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SUPPLEMENT ANALYSIS
FOR THE FOREIGN RESEARCH REACTOR SPENT
NUCLEAR FUEL ACCEPTANCE PROGRAM
Highly Enriched Uranium
Target Residue Material Transportation



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1.0 INTRODUCTION

The Department of Energy (DOE) has a continuing responsibility for safeguarding and managing highly enriched uranium¹ (HEU), including that found in existing and projected quantities of spent nuclear fuel (SNF) managed by DOE's Savannah River Site (SRS) in South Carolina. DOE has prepared analyses and issued records of decision (RODs) pursuant to the National Environmental Policy Act (NEPA) related to SNF management at SRS, including:

The Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF PEIS) (DOE/EIS-0203) (DOE 1995a, 1995b) evaluated alternatives for management of SNF for which DOE is responsible, including production reactor fuel, Naval reactor fuel, and domestic and foreign research reactor fuel;

The Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel Environmental Impact Statement (FRR SNF EIS) (DOE/EIS-0218) (DOE 1996a, 1996b), which is tiered from the *SNF PEIS*, evaluated alternatives for return to the United States for storage and disposition of foreign research reactor SNF and target material² containing uranium enriched in the United States and supplied to foreign countries; and

The Savannah River Site Spent Nuclear Fuel Management Environmental Impact Statement (SRS SNF EIS) (DOE/EIS-0279) (DOE 2000a, 2000b) evaluated alternatives for storage and disposition of the SNF and targets³ that SRS manages. The *SRS SNF EIS* is tiered from both the *SNF PEIS* and the *FRR SNF EIS*.

In addition, in March 2013, DOE issued the *Supplement Analysis – Savannah River Site Spent Nuclear Fuel Management (SRS SNF SA)* (DOE/EIS-0279-SA-01 and DOE/EIS-0218-SA-06) (DOE 2013), which addressed DOE's proposal to change the management method for 3.3 metric tons (heavy metal) of foreign research reactor SNF from a melt and dilute to a conventional processing approach, and to transport target residue material from Canada to the United States as HEU solutions rather than in a previously-analyzed solid form. These HEU solutions contain HEU that had been supplied to Canada by the United States. Informed by the *SRS SNF SA*, DOE determined that the proposed changes in the management methods for these materials would represent neither substantial changes to the actions evaluated in the *FRR SNF EIS* and the *SRS SNF EIS*, nor significant new circumstances or information relevant to environmental concerns.

Since publication of the *SRS SNF SA*, DOE has obtained additional information that bears on the proposed shipment of target residue material from Canada. Additional information has been obtained pertaining to

¹ HEU is uranium enriched in the fissile isotope uranium-235 to a level of 20 percent or greater.

² Targets are radioactive materials placed inside a nuclear reactor to produce particular radioisotopes. Target residue material is residue left after the desired radioisotopes have been removed from the targets. For example, the target residue material that is the subject of this SA consists of HEU and other radioactive materials from the production in a research reactor of molybdenum-99, which decays to technetium-99, a medical isotope (DOE 1996a, Appendix B, Section B.1.5). The target residue material addressed in this SA is in the chemical form of highly enriched uranyl nitrate, termed HEUNL or HEU solutions. Target residue material is not high-level radioactive waste.

³ See footnote 2.

the assessment of potential risks to public health and safety and the environment associated with the proposed transport.

In accordance with DOE NEPA Implementing Procedures (Title 10, Code of Federal Regulations, Section 1021.314(c) [10 CFR 1021.314(c)]) DOE has prepared this supplement analysis (SA) to assist in making a determination about whether the change in the chemical form of the HEU to be transported constitutes a substantial change in the proposed action that is relevant to environmental concerns, or whether there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its potential impacts. This SA provides a detailed review of the process for transport package certification in the United States and Canada, the DOE program to train and familiarize first responders about the proposed shipments, and an analysis prepared by the Canadian Nuclear Safety Commission (CNSC) of the potential impacts of transporting the target residue material within Canada.

1.1 Prior NEPA Review

Tiering from the *SNF PEIS*, the *FRR SNF EIS* (DOE 1996a) evaluated alternatives for return to the United States of SNF and target material containing HEU and low-enriched uranium enriched in the United States and supplied to foreign countries. Return of HEU for safe storage and disposition advances the United States' nuclear material nonproliferation goals. Appendix B.1.5 of the *FRR SNF EIS* discusses two methods for preparing target material for transport: calcining and oxidizing. For the *FRR SNF EIS*, DOE assumed that target material would be transported in solid form, and accordingly, evaluated the potential impacts of transportation of the material. In Appendix B.2.1.2, DOE stated that foreign research reactor shipments would be carried out in compliance with regulations set by the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC). In the *FRR SNF EIS* ROD (DOE 1996b), DOE decided, consistent with the programmatic decision to consolidate storage by fuel type, to transport to, and store aluminum-clad SNF and target material at, SRS.

The *SRS SNF SA* (DOE 2013) includes an analysis of the potential environmental impacts of transporting target residue material as HEU solution from Canada to SRS in the United States, and temporarily storing and then processing the material at H-Canyon. Because the proposed shipment of target residue material as HEU solutions represented a change from previous NEPA analyses, the *SRS SNF SA* includes a detailed evaluation of the potential environmental impacts that could occur during transport from the Canadian border to SRS. As addressed in Section 1.3, the impacts of transporting the target residue material were determined to be very small and less than those evaluated in the *FRR SNF EIS* (DOE 1996a).

1.2 Proposed Action

DOE proposes to transport target residue material, consisting of HEU of United States origin, from Canada as part of DOE's foreign research reactor SNF acceptance program. The material would be transported to SRS as HEU solutions in the chemical form of uranyl nitrate (HEUNL).

1.3 Transport and Receipt of Target Residue Material as HEU Solutions

Processing irradiated HEU targets to recover the produced radioisotopes leaves residue that contains HEU. Depending on the process used to recover the isotopes, the residue may be in liquid or solid form. About 6,000 gallons of target residue material from a research reactor used for radioisotope production is stored as HEUNL in the Fissile Solution Storage Tank at Chalk River Laboratories in Ontario, Canada. For the action evaluated in this SA, the HEUNL would be placed in small, 15.35-gallon capacity inner containers, and four of these inner containers would be secured within an NAC International, Inc. (NAC) Legal Weight Truck (LWT) Type B cask (NAC-LWT cask) certified for use in both Canada and the United States. For transport, each cask would be secured within a large shipping container qualified to International Standards

Organization standards (see **Figure 1**). Each truck shipment would transport one large container. The action addressed by this SA could involve up to 150 truck shipments. This is a conservative estimate for the number of shipments to account for uncertainty regarding factors such as the actual quantity of material in each inner container and the flushing rate of the HEUNL from the Fissile Solution Storage Tank.



Figure 1. Transport Truck with ISO Container in which the NAC-LWT Cask is Carried

All shipments would be conducted in a manner that meets or exceeds the regulatory requirements of DOT and NRC. This includes use of routes in the United States selected in accordance with DOT and NRC requirements; NRC-approved safe havens and emergency plans; DOE approval of transportation and security plans; an export license from the originating country (Canada); and DOE approval to transport, signifying that all advanced preparations are complete to receive the authorized material into the specified DOE receiving facility. Once a shipment has been unloaded at the receiving facility, the shipping container, cask, and inner containers would be returned to Canada for use in other shipments. The inner containers would contain residual radioactivity that remains after flushing them to remove the HEUNL.

