inhaled, absorbed or ingested.

CNSC needs to earn the trust of workers and the public when it comes to the unflinchingly accurate reporting of radiological risks and exposures. Most Canadians, including elected representatives and many atomic workers as well, are unaware of the fact that some very dangerous radioactive materials are indeed remarkable difficult to detect without specialized

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laboratory procedures. One is reminded of the historic contamination of Pickering workers with carbon-14 dust, tracked from the plant into the workers' homes over a period of weeks without triggering radiation alarms. One is also reminded of the internal contamination of the lungs of hundreds of contract workers during the Bruce refurbishment, through the inhalation of plutonium-contaminated alpha-emitting dust over a period of weeks in 2009. The now-contaminated trade workers were assured by supervisors that respirators were not needed. CNSC has an obligation to report on these exposure incidents with a full explanation of how and why the radioactive contamination of workers escaped detection for weeks at a time.

In the Age of Nuclear Waste and Decommissioning, Canada needs to develop new methods of classifying radioactive materials based on detailed considerations of health, safety and environmental integrity, not just on ease of handling and simple longevity considerations.

We must also recognize that proper detailed labelling is vitally important not only for safe transportation of radioactive wastes – especially in cases of accident – but also for responsible long term waste management, so that future generations can have access to information they will need to enable them to grasp the nature of the radioactive legacy we are leaving them.

It is recommended

- **that CNSC initiate a consultation process to develop a new classification scheme for radioactive waste materials based on health and environmental considerations rather than ease of handling;**
- **that CNSC require a thorough manifest of radionuclides, complete with half-lives, activity levels in becquerels, and type of radioactive emission, to accompany every shipment of radioactive waste material, easily accessible for use by first responders;**
- **that CNSC develop an entire suite of regulations focused exclusively on radioactive wastes, concentrating on questions of waste characterization, hazard analysis, packaging, labeling, and transport requirements.**



THE END?

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Five.Principles.for.Radwaste.

Anishinabek/Iroquois.Joint Declaration [May 2017]

1. No Abandonment: Radioactive waste materials are damaging to living things. Many of these materials remain dangerous for tens of thousands of years or even longer. They must be kept out of the food we eat, the water we drink, the air we breathe, and the land we live on for many generations to come. The forces of Mother Earth are powerful and unpredictable and no human-made structures can be counted on to resist those forces forever. **Such dangerous materials cannot be abandoned and forgotten.**

2. Monitored and Retrievable Storage: Continuous guardianship of nuclear waste material is needed. This means long-term monitoring and retrievable storage. Information and resources must be passed on from one generation to the next so that our grandchildren's grandchildren will be able to detect any signs of leakage of radioactive waste materials and protect themselves. **They need to know how to fix such leaks as soon as they happen.**

3. Better Containment, More Packaging: Cost and profit must never be the basis for long-term radioactive waste management. Paying a higher price for better containment today will help prevent much greater costs in the future when containment fails. Such failure will include irreparable environmental damage and radiation-induced diseases. **The right kinds of packaging should be designed to make it easier to monitor, retrieve, and repackage** insecure portions of the waste inventory as needed, for centuries to come.

4. Away from Major Water Bodies: Rivers and lakes are the blood and the lungs of Mother Earth. When we contaminate our waterways, we are poisoning life itself. That is why **radioactive waste must not be stored beside major water bodies for the long-term.** Yet this is exactly what is being planned at five locations in Canada: Kincardine on Lake Huron, Port Hope near Lake Ontario, Pinawa beside the Winnipeg River, and Chalk River and Rolphton beside the Ottawa River.

5. No Imports or Exports: The import and export of nuclear wastes over public roads and bridges should be forbidden except in truly exceptional cases after full consultation with all whose lands and waters are being put at risk. In particular, the planned shipment of highly radioactive liquid from Chalk River to South Carolina should not be allowed because it can be down-blended and solidified on site at Chalk River. **Transport of nuclear waste should be strictly limited and decided on a case-by-case basis with full consultation with all those affected.**