PREPARING FOR SAFEGUARDS IN THE CANADIAN DGR

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Abstract

In December 2024 Canada's Nuclear Waste Management Organization (NWMO) selected a site for its first Deep Geological Repository (DGR) for used nuclear fuel in the Wabigoon Lake Ojibway Nation – Ignace area of northwestern Ontario. Once operational by the early 2040s the facility will receive over 600 shipments of used fuel per year for the subsequent 40-50 years, with multiple emplacement packages processed daily. The success of this operation thus depends upon an effective and efficient safeguards approach, with highest intensity during the encapsulation process in the Used Fuel Packaging Plant (UFPP). It is critical therefore that this safeguards approach be integrated within the design of facilities and processes, which means planning must start now given that construction is less than 10 years away. The paper provides an overview of the Safeguards Plan recently developed by the NWMO, and the process of Safeguards by Design (SBD) that it will follow with the regulator and IAEA to ensure that an optimized safeguards approach is in place before the first used fuel is shipped – with operational efficiencies benefitting all stakeholders.

1. INTRODUCTION

The Nuclear Waste Management Organization (NWMO) is a not-for-profit organization established by Canadian legislation in 2002 to develop and implement the long-term management plan for Canada's used nuclear fuel. The plan involves isolation of used nuclear fuel in a Deep Geological Repository (DGR) using a multiple-barrier system in robust host geology. In December 2024 the NWMO selected a site for the DGR within the Wabigoon Lake Ojibway Nation – Ignace area of northwestern Ontario. Once operational by the early 2040s the facility will receive over 600 shipments of used fuel per year for the subsequent 40-50 years, with multiple emplacement packages processed daily. The fuel will consist of roughly 6 million fuel bundles (roughly 120 Mt of heavy metal) generated by the Canadian fleet of CANDU reactors from the start of operations in 1962 to the end of their projected lifetimes [1].

The used reactor fuel will largely be removed from dry storage at the NPPs and shipped to the DGR by road or rail. Over 90% of the used fuel will come from three NPPs plus Canadian Nuclear Laboratories (CNL) in Ontario, over an approximate distance of 1700 km. The remaining used fuel will come from NPP sites in Quebec and New Brunswick, over a distance of up to 3000 km [2]. Upon receipt at the Used Fuel Packaging Plant (UFPP) at the DGR site, fuel bundles will be repackaged into engineered Used Fuel Containers (UFC), encapsulated within rectangular Highly Compacted Bentonite (HCB) buffer boxes, transferred to the underground repository (500-800 m depth), emplaced in mined disposal chambers, and remaining excavated voids backfilled with bentonite clay.

All DGR operations involving the transportation, processing, packaging, internal transfers, emplacement, and ongoing stewardship of used nuclear fuel are subject to safeguards. The safeguards approach will be determined by the IAEA in consultation with the Canadian Nuclear Safety Commission (CNSC, Canada's nuclear regulator and safeguards authority), the NWMO, and fuel waste owners per Canada's safeguards agreement [3].

Prior to the onset of IAEA safeguards, the NWMO will pursue safeguards-by-design (SBD) engagement with the CNSC, IAEA, and fuel waste owners. By early 2026 the NWMO had established an Safeguards Program to provide organizational oversight of these preparations, and a Safeguards Plan to describe the activities, measures and processes related to safeguards implementation. This early engagement, including integration of safeguards into the design process, is necessitated by the critical impact that safeguards implementation will have on the efficiency of operations above and below ground at the DGR, and the associated used fuel transfers from waste owners. Canada has decades of experience in the safe handling and transportation of used nuclear fuel, but these operations will present new challenges due to the frequency and duration of fuel movement (roughly 2 shipments/day on average for half a century) and novel encapsulation and emplacement activities.

2. SAFEGUARDS PLAN

The NWMO Safeguards Plan establishes:

- the roles and responsibilities of safeguards personnel (Program Owner, Program Manager, Safeguards Specialists);
- the activities and processes that will support effective safeguards throughout the project lifecycle for each of its main operational areas (transportation, UFPP, and underground) per regulatory requirements [4];
- SBD best practices for both conventional activities and novel practices;
- a nominal safeguards approach creating the framework for later discussion with the CNSC and IAEA;
- key internal and external interfaces; and
- training needs.

3. ELEMENTS OF THE SAFEGUARDS APPROACH

A nominal safeguards approach (within SBD) establishes the framework for development of the later, official safeguards approach with the CNSC and IAEA, while informing the NWMO's design process based on general best practices. Key elements of this approach are as follows:

3.1. Objective

The safeguards approach will facilitate the effective and efficient implementation of safeguards at the DGR and associated transportation. The approach is anticipated to make optimal use of IAEA remote near-real-time monitoring capability, based on unattended Non-destructive Assay (NDA) and containment and surveillance (C/S) equipment and Remote Data Transmission (RDT).

3.2. Boundaries of Responsibility

The NWMO's responsibility for the used fuel begins after it is loaded for transportation at the waste owner sites and extends until after the DGR surface site is decommissioned, monitored, and is released from licensing.