DOE would receive the HEUNL at SRS for temporary storage within an existing tank in H-Canyon, pending processing at H-Canyon to recover the HEU. DOE would accumulate enough HEUNL for efficient processing, and anticipates processing the entire quantity in several batches through H-Canyon. The shipping schedule would be coordinated with the processing schedule to minimize the accumulation of the Canadian HEUNL at SRS and ensure adequate tank capacity is available prior to each processing campaign. Consistent with DOE's December 1, 2004, Revised ROD (61 *Federal Register* 69901) for the *FRR SNF EIS*, DOE would not accept target residue material from Canada if H-Canyon were unavailable (DOE 2004).

In Appendix A to the *SRS SNF SA* (DOE 2013), DOE evaluated the potential environmental impacts of transporting target residue material in the form of HEU solutions from the Canadian border to SRS. DOE determined that no latent cancer fatalities (LCFs) would occur in workers or the public as a result of

incident-free transportation, and that per-shipment incident-free impacts would be small and of the same order of magnitude as those estimated for the shipment types analyzed in the *FRR SNF EIS* (DOE 1996a). The transportation evaluation indicated that non-radiological accident risks (the potential for fatalities as a direct result of traffic accidents) presented the greatest risks related to transportation of the target residue material, but no traffic fatalities would be expected. The evaluation assumed a representative transportation route for purpose of analysis; actual routes would be determined by the shipper, in consultation with DOE, in accordance with all applicable transportation regulations to ensure the safety of transportation workers and the general public and security of the shipments. Radiation doses from the most severe accident, a long duration high-temperature fire, would not cause an LCF. The overall impacts of transporting the target residue material were determined to be very small and less than those described in the *FRR SNF EIS* (DOE 1996a). See Appendix A of the *SRS SNF SA* (DOE 2013) and Section 2.0 of this SA for more details on the potential impacts of transporting the target residue material as HEU solutions.

2.0 RECENT DEVELOPMENTS RELATED TO THE TRANSPORT OF TARGET RESIDUE MATERIAL AS HEU SOLUTIONS

This section summarizes activities related to the safe transport of target residue material which have occurred since the *SRS SNF SA* was issued in March 2013 (DOE 2013). As addressed in Section 1.3, the target residue material would be transported as HEUNL within NAC-LWT casks certified for use within Canada and the United States. Section 2.1 addresses the process in the United States and Canada for regulatory review and transport cask certification; Section 2.2 discusses the DOE program to train and familiarize first responders in the United States regarding the proposed shipments; Section 2.3 summarizes the analysis performed by NRC to support a regulatory decision to transport the target residue material within the United States; Section 2.4 summarizes the analysis performed by CNSC to support a regulatory decision to transport the target residue material from its location in Canada to the United States border; and Section 2.5 addresses additional information regarding the potential impacts of possible acts of sabotage or terrorism during transport. The information below is consistent with DOE's assumptions and analysis in the *SRS SNF SA* and confirms that transport of target residue material in the form of HEU solutions from Canada to SRS would be performed in a manner that would be protective of the public, transport workers, and the environment.

2.1 Transport Cask Certification

2.1.1 Regulatory Requirements

DOE proposes to transport target residue material in the chemical form of HEUNL within NAC-LWT casks. An NAC-LWT cask is an NRC-certified Type B package that has been used for many years to transport HEU and various types of SNF within the United States and internationally. This section describes the regulatory regime for gaining approval to use this package for transportation of radioactive material.⁴

To ensure public safety worldwide, the international community has developed and adopted *Regulations for the Safe Transport of Radioactive Material* (IAEA 2012). The international authority for these regulations is the International Atomic Energy Agency (IAEA). As IAEA regulations are issued and updated, individual nations promulgate compatible regulations that ensure safe transport of radioactive material both within those nations and between nations. In the United States, the DOT and NRC share

⁴ The requirements summarized in this section use the regulatory terminology packaging and package. When addressing the NAC-LWT Type B package, the more commonly used term cask is generally used.

regulatory authority for transport of radioactive material in commerce. In Canada, the regulatory authority is the CNSC.

To ensure safe transport of radioactive material, emphasis is placed on the performance of the transport package to shield workers and members of the public against the effects of radiation, to prevent an unwanted criticality, to prevent damage caused by heat, and to provide protection against dispersion of package contents. These objectives must be met under normal conditions of transport, which may include minor mishaps, and under severe accident conditions.

IAEA regulations identify five classification levels of radioactive material packaging that impose increasingly stringent requirements in accordance with the activity and physical form of the radioactive material contained in the package (IAEA 2012):

- Excepted
- Industrial
- Type A
- Type B
- Type C

Design requirements and test procedures are established for each package classification level. In addition to general design requirements that apply to all packaging, a graded set of requirements are imposed that depend on the types and quantities of radioactive material, including requirements for package integrity under accident conditions.

Type B packages (also called casks) would be used for transport of HEUNL from Canada to the United States. Detailed requirements for Type B packages are contained in IAEA *Regulations for the Safe Transport of Radioactive Material* (IAEA 2012) and United States regulations in 10 CFR Part 71, *Packaging and Transportation of Radioactive Materials*. Type B packages must be designed to meet the requirements of 10 CFR Part 71, including:

- *General packaging requirements.* These requirements include those ensuring that packages can be handled safely and easily, lifted safely and secured properly, and perform their containment function under conditions of normal transport. Additional requirements include those addressing internal heat generation and internal pressure. For packages containing fissile material (e.g., HEU), requirements are imposed to avoid criticalities; these requirements relate to package design, the arrangement of the fissile material within the package, and the configuration of multiple packages.
- *Normal conditions of transport.* Compliance with this requirement is demonstrated through tests simulating minor mishaps. These tests include a free drop test, depending on the mass of the package, from a height of 0.3 to 1.2 meters (1 to 4 feet); a stacking test in which the package is subject to an equivalent compressive load of at least 5 times the maximum weight of the package; and a penetration test involving a 6-kilogram (13-pound) bar dropped onto the package from a height of 1 meter (3.3 feet). Each test must be preceded by a water spray test simulating exposure to rainfall of 5 centimeters per hour (2 inches per hour) for 1 hour. A package subjected to these tests must neither lose nor disperse its contents nor show more than a 20 percent increase in the radiation level at package surfaces.
- *Hypothetical accident conditions of transport.* Compliance with this requirement is demonstrated through analysis or tests as summarized in **Table 2-1**.

Table 2–1 Summary of Test Requirements for Demonstrating the Ability of a Type B Package to Withstand Accident Conditions of Transport

Test	Requirement ^a
Free drop	A package is dropped freely from 9 meters onto a flat, horizontal, unyielding surface so that the package strikes its most vulnerable location (i.e., where maximum damage to the package could occur). ^b
Puncture	A package is dropped from a height of 1 meter onto a 15-centimeter-diameter steel bar at least 20 centimeters long, with the bar striking the package at its most vulnerable location.
Dynamic crush ^c	A 500-kilogram mass is dropped from 9 meters onto a package with the mass striking the package at its most vulnerable location.
Thermal	A package is totally engulfed in a fire of 800° C (1,475° F) intensity for 30 minutes.
Immersion	A package is completely submerged under at least 15 meters of water for 8 hours. For packages carrying a large amount of radioactive material, an additional immersion test is required where the package would be immersed to a depth of at least 200 meters for 1 hour.

