Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

UNPROTECTED/NON PROTÉGÉ

ORIGINAL/ORIGINAL

CMD: 21-H104

Date signed/Signé le : 16 June 2021

A Licence Revocation

Saskatchewan Research Council

SLOWPOKE-2 Reactor

Hearing in writing based solely on written submissions

Scheduled for:

July 2021

Submitted by:

CNSC Staff

Une révocation de permis

Saskatchewan Research Council

Réacteur SLOWPOKE-2

Audience par écrit fondée uniquement sur des mémoires

Prévue pour :

Juillet 2021

Soumise par :

Le personnel de la CCSN

e-Doc 6508002 (WORD)
e-Doc 6544042 (PDF)

Canada

Summary

This CMD presents information about the following matters of regulatory interest with respect to Saskatchewan Research Council for a decision regarding:

- the release from CNSC regulatory control of the decommissioned Saskatchewan Research Council SLOWPOKE-2 Reactor Facility

CNSC staff recommend the Commission take the following actions:

- revoke the current Saskatchewan Research Council licence NPROL-19.01/2023
- issue a Licence to Abandon
- release the Financial Guarantee held for the decommissioning of Saskatchewan Research Council SLOWPOKE-2 Reactor Facility

The following items are attached:

- current licence
- proposed Licence to Abandon

Résumé

Le présent CMD présente de l'information sur un ensemble de questions d'ordre réglementaire à l'égard du Saskatchewan Research Council aux fins de décision concernant :

- la levée du contrôle réglementaire de la CCSN pour le réacteur déclassé SLOWPOKE-2 du Saskatchewan Research Council

La Commission pourrait considérer prendre les mesures suivantes :

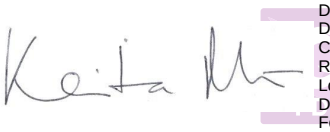
- révoquer le permis actuel NPROL-19.01/2023 du Saskatchewan Research Council
- délivrer un permis d'abandon
- libérer la garantie financière retenue pour le déclassement du réacteur SLOWPOKE-2 du Saskatchewan Research Council

Les pièces suivantes sont jointes :

- permis actuel
- permis d'abandon proposé

Signed/signé le

16 June 2021



Kavita Murthy

Director General

Directorate of Nuclear Cycle and Facilities Regulation

Directrice générale

Direction de la réglementation du cycle et des installations nucléaires

This page was intentionally left blank.

TABLE OF CONTENTS

This page was intentionally left blank.

EXECUTIVE SUMMARY

The Canadian Nuclear Safety Commission (CNSC), pursuant to section 24 of the *Nuclear Safety and Control Act* (NSCA), amended Saskatchewan Research Council's (SRC) SLOWPOKE-2 (Safe LOW POwer Kritical Experiment) non-power reactor operating licence and authorized the decommissioning of the Saskatchewan Research Council SLOWPOKE-2 Reactor Facility (SRCSF) [1] in December 2019. SRC has completed the decommissioning activities and requested a licence to abandon its SRCSF [2] and the revocation of the non-power reactor operating licence, NPROL-19.01/2023 [3], on October 27, 2020.

The decommissioning undertakings included defueling and dismantling of the SRCSF, packaging and shipment of the fuel and radioactive components to licensed nuclear waste facilities, removal and disposal of uncontaminated ancillary reactor components, purification and disposal of reactor pool water, decontamination of the SRCSF, and filling of the reactor pool and trenches with grout. Radioactive waste arising from decommissioning was characterized and the volume reduced to the extent possible. The characterization included monitoring for fixed and removable contamination and establishing radiochemical and physical properties that met CNSC staff's expectations. The proposed end state objective is unrestricted future use of the space occupied by SRCSF for non-CNSC regulated activities.

CNSC staff conducted a remote compliance inspection of the SRCSF from July 8 to 10, 2020 [4]. CNSC staff confirmed that SRC had conducted decommissioning activities in accordance with the Detailed Decommissioning Plan (DDP) [5].The inspection results found, that the rooms occupied by the SRCSF have been cleaned and decontaminated and there are no nuclear substances or residual radiological risks remaining that would require a CNSC licence. Overall, CNSC staff concluded that the decommissioning activities at the SRCSF meet regulatory requirements and that the decommissioning has reached the end state objective of unrestricted use of the location occupied by SRCSF. End state objectives for SRCSF are described in the DDP. CNSC staff's review of SRC's licence application has shown that SRC meets the requirements for a licence to abandon and revocation of its non-power reactor operating licence, NPROL-19.01/2023, as set out in the NSCA and its Regulations.

The abandonment of an existing nuclear reactor, or the revocation of a licence when the licensee no longer carries on the licensed activity, does not trigger an impact assessment (IA) under the *Impact Assessment Act*. An Environmental Protection Review was previously conducted by CNSC staff and approved by the Commission on December 6, 2019 [6] for the decommissioning of the SRCSF.

The final survey results conclude that radiological conditions following the decommissioning of the SRCSF were commensurate with background dose rate levels and that all remaining radiological contamination is below the regulatory clearance levels as defined by the *General Nuclear Safety and Control Regulations* and *Nuclear Substances and Radiation Devices Regulations.*

CNSC staff recommend that the Commission revoke the current non-power reactor operating licence NPROL-19.01/2023; issue the proposed attached licence to abandon the SRCSF; and release the financial guarantee held for decommissioning of the SRCSF.