The safeguards approach will be implemented beyond these boundaries however: (1) the safeguards measures relevant to transportation are applied under the responsibility of the fuel waste owners; and (2) the long-term safeguards measures applied in the Post-closure Phase are implemented by the IAEA under the responsibility of the designated authority of jurisdiction after the NWMO is released from licensing.

It is essential, therefore, that all interested parties (particularly the fuel waste owners at the front end) be engaged in SBD discussions with the NWMO, CNSC and IAEA.

3.3. Nuclear Material Verification

Used fuel will generally be in the form of CANDU bundles extracted from dry storage under existing *Difficult-to-Access* conditions and will have received an appropriate level of IAEA verification when first transferred to dry storage. If continuity of knowledge has been maintained both since then and during the transfer process, this will inform the IAEA's assessment of verification needs prior to transport.

During the processes of transportation and receipt at the DGR, the existing C/S measures on the used fuel will be removed twice – once when it is transferred from storage to the transport package by fuel waste owners, and again when transferred from the transportation packages to the UFC at the UFPP under the responsibility of the NWMO. It is essential that continuity of knowledge be maintained on the used fuel during these transitions, minimizing the need for extensive remeasurement. Follow-up procedures addressing loss of continuity of knowledge will also need to be pre-arranged with the CNSC and IAEA.

3.4. Safeguards Equipment

It is expected that the safeguards approach for the DGR will utilize traditional methods and technology where appropriate, but also leverage advanced instrumentation and techniques. It is recognized that safeguards policies, methods and technologies will likely evolve over the project lifecycle, and that these advances will also be incorporated. The NWMO would assist the IAEA as needed with the development of relevant methods and technologies, both during the SBD preparations prior to operations and as safeguards capabilities evolve.

It is expected that unattended C/S and nuclear material accountancy equipment will support a Near Real Time System (NRTS) as discussed below. It some cases it may prove beneficial for the IAEA to utilize shared operator data, particularly where environmental conditions present challenges for IAEA equipment, or where costly operator instrumentation is already in use. Security and infrastructure requirements related to safeguards equipment will be addressed as part of SBD.

It is also expected that IAEA seals will be routinely placed and removed by operators rather than by IAEA inspectors, and protocols for these processes that ensure continuity of knowledge by the IAEA will need to be agreed with the CNSC and IAEA.

3.5. Near Real Time System (NRTS)

The safeguards approach is likely to employ an NRTS to meet the efficiency objectives discussed earlier, at all stages of operation. An NRTS performs automated analysis in near real time, matching operator declared events with events generated through installed safeguards equipment. The IAEA has had success in implementing NRTS in difficult-to-access conditions at Chornobyl [5] and has incorporated an NRTS in its safeguards approach at the Finnish DGR [6]. The Canadian application may challenge the efficiency of current IAEA algorithms due to the high frequency of daily transfers, unlike in the case Finland (weekly) or Chornobyl. The Canadian case also involves multiple fuel waste owners potentially shipping simultaneously, and potentially simultaneous emplacement in multiple placement rooms. These aspects will be addressed as part of the SBD discussions.

4. THE IMPORTANCE OF SAFEGUARDS BY DESIGN

The DGR will present novel technology and processes that may require new or modified safeguards measures and/or equipment. Challenging aspects of the DGR and associated transportation include:

- Volume and frequency of nuclear material transported and processed;
- Distance, weather conditions, and other conditions associated with used-fuel transportation;
- Size and remote location of the facility;
- Duration of the project;
- Continuing hybrid status of project as a construction and operational site;
- Transfer of nuclear material through several safeguards regimes (waste owner to transportation to DGR receipt to DGR processing to DGR emplacement), while minimizing safeguards remeasurement, reverification, and inspector presence;
- Transfer of nuclear material underground with associated health, safety, and practical challenges for independent monitoring;
- Inability to reverify nuclear material once emplaced; and
- Risk of damage or false readings from underground installed monitoring equipment due to environmental conditions, operational activity, and ongoing construction (e.g., excavation by drill-and-blast or other methods).

SBD will play an important role in the preparations by all stakeholders (internal and external) for efficient and effective safeguards implementation. In particular, the many interfaces between internal stakeholders – e.g., security, infrastructure and operations – and safeguards will be considered.

It is expected that a multilateral task force (NWMO, CNSC, IAEA, fuel waste owners) will be established that identifies safeguards requirements in consideration of the above novel aspects and objectives, and develops a work plan to ensure that these requirements are met in a timely manner. This task force would necessarily interface

with other DGR developers (e.g., Posiva and STUK in Finland) to learn from experience related to similar novel aspects

5. SUMMARY

The NWMO's Safeguards Plan lays the groundwork for discussions with the CNSC, IAEA, and fuel waste owners to establish an efficient and effective safeguards approach addressing all life cycle phases of Canada's first DGR (pre-operation, operation, post-closure). The Plan integrates safeguards planning into design engineering at the earliest stages (safeguards by design), in order to minimize impact on construction and operation while meeting all regulatory requirements and international obligations. This integration also links transportation, encapsulation (UFPP), and emplacement (underground) activities, as the safeguards approach will seamlessly span all three stages and involve multiple stakeholders. Early engagement of these stakeholders is thus paramount, in addition to multi-level training and incorporation of international best practices, and this will further inform project development in collaboration with the CNSC and IAEA.

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