^a The listed free drop, puncture, dynamic crush, and thermal tests must be considered in sequence to determine their cumulative effects on a package.

^b Generally, a drop striking a package corner on the end containing the package lid.

^c Applicable only to packages having a mass not exceeding 500 kilograms, an overall density not exceeding 1,000 kilograms per cubic meter, and radioactive contents exceeding a specified quantity.

Note: To convert meters to feet, multiply by 3.2808; centimeters to inches, by 0.3937; kilograms to pounds, by 2.2046.

Source: IAEA 2012, WNTI 2015.

The tests summarized in Table 2–1 have been internationally accepted as simulating the damage to the package that could occur during the most severe credible accidents. Compliance with the packaging requirements must be demonstrated through analysis and testing. The impact, puncture, dynamic crush (if applicable),⁵ and thermal tests listed in Table 2–1 must be considered in sequence to determine their cumulative effects on one package. After completing the cumulative tests, the radiation level at 1 meter from the package must not exceed 1 rem per hour (10 millisievert per hour), and the accumulated loss of its radionuclide content must not exceed specified small quantities over a period of 1 week⁶ (IAEA 2012).

If the package is intended to carry large quantities of radionuclides, the package is subject to an additional immersion test. It must be designed and constructed so that its undamaged containment system would withstand an external water pressure of 2 million pascals (290 pounds per square inch), or immersion in 200 meters (660 feet) of water, for at least 1 hour without collapse, buckling, or allowing water to leak into the package.⁷

Under internationally-recognized procedures, Type B package designs proposed by a vendor or government agency must be reviewed by a delegated national authority, called a Competent Authority. If the Competent Authority determines that the cask design meets all performance requirements (see above), the Competent Authority may issue a certificate for use of the package for transporting specified radioactive material within specified parameters, including use of the package for radioactive material transport during a

⁵ The dynamic crush test is not applicable to the NAC-LWT cask because its mass greatly exceeds 500 kilograms (see Table 2–1).

⁶ Over a period of one week, the accumulated loss of the radioactive content must not exceed 10 times an “A₂” quantity for krypton-85 or an A₂ quantity for all other radionuclides. A₂ values (activity limits) for individual radionuclides are listed in Table 2 of the IAEA regulations and are equal to, for example, 16 curies (0.6 terabecquerels) for cesium-137 and 0.027 curies (0.001 terabecquerels) for plutonium-239. A sum-of-fractions assessment is made for mixtures of radionuclides (IAEA 2012).

⁷ Although a water immersion test of 15 meters (49 feet) is required for the HEUNL content, the NAC-LWT cask was subjected to a more conservative water immersion test at 200 meters (660 feet) for one hour (CNSC 2014).

specified period of time. After the specified period of time, the Certificate of Approval lapses and continued use of the package for radioactive material transport must be re-authorized by the Competent Authority. This ensures that advances in technical information and analysis can be incorporated into the package design. In addition, proposed amendments to the package design – for example, to authorize transport of additional radioactive materials (e.g., additional types of SNF) – must be approved by the Competent Authority.

Pursuant to a 1979 Memorandum of Understanding (MOU) with the NRC (NRC/DOT 1979), DOT is the designated United States Competent Authority. DOT is the United States representative to the IAEA for purposes of radioactive material transportation and is responsible for issuing Competent Authority Certificates for Type B packages, which DOT titles Competent Authority Certifications. In order to issue a Competent Authority Certification, DOT requires that certain packages (other than DOT specification packages) be approved by the NRC through the issuance of a Certificate of Compliance. The application for an NRC Certificate of Compliance typically includes an applicant-prepared safety analysis report (SAR) addressing package structural and thermal performance, radiation shielding, nuclear criticality, material confinement, testing and maintenance requirements, operating procedures, and conditions for package use. DOT also requires NRC approval of revised or renewed Certificates of Compliance before issuing revised or modified Competent Authority Certifications.

Shippers proposing to use a Type B package outside the country of origin must obtain a Certificate of Competent Authority (COCA) from the country of intended use. That is, a Competent Authority for the country of intended use would review the certificate issued by the Competent Authority for the country of origin, and, as required, additional information supporting the regulatory review. The Competent Authority would issue a COCA if it determines that the package meets its regulatory requirements. As discussed in Section 2.1.2, for the proposed shipment of HEUNL from Canada to the United States, DOT has issued a Competent Authority Certification for the package in consultation with the NRC and in consideration of the NRC Certificate of Compliance. As the Competent Authority for Canada, CNSC has issued a COCA for use of the package within Canada.

The regulatory approval process, including the analysis and testing described above, ensures an extremely low risk of any material being released from a package during normal and accident conditions of transport. Consequently, the potential for impacts on the public and contamination of surface or ground water are extremely low.

2.1.2 Certification of the NAC-LWT Cask for HEUNL

When the *SRS SNF SA* was published in March 2013 (DOE 2013), the vendor for the designated shipping cask, NAC International (NAC), had submitted applications to the appropriate regulatory agencies in the United States and Canada to authorize shipment of HEUNL within the NAC-LWT cask, but had not yet received regulatory approval (see below). The NAC-LWT cask has been used internationally for more than 20 years for safe transport of HEU and many types of SNF. Transport of HEU within the NAC-LWT cask is certified within the United States (certificate number USA/9225/B(U)F-96) and Canada (certificate number CDN/E173/96). Both certificates have been renewed or amended several times, indicating that several regulatory reviews have occurred over the years for variants of material to be shipped in the same basic package. The NAC-LWT cask is a lead-lined package with a cylindrical cavity designed to enable shipment of HEU and various types of SNF by reconfiguring the internal components which secure the shipped material within the cavity. To ship HEUNL using the NAC-LWT package, NAC modified the package to enable safe containment of four liquid-holding containers within the internal cavity and has received a Certificate of Compliance for the modifications from the NRC (NRC 2014a), a Competent Authority Certification from DOT, and Certificate of Competent Authority from CNSC (CNSC 2015).

United States Regulatory Process

On June 18, 2010, NAC submitted an application to NRC requesting the addition of HEUNL to the approved content for the NAC-LWT package design. On December 24, 2014, after reviewing the application and additional information provided by NAC, NRC issued Revision Number 61 of the Certificate of Compliance for the NAC-LWT cask, certifying use of the cask for shipment of HEUNL. NRC concluded that the cask meets the applicable safety standards of 10 CFR Part 71 (NRC 2014a, 2014b). Under the revised Certificate of Compliance (2014a), each cask may ship up to 4 inner containers⁸ holding HEUNL, with up to 58.1 liters (15.35 gallons) within each container, or a total within the cask of 232.4 liters (61.4 gallons) of HEUNL (although each container must include a minimum of 1 gallon [3.8 liters] of headspace). Additional restrictions on HEUNL shipment are summarized in **Table 2–2**. On January 29, 2015, informed by the NRC analysis and the revised Certificate of Compliance, DOT issued a Competent Authority Certification certifying that the package met regulatory requirements for a Type B package for fissile radioactive material as prescribed by IAEA and United States regulations (DOT 2015).