OVERVIEW

1.1 Highlights

SRC has completed the decommissioning activities and requested a licence to abandon its SRCSF [2] and the revocation of the non-power reactor operating licence, NPROL-19.01/2023 [3], on October 27, 2020.

In response to SRC's application, CNSC staff confirmed that:

- decommissioning activities have been completed
- the end state objective of unrestricted use of the location occupied by the SRCSF has been reached
- SRCSF does not present any hazards that are radiological, environmental or conventional health and safety in nature
- the SRCSF does not contain any licensable waste.

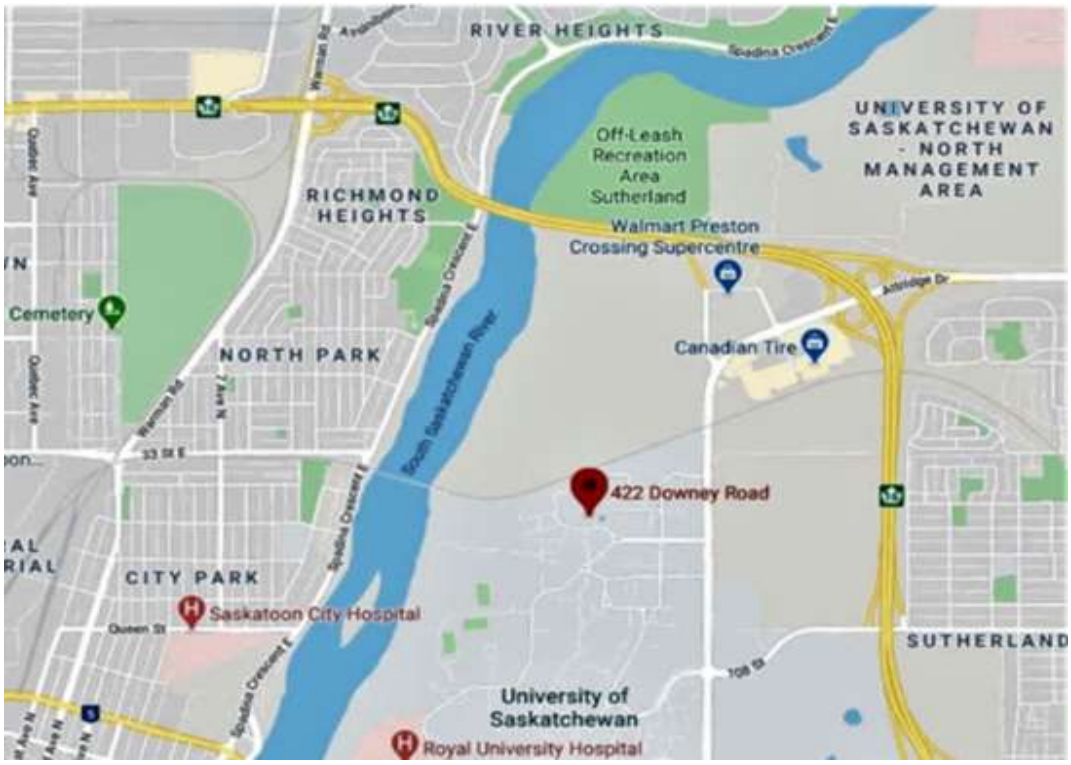
There are no specific regulatory requirements for revocation of a licence on receipt of an application – it is at the Commission's discretion whether or not to do so.

CNSC staff recommend that the Commission revoke the non-power reactor operating licence NPROL 19.01/2023; issue a licence to abandon the SRCSF; and release the financial guarantee held for decommissioning.

1.2 Background

The Saskatchewan Research Council's (SRC) SLOWPOKE-2 (Safe LOW POwer Kritical Experiment) reactor was a 20 kW-thermal sealed-container-in-pool type research reactor. The reactor was cooled and moderated with light water and operated on 93% enriched uranium fuel, also known as high-enriched uranium (HEU). The core was cooled by natural convection and surrounded by a beryllium reflector; the reactor core, which was about the size of a shoe box, contained slightly less than 1 kg HEU. The SRCSF came on line in 1981 and ceased operation in April 2019.

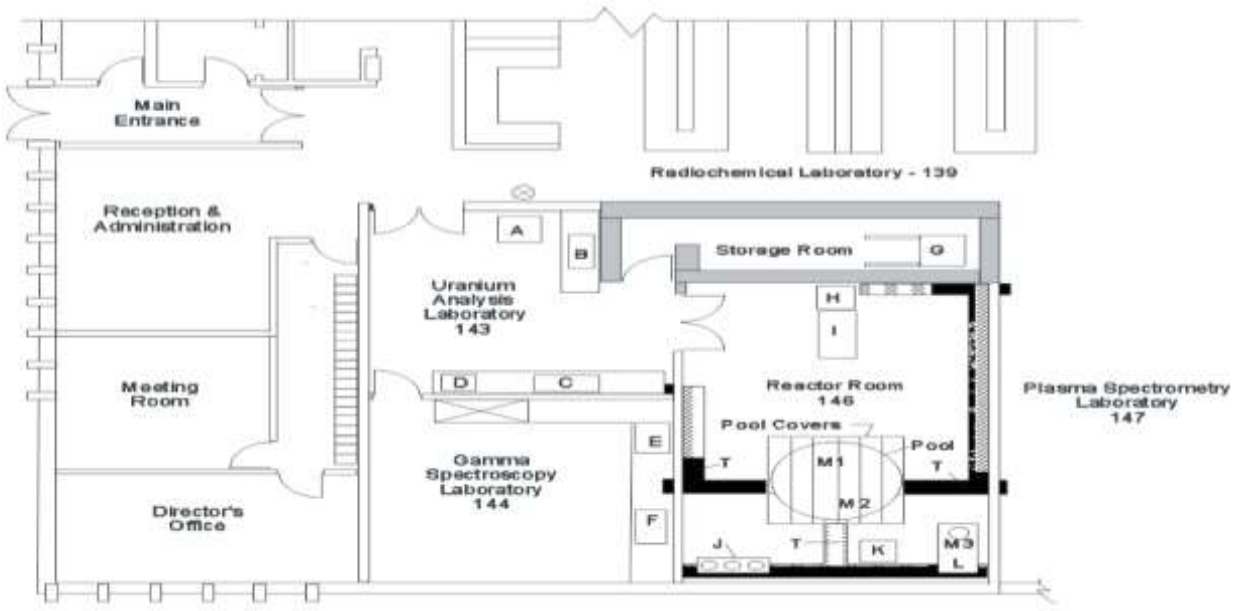
Figure 1: Map of SLOWPOKE-2 Reactor Facility (422 Downey Rd.) and University of Saskatchewan located in Saskatoon