Table 2–2 Summary of Restrictions on Shipment of HEUNL within NAC-LWT Casks

<i>Liquid Parameter</i>	<i>Limiting Values</i>
Maximum HEUNL payload per inner container ^{a,b}	58.1 liters (15.35 gallons)
Maximum package heat load	4.65 watts
Maximum inner container heat load (per container)	1.16 watts
Maximum HEUNL heat load	0.02 watts per liter
Maximum radionuclide content (gamma emitters)	9.0 curies per liter
Maximum uranium-235 content	7.4 grams per liter
Maximum uranium-235 enrichment	93.4 weight-percent

HEUNL = highly enriched uranyl nitrate liquid; NAC-LWT = NAC International, Inc., Legal Weight Truck.

^a Each inner container must include a minimum of 1 gallon (3.8 liters) of headspace.

^b Because each NAC-LWT package contains 4 inner containers, an NAC-LWT package can ship up to 232.4 liters (61.4 gallons) of HEUNL.

Source: NRC 2014a.

Canadian Regulatory Process

On December 28, 2012, NAC submitted an application to CNSC for approval of shipment of HEUNL within the NAC-LWT cask. CNSC staff reviewed the application and information independently from NRC to determine whether Canadian regulatory requirements were met. After issuing a draft document for public review and comment, in December 2014, CNSC issued *Technical Assessment Report: NAC-LWT Package Design for Transport of Highly Enriched Uranyl Nitrate Liquid (Technical Assessment Report)* (CNSC 2014). This document summarizes the CNSC staff review of NAC's application and states that CNSC staff was satisfied that the transport package design for the proposed shipment of HEUNL met all Canadian and international regulatory requirements (see Section 2.4). Certification of the cask is only one of the regulatory requirements that must be met prior to transport of the HEUNL. At the time the *Technical Assessment Report* was issued, the CNSC had not yet received an application to transport or export HEUNL to the United States. CNSC stated that prior to approval of shipments of HEUNL in a certified package,

⁸ Appendix A of the *SRS SNF SA* (DOE 2013) assumed that each NAC-LWT cask would transport 60 gallons of HEUNL in a single container; that information is superseded by the NRC Certificate of Compliance which specifies that the cask cavity contain four containers, with a maximum total payload volume of 61.4 gallons (see Table 2–2). As required by the NRC Certification of Compliance, empty containers (or suitable spacers) would be used as needed to occupy space within the cask cavity.

CNSC would ensure that all regulatory requirements would be met including the approval of a transport security plan for the shipments, the approval of an Emergency Response Assistance Plan by Transport Canada, and the issuance of a CNSC export license (CNSC 2014). CNSC has issued its Certificate of Competent Authority for the NAC-LWT cask (CNSC 2015).

2.2 Training and Familiarization of Emergency Responders Regarding HEU Shipments

Appendix A of the *SRS SNF SA* (DOE 2013) summarizes Federal responsibilities within the United States for developing and implementing emergency response plans in the event of a transportation incident. Plans are developed with state and, where appropriate, tribal participation. The response to an incident, including the parties involved in the response, would depend on the nature of the accident, the location, and the quantity (if any) of radioactive material released. The CNSC Technical Assistance Report describes emergency preparedness and response procedures within Canada (CNSC 2014).

DOE offers a variety of training courses to prepare emergency responders for response to transportation accidents involving radioactive material. The training activities summarized in **Table 2–3** occurred over the last 3 years in preparation for the shipment of the HEUNL. DOE conducted more than 100 training classes, attended by more than 2,000 students, in the 7 states along possible transportation routes between the Canadian ports of entry at Buffalo, New York and Alexandria Bay, New York to SRS. In addition, DOE conducted 4 table-top exercises attended by approximately 260 trainees, as well as 3 full-scale emergency response exercises.⁹ DOE has made a number of presentations to state and tribal officials and emergency response audiences along the potential transportation routes regarding the proposed shipments. In June 2015, Canadian Nuclear Laboratories (CNL), the operator of Chalk River Laboratories in Ontario, Canada, and DOE undertook a two-week demonstration that traversed the proposed shipping routes, whereby DOE met with participating tribal, state agency, emergency response, fire, and police personnel (see **Figure 2**). This demonstration included presentations about the shipment program, examples of equipment that would be used during the shipping campaigns, and the display of an actual empty HEUNL container and NAC-LWT cask (see **Figures 3** and **4**). The cask was physically opened to enable attendees to visually inspect the cask and to enhance the attendees' understanding of its appearance, construction, and inherent safety characteristics.

⁹ Training classes typically include instruction in radioactive material identification; radiation protection principles, instrumentation, and accident victim decontamination techniques; resources available to first responders; and the types of packages that may be encountered. A table-top exercise is one where the participants gather in a round-table, moderated setting and talk through expected actions in response to hypothetical emergency scenarios. A full-scale exercise is a drill where the participants respond to an accident scenario as they would during an actual emergency (DOE 2002a).

Table 2-3 DOE Transportation Emergency Preparedness Program Training and Exercises

<i>State</i>	<i>Training Classes</i>		<i>Exercises</i>		
	<i>Number of Classes</i>	<i>Number of Students</i>	<i>Table-Top Exercises</i>	<i>Table-Top Participants</i>	<i>Full-Scale Exercises</i>
Maryland	2	37			
New York	30	638	2	100	1
North Carolina	13	346	1	46	
Pennsylvania	26	349	1	110	1
South Carolina	13	185			
Virginia	18	405			1
West Virginia	4	72			
Totals	106	2,032			

^a Summary of training classes and exercises in the listed states in the listed states conducted by DOE from May 1, 2012, through March 18, 2015.



Figure 2. Demonstration Equipment and Attendees

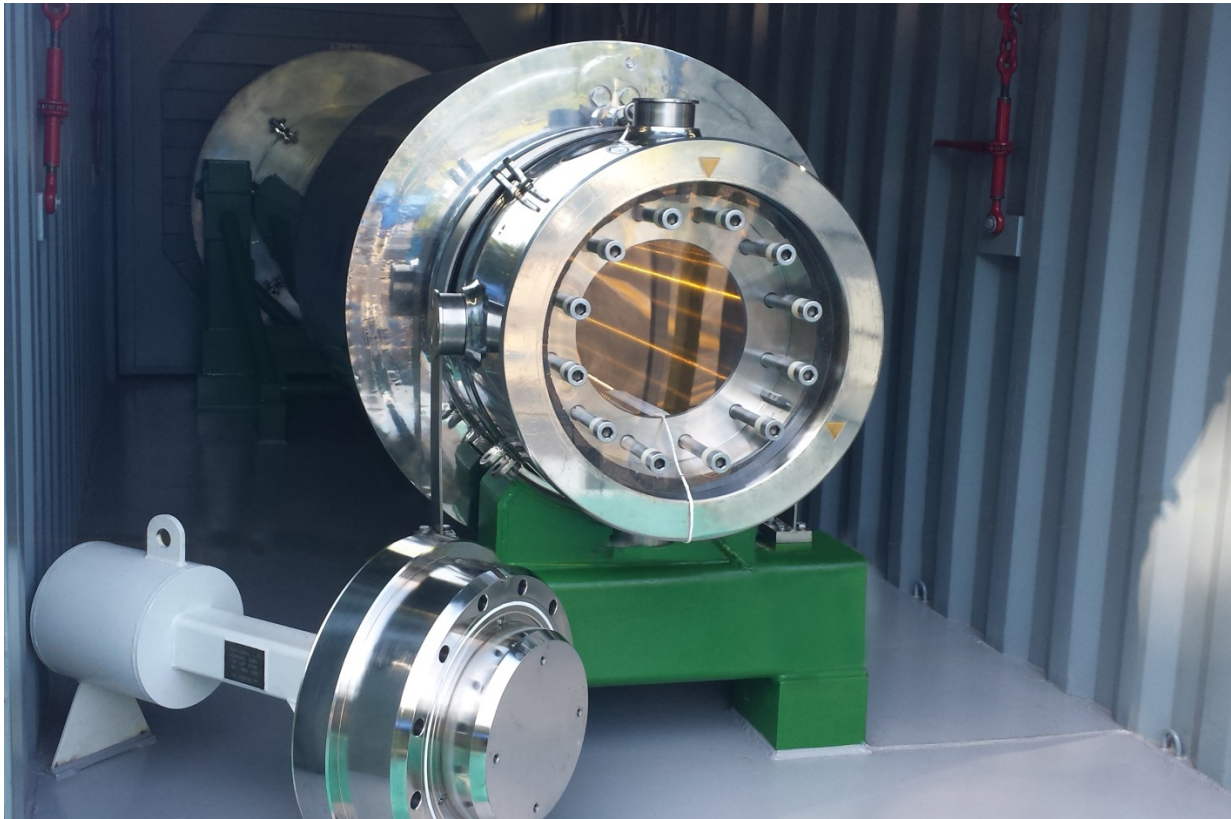


Figure 3. NAC-LWT Cask

2.3 NRC Analysis of the NAC-LWT Cask

NRC issued Revision Number 61 of the Certificate of Compliance for the NAC-LWT cask (NRC 2014a) based on its technical review as documented in a safety evaluation report (SER) (NRC 2014b). NRC performed its review of NAC’s application for certification of the NAC-LWT cask for transport of HEUNL using guidance in NUREG-1609, *Standard Review Plan for Transportation Packages for Radioactive Materials* (NRC 1999).

NRC staff evaluated the ability of the cask to meet safety requirements under normal and hypothetical accident conditions of transport, including those pertaining to containment of package contents, external radiation levels, and criticality. For example, NRC staff evaluated the package for hypothetical accident conditions using “classical, closed-form calculations and finite element analysis results” and determined a minimum margin of safety of 3.5 for a drop from 9-meters (30-feet) on the bottom of the cask, and a minimum margin of safety of 7.47 for a drop from the same height on the side of the cask. Assuming a hypothetical fire accident as prescribed in NRC and international regulations (see Table 2–1), NRC staff concluded that their evaluations demonstrated a minimum margin of safety of 10 for an increase in internal cask pressure resulting from the fire. Considering all applicable requirements, NRC staff determined that the structural design had been adequately described and evaluated



Figure 4. HEUNL Inner Container

and that the package had adequate structural integrity to meet the requirements of 10 CFR Part 71. This determination included a statement of reasonable assurance that the NAC-LWT package with the HEUNL content within individual containers would meet the containment requirements of 10 CFR Part 71 (NRC 2014b).

With respect to external radiation levels, NRC staff evaluated the submitted information provided by NAC as part of the application and determined that NAC's conservative assumptions and analysis methods were appropriate. NRC also performed confirmatory analyses to verify possible package dose rates resulting from the presence of HEUNL in the cask. For example, NAC projected a maximum dose rate at 1 meter from the cask surface of 3.13 millirem per hour, which is about 0.3 percent of the limit in 10 CFR 71.51, "Additional requirements for Type B packages," of 1 rem per hour following completion of all accident tests. NRC's confirmatory analysis was in "reasonable agreement" with NAC's analysis. NRC determined that the transportation of the HEUNL within the NAC-LWT cask would not affect its ability to meet the dose limits in 10 CFR Part 71 under normal and accident conditions (NRC 2014b).

With respect to criticality safety, NRC performed in-depth evaluations of the information provided by NAC as part of its application and performed confirmatory analyses. Informed by these evaluations and analyses, NRC determined that HEUNL transported within NAC-LWT casks would maintain in a sub-critical condition under both normal and hypothetical accident conditions of transport (NRC 2014b).

To summarize, NRC staff agreed that the proposed addition of HEUNL as an authorized content to the NAC-LWT cask would not change the ability of the package to meet the requirements of 10 CFR Part 71 (NRC 2014b).

2.4 CNSC Analysis of the NAC-LWT Cask

As stated in Section 2.1.2, CNSC issued a *Technical Assessment Report* addressing the NAC application to use the NAC-LWT cask for transport of HEUNL within Canada (CNSC 2014). CNSC staff conducted a technical assessment of the application submitted by NAC to CNSC for the certification of the NAC-LWT cask to contain HEUNL. CNSC staff also prepared an environmental assessment information report (EAIR) under the Canadian Nuclear Safety and Control Act (NSCA) evaluating the proposed transport of HEUNL within Canada using the NAC-LWT cask. CNSC staff took this EAIR into account during their review of the NAC application for certification of the NAC-LWT cask.

2.4.1 Technical Assessment of the NAC-LWT Cask

The CNSC technical assessment focused on whether the package design met the regulatory requirements specified in Canada's Packaging and Transport of Nuclear Substances Regulations (PTNSR) and the IAEA *Regulations for the Safe Transport of Radioactive Material* (2009 Edition),¹⁰ namely:

- Package design requirements under normal conditions of transport
- Package design requirements under accident conditions of transport
- Criticality safety

The technical assessment was conducted using CNSC regulatory document RD/GD-364, *Joint Canada – United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages*. This document describes the requirements to ensure compliance with the Canadian PTNSR, which incorporate,

¹⁰ Type B package and test requirements in the 2009 edition of the IAEA Regulations for the Safe Transport of Radioactive Material (IAEA 2009) are the same as those in the 2012 edition of these same regulations (IAEA 2012).

in part, the 1996 Edition (Revised) (IAEA 2000) and the 2009 Edition of the IAEA regulations (IAEA 2009). These regulations are acceptable to DOT and NRC for complying with United States regulations in 10 CFR Part 71, which also incorporates, in part, the IAEA regulations.

The CNSC *Technical Assessment Report* describes the characteristics of the HEUNL to be transported within the NAC-LWT cask. It states that these characteristics are well within the limits evaluated in the NAC-LWT application. Table 2 of the report provides a listing of the important radionuclides in the HEUNL and the expected external dose rates at the cask surface and at 1 meter (3.3 feet) from the cask surface. The report enumerates the various regulatory tests required for the certification of the cask, including those described in Section 2.1.1 of this SA, to demonstrate safety during normal and accident conditions of travel.

CNSC staff verified and confirmed the NAC analysis which concluded that the only damage to the NAC-LWT cask that could arise from normal and accident conditions of transportation would be possible damage to the cask's neutron shielding from the specified 9-meter (30-foot) drop test followed by the puncture test. The effect of this hypothetical damage to neutron shielding, however, would be a slight increase in the radiation dose rate at 1 meter (3.3 feet) from the package surface from 2 millirem per hour (0.02 millisievert per hour) to 3 millirem per hour (0.03 millisievert per hour) (CNSC 2014). The increased dose rate (3 millirem per hour [0.03 millisievert per hour]) is a small fraction (0.003) of the PTNSR and IAEA regulatory limit (following completion of the accident tests) of 1 rem per hour (10 millisievert per hour) at 1 meter (3.3 feet) from the package surface (CNSC 2014). (The dose limit of 1 rem per hour following completion of accident tests cited by CNSC staff in the *Technical Evaluation Report* is the same as the NRC limit specified in 10 CFR 71.51, "Additional requirements for Type B packages" [see Section 2.3].)