The SRCSF is located at 422 Downey Road, within the Innovation Place Research Park, in Saskatoon, Saskatchewan. Figure 1 shows a map of SRCSF and University of Saskatchewan located in Saskatoon. The site is bound by the University of Saskatchewan to the south and west; the Canadian Pacific Railway tracks to the north; Preston Avenue to the east; and 400 meters from the South Saskatchewan River. The SRCSF consisted of a reactor room, two rooms for support equipment and a storage room. The reactor itself was located in a concrete well underneath the floor of the reactor room. The layout of the SRCSF is presented in figure 2.

In May 2018, SRC notified CNSC staff of its intention to decommission the SRCSF. On December 14, 2018, SRC applied to the CNSC for an amendment to its existing licence to allow for the decommissioning of SRCSF. Following the hearing on the application for decommissioning, the Commission granted SRC's request on December 6, 2019 [1].

Figure 2: Layout of Saskatchewan Research Reactor Facility



1.3 Overall Conclusions

CNSC staff conclude that the licensee:

1. Has fully decommissioned the SRCSF and has met CNSC regulatory requirements over the course of decommissioning activities.
2. Has left no nuclear substances in place and no activities are performed that would require an operating licence under the NSCA.

1.4 Overall Recommendations

CNSC staff recommend that the Commission:

1. Revoke the current Saskatchewan Research Council Licence NPROL-19.01/2023.
2. Issue a licence to abandon the SLOWPOKE-2 Reactor Facility.
3. Release the financial guarantee held for decommissioning of Saskatchewan Research Council SLOWPOKE-2 Reactor Facility.

2. MATTERS FOR CONSIDERATION

2.1 Relevant Safety and Control Areas

All CNSC licensed activities performed at the SRCSF have ceased. For the purpose of releasing the SRCSF from CNSC regulatory oversight, the following safety and control areas (SCA) are relevant. The table below shows the relevance and rating of each SCA for this CMD.

Table 1: Relevant Safety and Control Areas

FUNCTIONAL AREAS	SAFETY AND CONTROL AREAS	RELEVANT TO THIS CMD	RATING
1. Management	Management System	No	NA
	Human Performance Management	No	NA
	Operating Performance	No	NA
2. Facility and Equipment	Safety Analysis	No	NA
	Physical Design	No	NA
	Fitness for Service	No	NA
3. Core Processes	Radiation Protection	Yes	SA
	Conventional Health and Safety	Yes	SA
	Environmental Protection	Yes	SA
	Emergency Management and Fire Protection	No	NA
	Waste Management	Yes	SA
	Security	No	NA
	Safeguards and Non-Proliferation	Yes	SA
	Packaging and Transport	No	N/A

NA Not Applicable, SA Satisfactory

This CMD provides information on CNSC staff's assessment whether a final end state has been reached where the SRCSF can be released from regulatory control and whether Canada's safeguards obligations are satisfied. The applicable SCAs (table 1) are explained in this context, departing from the CMD structure applied to facilities remaining under regulatory control. The radiation protection, waste management, conventional health and safety, and environmental protection SCAs are included in section 2.5.1 End State. Section 2.3 *Canada's Safeguards Agreement* addresses the safeguards and non-proliferation SCA with respect to aspects of decommissioning.

During the decommissioning, the SRCSF stopped all operational activities, the fuel was shipped out and the systems and components were dismantled according to the DDP [5], submitted in March, 2019, and accepted by CNSC staff. As such, the hazards from operating the SLOWPOKE-2 reactor do not exist. Therefore, the SCAs associated with the Facility and Equipment Functional Area (table 1), along with the operating performance SCA are not applicable any more.

With respect to the management and core processes functional areas, management system, human performance management, emergency management and fire protection, security, and packaging and transport activities, have been implemented according to decommissioning project plans, work packages and instructions. The decommissioning has been safely completed as planned with no events reported. These SCAs are not applicable to the request for a licence to abandon.

2.2 Enriched Uranium

The SRC SLOWPOKE-2 research reactor contained a HEU fuel (93% of ^{235}U). On August 15, 2019, the HEU fuel was removed from the reactor pool in the presence of the International Atomic Energy Agency (IAEA), CNSC and United States Department of Energy (US DOE) representatives. The HEU fuel was loaded into a CNSC-certified F-257 transport flask and sealed by the IAEA for safeguards purposes.