Based on its detailed review of the information provided by NAC, the CNSC staff confirmed that the cask would meet all regulatory requirements when transporting HEUNL, including compliance with temperature, internal pressure, and criticality prevention requirements, under both normal and accident conditions of transport (CNSC 2014).

2.4.2 Environmental Assessment of Transport of HEUNL within Canada

CNSC staff conducted an environmental assessment under the Canadian NSCA which evaluated the potential impacts of transporting HEUNL within Canada using the NAC-LWT cask. This environmental assessment considered the information supplied by NAC as well as DOE's *SRS SNF SA* (DOE 2013). This environmental assessment is summarized in the CNSC *Technical Assessment Report* as an EAIR, focusing on the following areas:

- Dose to the public and workers during normal transport conditions;
- Dose to the public and workers during severe transport accident conditions, including impacts on drinking water; and,
- Emergency response planning to mitigate potential environmental effects during a transportation accident.

CNSC staff concluded that the NAC-LWT package proposed for transport of HEUNL will ensure the protection of the environment and health and safety of people (CNSC 2014), as discussed below.

2.4.2.1 Normal Conditions of Transport

Risks from normal transport conditions are limited to external exposure to gamma and neutron radiation from the radionuclides sealed within the cask, as identified in the NAC SAR for the NAC-LWT cask (CNSC 2014). For its EAIR, CNSC staff evaluated potential radiation doses to the same three receptors that DOE identified in the *SRS SNF SA* (DOE 2013) as representative of individuals most likely to be exposed, and thus representing the general public for purposes of analysis. These receptors consisted of a person assumed to be stuck in traffic next to a NAC-LWT cask transporting HEUNL; a resident along the route used by the

transport vehicles; and a service station worker during a stop to fuel or otherwise service the transport vehicle during shipment.

CNSC staff evaluated radiation doses to the selected receptors using two methods. The first method considered the analysis parameters used by DOE in the *SRS SNF SA* (DOE 2013), but assumed a radionuclide inventory within the cask using information obtained from the NAC SAR and CNL. The second method evaluated potential impacts assuming a transport index (TI) of 10 – that is, a number equivalent to a dose rate of 10 millirem/hour (0.1 millisievert/hour) at 1 meter (3.3 feet) from the package surface (i.e., independent of the inventory). The DOE analysis was also performed assuming a TI of 10 (DOE 2013).

The results of the CNSC assessment are compared in **Table 2–4** with the results of the DOE analysis in the *SRS SNF SA*. As shown, the estimated doses to members of the public and truck drivers are higher in DOE’s *SRS SNF SA* than those estimated by CNSC, even though DOE and CNSC (for its second analysis method) both assumed the same package radiation dose (10 millirem/hour [0.1 millisievert/hour] at 1 meter from the package surface). The reason for the difference is that the DOE estimate was made using the RADTRAN computer code which uses a more conservative approach for determining external radiation dose at distances from a package surface. Even so, the doses to members of the public and truck drivers under the DOE analysis protocol are also low and well below the applicable regulatory dose limits.

As shown in the table, the results from the CNSC analysis (both methods) and the *SRS SNF SA* demonstrate that radiation doses to the evaluated members of the public would be small and well below the United States and Canadian regulatory dose limit of 100 millirem/year (1 millisievert/year). In addition, the doses to the truck drivers would be well below the regulatory limits of 5 rem/year (50 millisievert/year) and 10 rem (100 millisievert) over 5 years for nuclear energy (trained radiation) workers.

Table 2–4 CNSC Assessment of Radiation Dose per Shipment for Representative Receptors

<i>Receptor</i>	<i>Inventory based dose (millirem/shipment)</i>	<i>TI-based dose (millirem/shipment)</i>	<i>US DOE SA (millirem/shipment)</i>
A person in traffic for 30 minutes at 1.2 meters from the cask	0.44	3.5	15
A resident living 30 meters from the transport route	0.00013	0.00034	0.00098
A service station worker 16 meters from the cask for 50 minutes	0.108	0.26	0.83
A driver located 2 meters from the cask for a duration of 26 hours	12	94	280 ^a

SA = supplement analysis; TI = transport index.

^a Dose to two drivers.

Note: To convert a dose in millirem to the equivalent dose in millisievert, multiply by 0.01; to convert meters to feet, multiply by 3.281.

Source: CNSC2014; DOE 2013.

CNSC staff concluded that DOE’s analysis (DOE 2013) was “sufficiently conservative and thorough to demonstrate radiation protection of the public, as the dose rates per event are well below the regulatory dose limit” (1 millisievert [100 millirem] per year) (CNSC 2014). CNSC staff additionally concluded that “the dose to the [truck] driver remains low and well within the annual dose limit for nuclear energy workers” (CNSC 2014).

2.4.2.2 Accident Transport Conditions

Land-Based Accidents

Similar to the DOE's assessment in the *SRS SNF SA* (DOE 2013) (Appendix A, Table 6), CNSC staff evaluated the public doses that could result from an extremely low-probability transportation accident resulting in the release and dispersal of radioactive material into the environment (a probability of 6.6×10^{-12} per year, assuming all shipments occurred in one year). As stated in the *Technical Assessment Report*, CNSC staff considers this accident scenario to be non-credible, because the proposed NAC-LWT cask is designed to withstand conditions of transport with no or minimal release of material from the package under severe accidents (CNSC 2014). Nonetheless, CNSC staff performed an analysis to assess the potential dose to the most exposed individual resulting from a postulated severe accident.

As part of its analysis summarized in the *Technical Assessment Report*, CNSC verified that NAC had demonstrated that the NAC-LWT cask would maintain a leak tightness of 1×10^{-7} ref-cubic centimeters per second (ref-cm³/s)¹¹ per ANSI N14.5-1997¹² during normal conditions of transport and following the tests for accident conditions of transport. In so doing, the CNSC staff did not credit the inner containers in preventing a release inside the package cavity during accident conditions. The performance of the inner container adds to the overall performance and level of safety of the package design (see Section 2.1.2). Although CNSC staff considered "this accident scenario to be non-credible," the assessment was performed because experience "demonstrated that this could be a potential area of interest" (CNSC 2014).

CNSC staff assumed that a severe accident would result in a leak from the package equal to the maximum leak rate specified in the PTNSR and IAEA regulations – that is, a release of 0.033 percent of the HEUNL contents (or 0.022 gallons [0.085 liters]) – and assessed the effects of such a release on potentially exposed individuals.¹³ For purposes of analysis, CNSC staff assumed that the release caused spillage of radioactive material onto the ground and that individuals would be exposed to radiation from these spills. CNSC staff identified two exposure scenarios (presented in **Table 2–5**) that could reasonably represent highly exposed individuals for the purposes of the assessment. The scenarios differed with respect to the area over which the spilled radioactive material was assumed to be spread. The 30-minute exposure time assumed in each scenario was deemed conservative, as first responders would likely move people away and cordon off the area within this timeframe (CNSC 2014).

Based on the DOE and CNSC staff analysis of land-based accident scenarios, CNSC staff concluded that "even under extremely unlikely accident conditions, the doses to the most exposed individuals would remain low and well within the [Canadian] emergency regulatory dose limits for the public and nuclear energy workers" (CNSC 2014).

¹¹ Ref-cubic centimeter per sec is defined as a volume of 1 cubic centimeter of dry air per second at a pressure of one atmosphere absolute and 25 degrees Celsius.

¹² *American National Standards Institute (ANSI), Radioactive Materials – Leakage Tests on Packages for Shipment*, ANSI N14.5-1997.

¹³ Under PTNSR, IAEA, and NRC regulations, a Type B package (e.g., a NAC-LWT) must be designed, constructed, and prepared for shipment so that under the tests specified in the regulations there would be no release of radioactive material, except for krypton-85, exceeding an A₂ quantity of material in 1 week (see footnote 5). DOE confirmed that the value cited in the *Technical Assessment Report* (0.033 percent released) corresponded to a release of an A₂ quantity of radioactive material from the NAC-LWT cask under the hypothetical accident conditions.

Table 2–5 CNSC Assessment of the Radiation Dose to Two Highly Exposed Receptors under Accident Conditions

<i>Receptor</i>	<i>Dose (millirem per event)</i>
A person standing in the center of a 1-meter radius spill of 0.033% of the inventory of the Type B package for 30 minutes	81.9
A person standing in the center of a 10-meter radius spill of 0.033% of the inventory of the Type B package for 30 minutes	0.9

^a To convert a dose in millirem to an equivalent dose in millisievert, multiply by 0.01; meter to feet, multiply by 3.281.
Source: CNSC 2014.

Aquatic-Based Accidents

CNSC staff analyzed the potential impacts on major water bodies resulting from a release to the environment from a severe accident hypothetically occurring on a bridge near the outlet of Lake Ontario and near the Ottawa River (CNSC 2014). CNSC staff considered these water bodies to be the ones most likely affected on a direct transport route. CNSC considered the “probability of this type of accident to be extremely low – lower than the land-based accident of 6.6×10^{-12} – as the distances traveled on bridges near these water bodies are only a fraction of the total distance traveled, thereby reducing the overall probability of an accident” (CNSC 2014).

Similar to the land-based accident scenarios and commensurate with IAEA regulations, CNSC staff assumed a 0.033 percent release of the inventory (0.022 gallons [0.085 liters]) from the package into the receiving water bodies. The assessment concluded that assuming a hypothetical spill into Lake Ontario, the concentrations of radionuclides would be well below human health and environmental protection guidelines. This was primarily attributed to the large volume of water and high flow rates observed in Lake Ontario. Assuming a hypothetical spill into the Ottawa River, CNSC staff estimated the doses that an individual would receive from consuming river water at varying distances downstream from the spill (see **Table 2–6**). The doses were estimated assuming that the individual consumed the affected river water for 1 year, even though such a hypothetical accident would trigger intervention by government authorities, involving continuous monitoring and other public protection measures. In addition, it was assumed for analysis that the radionuclides would all be present in the consumed water and not be absorbed onto sediments or suspended particulates that may be filtered from the consumed water. CNSC staff concluded that normal drinking water quality criteria set by Health Canada would be met within 0.5 kilometer (0.3 mile) of the location of the spill (CNSC 2014). In Canada, drinking water quality criteria are based on a limiting dose of 10 millirem per year (0.1 millisievert per year) during normal conditions, and 100 millirem per year (1 millisievert per year) during an emergency, as set by Health Canada.¹⁴

CNSC staff concluded that “the potential environmental impacts of a severe transportation accident resulting in a release to Lake Ontario or the Ottawa River would be minimal. Confidence in this conclusion is largely due to the multiple levels of conservatism included in the assessment, the short-term nature of any impacts, and the extremely low probability of any accident occurring over or near a major water body” (CNSC 2014).

¹⁴ In the United States, the Environmental Protection Agency has established “National Primary Drinking Water Regulations” (40 CFR 141). For regulated systems, they establish maximum contaminant levels for radionuclides in drinking water of 4 millirem per year for beta particle and photon radioactivity; 5 picocuries per liter for gross alpha particle activity; 5 picocuries per liter for radium-226 and radium-228 (combined); and 30 micrograms per liter for uranium.

Table 2–6 CNSC Assessment of Radiation Dose to an Individual from the Drinking Water Pathway Following an Accidental Spill into the Ottawa River

<i>Distance from Spill (kilometers)</i>	<i>Dose (millirem)</i>
0.5	8.4
1	4.54
5	1.09
10	0.59

Note: To convert millirem to millisievert, multiply by 0.01; kilometers to miles, by 0.62137.
Source: CNSC 2014.

2.4.2.3 Comparison of the Environmental Analysis in the CNSC *Technical Assessment Report* with the Analysis in Appendix A of the *SRS SNF SA*

The CNSC *Technical Assessment Report* (CNSC 2014) and Appendix A of the *SRS SNF SA* (DOE 2013) both assessed the possible environmental impacts from transporting HEU solutions from Canada to the United States, addressing possible radiation doses to members of the public and truck drivers during incident-free transport, and possible doses to members of the public under hypothetical accident conditions. The CNSC analysis of incident-free impacts features comparable exposure scenarios to those in Appendix A (Table 5) of the *SRS SNF SA*, and showed that possible impacts on members of the public and truck drivers would comply with national and international regulations and be less than those estimated in Appendix A.

The CNSC analysis of potential doses to members of the public under hypothetical accident conditions complemented the analysis of possible transportation accidents in Appendix A (Table 6) of the *SRS SNF SA* (DOE 2013). Both analyses documented the extremely low probability of a severe transportation accident that involves the potential release and dispersal of radioactive material. Both analyses addressed the potential impacts on a maximally exposed individual (MEI) from a severe accident. Both analyses demonstrated that in the unlikely event of a severe accident on land that caused the release of radioactive material from the cask, the chances of the MEI experiencing an LCF would be less than 1 in 10,000.¹⁵

CNSC performed an additional analysis (compared to that in Appendix A of the *SRS SNF SA*) to assess the impacts on a member of the public assuming that an accident resulted in the spillage of radioactive material into a major water body. This assessment was performed despite the CNSC staff determination that the probability of such an accident scenario was smaller than that for the analyzed land-based accident which the CNSC staff believed to be not credible.¹⁶ CNSC concluded that the potential impacts of a severe transportation accident resulting in a release would be minimal (CNSC 2014).

The CNSC staff concluded that there is an extremely low risk of radiation exposure from a hypothetical severe accident involving release of radioactive material from the NAC-LWT cask into a major water body in Canada. DOE acknowledges the extremely low probability of an accident that would result in a release from the cask and the even lower probability that such an accident would occur over or near a water body,

¹⁵ Appendix A of the *SRS SNF SA* (DOE 2013) concluded that the risk of an LCF to an MEI under maximum reasonably foreseeable accident conditions would range from 7×10^{-6} to 1×10^{-4} (Table 6), depending on atmospheric conditions. The *Technical Assessment Report* addressed the exposure scenario differently, but assessed a maximum MEI radiation dose of 81.9 millirem (CNSC 2014). Assuming a risk factor of 0.0006 LCF per rem of radiation exposure (DOE 2003), a dose of 81.9 millirem would result in an LCF risk of 5×10^{-5} .

¹⁶ The *SRS SNF SA* did not quantitatively evaluate the risks of an accident releasing radioactive material from the NAC-LWT cask into a major water body because of the low probability that any accident would result in a release of material from the cask and the even lower probability that the accident would occur over or near a major water body.

the robust design and construction of the cask as documented in multiple regulatory reviews in the United States and Canada, the small public radiation doses estimated by CNSC in its *Technical Assessment Report*, and the multiple levels of conservatism included in the CNSC assessment. DOE believes that the risk of radiation exposure due to the hypothetical release of radioactive material into a water body would similarly be extremely low for such an accident in the United States.