SRC submitted a transport licence application, which was issued by a CNSC Designated Officer. In support of the transport licence, a transportation security plan was also submitted by SRC and accepted by CNSC staff. The transport flask was delivered safely to the US DOE's Savannah River Site (SRS) in South Carolina [7].

2.3 Canada's Safeguards Agreement

Canada entered into a safeguards agreement with the IAEA in 1972 pursuant to its obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons*. The objective of the Canada/IAEA Safeguards Agreement is for the IAEA to provide assurance on an annual basis to Canada and to the international community that all declared nuclear materials are in peaceful, non-explosive uses and that there is no indication of undeclared nuclear materials or activities. This conclusion confirms that Canada is in compliance with its obligations under the Canada/IAEA safeguards agreements.

- *Agreement Between the Government of Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* (INFCIRC/164); and
- *Protocol Additional to the Agreement Between Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (INFCIRC/164/Add.1).*

The CNSC is the governmental authority responsible for implementing the Canada/IAEA safeguards agreements. Under Article 5 of the Additional Protocol (INFCIRC/164/Add.1), Canada is required to, inter alia, provide the IAEA access to "any decommissioned facility". Once decommissioned and released from CNSC regulatory control, Canada will continue to be required to provide access to SRCSF to the IAEA with 24 hours notice, if so requested.

The CNSC's regulatory framework provides for such access by a CNSC inspector under either subsection 14(4) of *the Class I Nuclear Facilities Regulations*, or section 30 of the NSCA. When a CNSC inspector is exercising this authority under the Act, the inspector may be accompanied by any other person chosen by the inspector, such as an IAEA inspector. SRC may also provide CNSC and IAEA inspectors access to the location on a voluntary basis.

IAEA and CNSC access to the decommissioned SRCSF will be ensured through several means:

- The CNSC can perform inspections on the location to confirm that records are being kept for a period of 10 years past the expiry date of the licence to abandon, or the date the licence is revoked, in compliance with subsection 14(4) of the *Class I Nuclear Facilities Regulations*.

- CNSC inspectors have the authority to inspect locations under section 30 of the NSCA. This includes a vehicle or place in which the inspector believes, on reasonable grounds, there is a nuclear substance, prescribed equipment, prescribed information or a record that is required by the NSCA, its associated Regulations, an order or a decision made under the NSCA, or a condition of a licence.

Access by a CNSC inspector under either subsection 14(4) of the *Class I Nuclear Facilities Regulations* or section 30 of the NSCA to a location that has been decommissioned and released from regulatory control provides access to the IAEA. This access would be permitted under section 33 of the NSCA which states:

While exercising any authority under this Act, an inspector may be accompanied by any other person chosen by the inspector.

CNSC staff conclude that the obligation to provide access to the IAEA to the decommissioned SRCSF can be met for a period of at least 10 years under subsection 14(4) of the *Class I Nuclear Facilities Regulations* in conjunction with section 30 of the NSCA.

To consider a facility 'decommissioned' (for safeguards purposes) the IAEA requires the submission of a final design information questionnaire (DIQ) describing the facility and an opportunity to verify that information during an inspection. SRC submitted the final DIQ to the CNSC on March 30, 2021. The IAEA will verify the decommissioned status of the facility during a design information verification in the near future.

2.4 Release of the SRCSF from CNSC Regulatory Control

The release of the decommissioned SRCSF from CNSC regulatory control can be done through the revocation of the current licence NPROL-19.01/2023.

The draft licence to abandon as attached to the CMD has an expiry date that coincides with the issue date of the licence, for the following reason: The licence to abandon invokes 14(4) of the *Class I Nuclear Facilities Regulations*, requiring the licensee to "retain the record for 10 years after the expiry date of the licence to abandon issued in respect of the Class I nuclear facility". In order to verify compliance with the requirement, section 30 of the NSCA grants CNSC inspectors the authority to enter the place where the records are retained to inspect the records. Further, section 33 of NSCA, CNSC inspectors while exercising their authority, "may be accompanied by any other person chosen by the inspector". Thus, for a period of 10 years following the expiry date of the licence to abandon, CNSC inspectors and if required, IAEA inspectors, would have access to the site.

Based on SRCSF's completion of the following activities, CNSC staff confirm that the decommissioning of the SRCSF is complete:

- The reactor core and radioactive components have been shipped to licensed waste storage and/or processing facilities.
- The equipment and material that satisfied the unconditional release and surface contamination criteria were removed from the SRCSF site.
- The final survey of the SRCSF found that radiological conditions following the decommissioning of the SRCSF were commensurate with background dose-rate levels.
- Surface contamination and radionuclide concentrations in the remaining structures are below the regulatory limits for unrestricted use of SRCSF.
- The reactor pool and the trenches were filled with the grout which provides consistent density and bearing strength.

CNSC staff reviewed the submissions from SRCSF and also independently verified this result in a virtual inspection, due to COVID-19 restrictions. This inspection took place from July 8 to 10, 2020. Section 2.6 includes details of CNSC staff's verification. The SRCSF has been cleaned-up and there are no nuclear substances or residual radiological risks left that would require a licence from the CNSC. Given the detailed decommissioning activities completed, CNSC staff recommend the revocation of the current licence NPROL-19.01/2023 be granted under subsection 24(2) of the NSCA.

2.5 Assessment of the Application

SRC submitted an application for a licence to abandon [2]. Section 3 of the *General Nuclear Safety and Control Regulations* provides regulatory requirements for any licence application and section 4 provides application requirements specifically for a licence to abandon. Section 8 of the *Class I Nuclear Facilities Regulations* also provides requirements for a licence to abandon.

The application for a licence to abandon the SRCSF and the supporting documents described how each of the above requirements of the NSCA and Regulations are addressed.

SRC also submitted the End State Decommissioning Report (ESDR) [8] in support of SRC's application to revoke the current operating licence and to obtain the licence to abandon the space that is occupied by SRCSF. The ESDR is structured to meet the requirements outlined in the CNSC Regulatory Guide G-219, *Decommissioning Planning for Licensed Activities*. CNSC staff reviewed SRC's application and concluded that it meets all regulatory requirements for a licence to abandon.

2.5.1 End State

End State Decommissioning Report

Following the completion of decommissioning, the CNSC requires a licensee to prepare a final End State Decommissioning Report to demonstrate that the final end state has been achieved in accordance with the Detailed Decommissioning Plan (DDP). The report shall also document the final physical, chemical and radiological condition of the facility at the end of the decommissioning.

CNSC staff reviewed the ESDR [8] submitted by SRC in support of its application for a licence to abandon and concluded that SRC met all requirements found in regulatory document G-219, *Decommissioning Planning for Licensed Activities*. The structure and content of the report are consistent with Annex D of CSA standard N294-19, *Decommissioning of Facilities Containing Nuclear Substances*. The ESDR confirms that decommissioning activities have been completed in accordance to the DDP [5] and all equipment/material associated with the operation of the SRCSF has been removed.

The following sub-sections summarize the activities, etc. related to the completion of the decommissioning and achieving the end state.

Unconditional Release and Unrestricted Use

SRC's ESDR and the Technical Letter [9] demonstrate that the acceptance criteria for unconditional release and unrestricted use have been met and the SRCSF can be released from the regulatory control:

- The remaining reactor pool floor and wall are below the Unconditional Clearance Level (UCL), as required by *Nuclear Substances and Radiation Devices Regulations*, SOR/2000-207 [10].
- The surface contamination at the decommissioned SRCSF is below the criteria for unrestricted use, as given in REGDOC-1.6.1, *Licence Application Guide: Nuclear Substances and Radiation Devices* [11], Appendices R *Regulatory Quantities for Typical Radionuclides* and Y *Classes of Nuclear Substances.*
- All equipment/material associated with the nuclear operation has been removed from SRCSF.

In order to achieve below UCL, numerous samples from the reactor pool concrete were drawn and analyzed according to SRC's sampling plan (ESDR, Appendix H), and depending on the results, portions of the concrete and rebar were excavated from the pool floor to different depths at various radii. Segments of the pool wall close to the core centerline were also removed to various depths. Please see table 2 and picture 1 for clarity. CNSC staff reviewed and accepted the sampling plan.

Picture 1: Excavation depths of the reactor pool floor and excavated section of the reactor wall (left, mid and right segments)

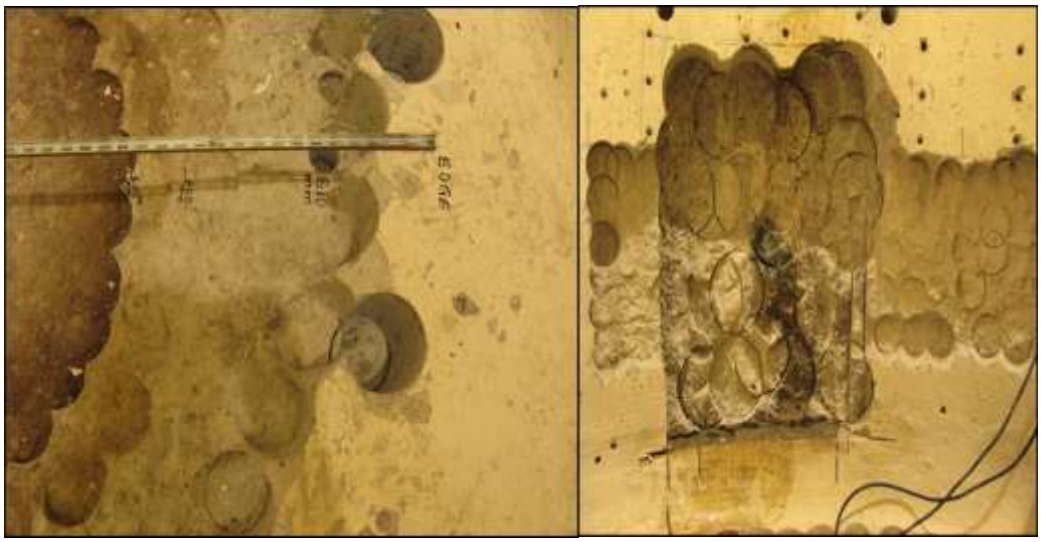


Table 2: Excavation dimensions

Reactor Pool Floor	
Radius from reactor core centerline (r)	**Depth removed (d)**
0 to 500 mm	335 mm (all the concrete floor have been removed)
500 mm to 600 mm	280 mm
600 mm to 810 mm	190 mm
810 mm to 910 mm	Rebar removed
910 mm to pool edge	None
Reactor Wall	
Wall segments (left and right segments)	Width = 400 mm Height = 460 mm Depth = 100 mm
Wall segment (mid segment)	Width = 720 mm Height = 920 mm Depth = 160 mm

The *Nuclear Substances and Radiation Devices Regulations,* SOR/2000-207 describe the condition for achieving UCL as follows:

- The sum of the quotients obtained by dividing the measured activity, Bq/g, of each radionuclide by its corresponding unconditional release limit, Bq/g, (column 2, Schedule 2, SOR/2000-207) ≤ 1.