Neither DOE nor CNSC performed an analysis of the potential human health impacts of a release to groundwater. DOE does not consider a release of radioactive materials to the groundwater to be a credible pathway to a human exposure. If an accident were to occur, an emergency response effort would be initiated. In the unlikely event that the cask were to leak, as discussed in Section 2.4.2.2, a conservative estimate of the quantity leaked is 0.022 gallons (0.085 liters or about one third cup). CNSC analyzed the potential impacts of this material being released entirely into a major water body and dissolved in water that is then consumed (Section 2.4.2.2). If this quantity were leaked onto the ground, it would be absorbed in the soil very near the point of release. As part of the near-term response effort, the contaminated soil would be recovered, packaged, and sent to a low-level radioactive waste disposal facility. Because the material would represent a small volume of contamination and cleanup would be expected as part of the near-term response, contamination of the groundwater to any meaningful level is not considered credible.

2.5 Hypothetical Acts of Sabotage or Terrorism

DOE has always provided, and continues to provide, substantial safeguards and security measures for transportation and storage of nuclear material, including HEU. Safeguards and security are designed to prevent theft or diversion of material, and to prevent exposure of workers and the public to radiation from the material. DOE recognizes that an attack against radioactive material cargo does not have to result in diversion of the material to cause very undesirable consequences, such as release of radionuclides into the environment.

Following the events of September 11, 2001, DOE continues to consider and implement measures to minimize the risk and consequences of potential terrorist attacks on DOE facilities and shipments of radioactive materials. It is not possible to predict whether or where terrorist attacks (sabotage events) would occur, or the nature or types of attacks. DOE considers the threat of terrorist attacks, and makes a concerted effort to reduce any vulnerability to such a threat. For the proposed shipment of HEUNL, DOE would employ an integrated approach that relies on information and physical security to protect the shipments. Although the proposed project to transport HEUNL from Canada to SRS is public information, to reduce the likelihood of in-transit events, DOE would not publicly announce the timing and routes of individual shipments pursuant to NRC safeguards information regulations (10 CFR 73.21 through 73.23). Prior to and during shipment activities, DOE would coordinate with Federal and state intelligence agencies to remain current on any information relevant to potential threats to shipments in transit. Physical security would be provided from the time the shipment enters the United States at the Canadian border until its arrival at SRS. State police of each state through which the shipment passes would provide security escorts while the shipment is in their state.

With respect to transportation, DOE has evaluated the impacts of acts of sabotage and terrorism on transportation of SNF and high-level radioactive waste shipments (DOE 1996a, 2002b). In the *SRS SNF SA*, DOE concluded that the estimates of risk for a sabotage event in the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain EIS)* (DOE 2002b) would bound the risks from an act of sabotage or terrorism involving HEU solutions (DOE 2013). DOE reached this conclusion by comparing the potential radiological impacts on the maximally exposed individual from the release of

the entire contents of an HEUNL shipment¹⁷ to those of the sabotage event in the *Yucca Mountain EIS*. The *Yucca Mountain EIS* sabotage event was assumed to involve either a truck or rail cask containing light-water reactor spent nuclear fuel. DOE estimated that the event evaluated in the *Yucca Mountain EIS* could result in a radiation dose to the MEI of 110 rem (0.40 to 1.1 sieverts) for an event involving a truck-sized cask containing light-water reactor fuel. These events would lead to an increase in risk of fatal cancer to the MEI by 7 percent (DOE 2002b).¹⁸ With respect to the storage and management of HEUNL at SRS, the material would be received, stored, and processed at H-Canyon. Informed by the *SRS SNF SA* (DOE 2013), DOE determined that the consequences of a terrorist attack on the SNF storage and processing facilities would not likely be greater than the accident scenarios evaluated in the *SRS SNF EIS*. Nothing was identified in this SA that would indicate a need to re-assess this determination. It is also important to note that the security posture for all HEUNL shipments will meet or exceed all CNSC, NRC, and DOE requirements for the safe transport in Canada and the United States. The transporter would comply with the security requirements of 10 CFR 71.37 and would include, but not be limited to, having armed escorts, varying schedules and routes, and observing safeguards information requirements.

3.0 CONCLUSION

After review of previous NEPA documents addressing programs for management of SNF and target residue material, including the *SRS SNF EIS*, *FRR SNF EIS*, and *SRS SNF SA*, DOE prepared this SA to reflect recent information that bears on the potential impacts that could result from transporting target residue material in the form of HEU solutions (i.e., as HEUNL) from Canada to the United States. This SA supports DOE's determination in the *SRS SNF SA* (DOE 2013) that the potential environmental impacts associated with transport of target residue material in the form of HEU solutions from Canada to SRS would be very low and not significantly different from the impacts reported in the *FRR SNF EIS* (DOE 1996a). Nothing was identified in this SA that would indicate a need to re-assess DOE's conclusions in the *SRS SNF SA* (DOE 2013) that once the HEU solutions were received on site, the potential risks associated with onsite storage, conventional processing in H-Canyon, and HEU down-blending would not significantly differ from those reported in previous NEPA reviews.

¹⁷ Table 6 of the *SRS SNF SA* (DOE 2013), Appendix A, shows the dose to the maximally exposed individual would range from 0.012 to 0.24 rem for the maximum reasonably foreseeable accident resulting in release of all 61 gallons (230 liters) of HEUNL solution in a shipment.

¹⁸ In an errata sheet for the *Yucca Mountain EIS* (<http://energy.gov/sites/prod/files/EIS-0250-FEIS-ErrataSheet-2002.pdf>) DOE stated that the radiation dose from the evaluated sabotage event should be raised to 277 rem (27.7 sieverts) for the event involving the truck-sized cask, which would lead to an increase in the risk of a fatal cancer to the MEI by 17 percent. In a subsequent analysis, the *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Supplemental Yucca Mountain EIS)* (DOE/EIS-0250F-S1) (DOE 2008), the analysis of a sabotage event referred to German and French fuel tests that were not available when the *Yucca Mountain EIS* was prepared. Based on the new data, DOE stated that the calculated consequences of a sabotage event in the *Yucca Mountain EIS* could be overstated by a factor of 12 (DOE 2008). These changes in estimated doses do not alter the DOE conclusion in the *SRS SNF SA* that the estimates of risk in the *Yucca Mountain EIS* would bound the risks from an act of sabotage or terrorism involving shipments of HEU solutions.

4.0 DETERMINATION

The analysis in this SA supports DOE's previous determination (DOE 2013) that the transport of HEU solutions would represent neither substantial changes to the actions evaluated in previous NEPA analysis, including the *FRR SNF EIS*, nor represent significant new circumstances or information relevant to environmental concerns. This SA reaffirms that the potential environmental impacts associated with transport of target residue material in the form of HEU solutions from Canada to SRS would be very low and not significantly different from the impacts reported in the *FRR SNF EIS* (DOE 1996a). There would be no expected radiological or non-radiological fatalities. Therefore, pursuant to 10 CFR 1021.314(c), I have determined that a supplemental or new EIS is not required.

Issued at Washington, DC on November 30, 2015



Monica C. Regalbuto
Assistant Secretary
for Environmental Management

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