The analyses of the samples taken after the excavations confirm that the reactor pool floor and wall were below the UCL. Tables 3 and 4 give confirmatory sample analyses for the reactor pool.

Table 3: Confirmatory sample analyses for the reactor pool floor

Nuclides	Bq/g (UCL limit from column 2, Schedule 2, SOR/2000-207)	Highest Bq/g (r=500-600 mm, d=280 mm)	Highest Bq/g (r=600-810 mm, d=190 mm)	Highest Bq/g (r=810-910 mm, d=0 mm)	Highest Bq/g (r=910 mm - pool edge, d=0 mm)
Eu-152	0.1	0.012	0.021	0.005	0.004
Eu-154	0.1	0.003	0.002	0.003	0.002
Sc-46	0.1	0.006	<0.002	<0.001	0.006
Cs-134	0.1	0.002	<0.001	0.0007	<0.001
Cs-137	0.1	<0.001	<0.0009	0.004	<0.0006
Co-60	0.1	0.01	0.011	0.004	0.002
Fe-59	1	<0.002	<0.002	<0.002	<0.0008
Mn-54	0.1	<0.001	0.003	0.002	<0.001
Zn-65	0.1	<0.002	<0.002	<0.002	<0.001
K-40	10	0.57	0.58	0.55	0.53
Total	N/A	<0.61	<0.62	<0.57	<0.55
Quotients (Criterion: sum of quotients ≤1 for UCL)		**0.4**	**0.5**	**0.3**	**0.2**

Difference between the 2 radii and depth represent the volume excavated, all the concrete floor with r=500 mm and d=335 mm has also been removed; the area formed by the 2 radii is where the samples were taken at the specified depth.

The analyses of crushed samples representing the reactor pool floor concrete below the core, by Kinectrics, showed that pure beta emitters and difficult-to-measure radionuclides, such as H-3, C-14, Cl-36, and Ni-59, exist in very low activity concentrations (Bq/g). Their contribution to the sum of quotients (tables 3 and 4, for satisfying the UCL requirements (Column 2, Schedule 2, SOR/2000-207), is insignificant (less than 1% of the sum of the quotients). Hence, the acceptability of the pool concrete for unconditional release are based only on gamma emitting radionuclides.

All final surface contamination readings were below the most stringent limit of 0.3 Bq/cm^2 in REGDOC-1.6.1 [11]. Table 6 and section 2.6 provide more information on surface contamination surveys at SRCSF. The final surface surveys included alpha/beta/gamma direct checks and swipes (removable contamination) in the reactor pool and all the rooms in SRCSF (i.e., Room 143 Uranium Analysis Laboratory, Room 144 Gamma Spectroscopy Laboratory, Room 145 Radioactive Storage Room and Room 146 Reactor Room).

Table 4: Confirmatory sample analyses for the reactor wall

Nuclides	Bq/g (Column 2, Schedule 2, SOR/2000-207)	[1]Highest Bq/g Width = 400 mm Height = 460 mm Depth = 100 mm	[2]Highest Bq/g Width = 720 mm Height = 920 mm Depth = 160 mm	[3]Highest Bq/g Width = 400 mm Height = 460 mm Depth = 100 mm
Eu-152	0.1	0.005	0.017	0.011
Eu-154	0.1	<0.002	<0.002	0.003
Sc-46	0.1	<0.002	<0.002	<0.002
Cs-134	0.1	0.001	<0.001	<0.001
Cs-137	0.1	<0.0006	<0.001	<0.001
Co-60	0.1	0.004	0.009	0.006
Fe-59	1	<0.003	<0.001	<0.001
Mn-54	0.1	0.002	0.002	0.002
Zn-65	0.1	<0.002	<0.002	<0.002
K-40	10	0.48	0.58	0.5
Total	N/A	<0.50	<0.62	<0.53
Quotients (Criterion: sum of quotients ≤1 for UCL)		**0.2**	**0.4**	**0.3**

[1]left segment, [2]mid segment, [3]right segment, please see Picture 1 and Table 2

Waste Management

The wastes arising from the SRCSF decommissioning activities consist of radioactive solids (used fuel assembly, reactor components, ion exchange resins, concrete and cleaning material, etc.), liquids (the mixture water from the pool), and solid non-radioactive equipment and material.

Following the inspection of the used fuel, the IAEA informed the CNSC and DOE representatives that the results of the inspection were satisfactory [12] The used fuel elements and fuel cage were removed from the lower reactor container and placed in container F-257 for transportation to SRS (please see section 2.2 of this CMD for more information).

The equipment that did not meet unconditional release criteria, including the reactor components (i.e., lower reactor container, upper reactor container, all beryllium components, irradiation tubes, thermocouples, detectors and control rod) and other radioactive material including ion exchange resins and concrete from the reactor pool were removed from the SRCSF and shipped in Type A containers to the Chalk River Laboratories in Chalk River, Ontario for long term storage as radioactive waste [13]. SRC adhered to the *Packaging and Transport of Nuclear Substances Regulations,* 2015 and Transport Canada's *Transportation of Dangerous Goods Regulations* for all shipments. Table 5 summarizes packaging and transport characteristics of decommissioning radiological waste.

All equipment and material that satisfied the unconditional release and surface contamination criteria were removed from the SRC site after the completion of the required radiological surveys for fixed and non-fixed contamination. In order to minimize these wastes, SRC carried out disposal activities in the following ways and order of priority: 1. Reuse 2. Recycle 3. Landfill disposal.The majority of the waste meeting unconditional release was sent to local authorized recycling and waste disposal facilities.

The reactor water and pool water mixture were treated through the reactor water deionizer (ion exchange column) for several days to reduce the radioactivity to below the release limits. Following this, the water was safely discharged into the City of Saskatoon sanitary sewer system. CNSC staff reviewed SRC's analyses of radionuclides in the treated reactor water and pool water mixture and compared them against the clearance levels in Appendix R of CNSC REGDOC-1.6.1, R *Regulatory Quantities for Typical Radionuclides, Sewer* [11], as well as the exposure-based release limit derived using the methodology in CSA N288.1-14. These conditional clearance levels are based on a member of the public receiving a dose of 0.01 mSv/yr. CNSC staff also reviewed the results of the hazardous substances and compared them against the limits in schedule "B" of the City of Saskatoon's sewer use bylaw. CNSC staff confirmed that all of the results were below their respective conditional clearance level or release limit. Thus, CNSC staff concluded that the pool water could be discharged to the city sewer without any impacts to workers, human health, and the environment [14]. Following this, the pool water was discharged into the City of Saskatoon sanitary sewer system.

Some of the auxiliary reactor components were released to various establishments: one Irradiation Controller and one Capsule Receivers to Royal Military College; one Capsule Receiver, one Irradiation Controller, and the Uranium Analysis System to IAEA; and the pool water purification system to the École Polytechnique SLOWPOKE-2 facility.

Table 5: Summary of packaging and transport characteristics of decommissioning radiological waste (except fuel)

Container	Label category	TI	Gross mass (kg)	Contact µSv/h	At 1 m µSv/h
Type A (B-25-16592) Beryllium reflectors, shims, PPE&C	III Yellow	3.5	2100	129	35
Type A (B-25-16593) Lower reactor components, Cd control rod, PPE&C, IX resin	II Yellow	0.4	2600	194	4
Type A (B-25-16594) Upper reactor components, irradiation tubes, PPE&C, excavated concrete	I White	n/a	2100	1.4	0.4

Personnel Doses

Worker doses were assessed during all phases of decommissioning activities. The action level for the project was determined as 1 mSv/person. Only one person received a dose beyond 0.1 mSv for the entire project. The total collective dose to the decommissioning crew was 0.16 mSv (whole body), with an average individual dose of 0.018 mSv. No recordable dose to the extremities was received by any member of the crew.

All workers involved in the removal of concrete from the pool wore full personal protection equipment, including Tyvek, gloves, safety glasses and half-face respirators. Internal Whole Body Counts, both before and after the removal of the concrete, using a sensitive gamma spectrometer showed “no unknown peaks and passed sensitivity test” for all workers involved.

Airborne Emissions

An alpha/beta Integrated Continuous Air Monitoring (i-Cam) was used throughout the decommissioning project to monitor for any potential radioactive airborne contaminants. Throughout the entire decommissioning process, there were no detectable concentrations of airborne radioactivity above normal background.

Reportable Events

Lessons learned during the decommissioning of the SLOWPOKE-2 reactors at the University of Toronto, Dalhousie University and University of Alberta were applied during SRCSF decommissioning and no reportable events occurred as a result of decommissioning work at the SRCSF.

Final Status

Following the dismantling of the SRCSF, the removal of radioactive and non-radioactive waste, and the removal of fixed contamination, SRC performed a final site clearance survey for each area, room and enclosure where the licensed activity was carried out.

The surveys consisted of gamma dose rate measurements, direct and removable surface contamination measurements (beta/gamma and alpha emitters). During the review of 147-CECNSC-20-0001, Technical Letter [9], two small areas were observed to be above the release criteria of 0.3 Bq/cm^2 surface contamination. They were subsequently reduced to acceptable levels by additional excavations. The results of the final surveys confirmed that all areas of the SRCSF are below the maximum values for unrestricted use, as presented in table 6.

Picture 2: Reactor pool ready for grouting (left) and SRCSF with the pool and overflow channels filled with grout

The current state of the SRCSF does not present any conventional health and safety hazards. All equipment in Rooms 143-146, including all reactor components from the reactor pool, reactor control console, sump pump, water purification system, gamma spectroscopy equipment, the uranium analysis system, were removed from the SRCSF. The attachments securing the equipment to the floor were removed to the floor level, preventing any slip and fall hazards.

The following work was completed under civil work and restoration: filling and covering the reactor pool with grout, filling the trenches with grout, general cleaning of the rooms, providing a smooth finish on the concrete leveling it to current floor level, confirming that the lighting, fire alarm and internal access doors are all operational, ensuring that appropriate signage is in place and locks are installed to the SRC standard. The ventilation system and other service systems (e.g., water, air, electrical, security) remain in service.

The final 6 inches of concrete in the pool and final 2 inches in the trenches were filled with standard concrete to provide the structural strength to match the existing floor in the SRCSF Reactor Room. The concrete was troweled to ensure that the concrete matched the existing floor without creating a tripping hazard. Picture 2 shows reactor pool ready for grouting and SRCSF Reactor Room with the pool and overflow channels filled with grout.

Table 6: Final Radiological Status (maximum readings)

Locations	Dose rate µSv/h	On swipe Bq/cm (removable)		Direct Bq/cm (fixed)		Bq/cm Clearance Level
		α	γ/β	α	γ/β	
Reactor Room (R-146)	Background	<MDA	<MDA	0.013	<MDA	0.3
Pool Floor	Background	<MDA	<MDA	<MDA	<MDA	
Pool Wall	Background	<MDA	<MDA	<MDA	0.240	
Other Rooms (R-143,144, 145)	Background	<MDA	<MDA	<MDA	<MDA	

MDA: minimum detectable activity
MDA (α/swipe) = 0.045 Bq/cm2, MDA (γ/β /swipe) = 0.222 Bq/cm2, MDA (α/direct) = 0.007 Bq/cm2, MDA (γ/β /direct) = 0.075 Bq/cm2,
`
Background: 0.4 uSv/h
Clearance Level is given in REGDOC-1.6.1, Appendices R *Regulatory Quantities for Typical Radionuclides* and Y *Classes of Nuclear Substances*

2.6 CNSC Verification of Decommissioning

CNSC staff conducted a Type II remote compliance inspection of the SRCSF from July 8 to 10, 2020 [4] due to the COVID-19 pandemic restrictions. The inspection verified that the decommissioning activities were conducted safely and in compliance with the NSCA, its associated Regulations, the licence, DDP and the supporting documentation.

The CNSC Inspection Team carried out a virtual walk-down of the SRCSF, verification of direct and removable contamination and radiation levels on video and in real time. Prior to the inspection, the Inspection Team reviewed the photographs of selected locations of the pool floor and wall and Reactor Room with clearly visible direct contamination readings and dimensions of excavated areas reported in the 147-CECNSC-20-0001, Technical Letter [9]. The Technical Letter demonstrated in detail that the decommissioning activities were completed in accordance with DDP and the SRCSF was ready for the upcoming decommissioning inspection for unrestricted use.

CNSC Inspectors observed that SRC established 1m x 1m grids on the walls, floor and the pool for a systematic square meter baseline radiological survey of Room 146 (Reactor Room), as shown in picture 3. The reactor pool had been completely drained; components of the reactor and auxiliary systems, reactor console, sample irradiation tubes, pool water and reactor water deionizers and the concrete reactor shielding along with various waste materials had been shipped out. General cleaning of the rooms was conducted, and appropriate signage, facilities and access controls were in place.

CNSC Inspectors confirmed that all direct radiation readings in the SRCSF (i.e., the Reactor Room 146 and the pool, Room 143, Uranium Analysis Laboratory, Room 144, Gamma Spectroscopy Laboratory, Room 145, Radioactive Storage Room), were near background levels. The measurements were conducted with a detector sensitive for alpha, gamma and beta radiation.

Picture 3: Decommissioned Reactor Room (R-146) corner where active deionizer was located (left) and Gamma Spectroscopy Laboratory (R-144)

The dimensions of excavated concrete areas in the pool floor and the wall were observed to be as described in the Technical Letter - please see table 2 and picture 1. All the sample holes were visible, marked and at the locations as described in the Technical Letter.

As part of verification activities, CNSC Laboratory Services (CNSCLS) and Kinectrics carried out independent confirmations.

CNSCLS conducted measurements of over fifty swipes (removable contamination) specified in the Inspection Compliance Matrix (swipes were shipped to CNSCLS). These swipes were taken from the floor and the walls of the Reactor Room where the active deionizer was located (picture 3), sections of the pool wall closest to the reactor core and areas with higher than average removable contamination readings. The results from the CNSCLS [15] showed that the removable contaminations are in line with the reported values. CNSCLS also analysed 18 concrete and rebar samples from the pool floor and wall, verifying the results from Kinectrics and SRC.

Kinectrics, accredited by Standard Council of Canada, analyzed and verified the radionuclide content of the selected concrete samples (ESDR, Appendix A). The samples were taken from the reactor pool and wall and rebars embedded in the concrete, from the most activated to the less activated areas. All samples are archived for further confirmation, if required.

CNSC staff concluded that the decommissioning activities at the SRCSF met the intent and objectives of the decommissioning licence and all other regulatory requirements; the end state radiological conditions described in the DDP have been satisfied; and the licensed activities posed no health and safety risk to the public or the environment.

2.7 CNSC Confirmation of Waste Characterization

In the Record of Decision [1] regarding the authorization of SRC to undertake decommissioning of the SRCSF, the Commission required SRC, as part of an application for a licence to abandon the SRCSF, to submit detailed waste characterization data and a confirmation of the accuracy of the estimates, and that CNSC review this information.

CNSC staff confirmed that SRC carried out detailed characterization of decommissioning waste including accuracy of its estimates and that CNSC staff undertook an assessment of that information. The following paragraphs summarize those aspects.

Table 7: Summary of radiological characteristics of major decommissioning waste packages (except fuel)

Container	Radionuclides	Physical form	Chemical form	Activity (actual)	Activity (estimated)
Type A (B-25-16592), Beryllium reflectors, shims, PPE&C	Co-60, Zn-65, Eu-152, Eu-154	Solid	Metal (mainly)	41.1 MBq	26.7 GBq
Type A (B-25-16593), Lower reactor components, Cd control rod, PPE&C, IX resin	Co-60, Zn-65, Mn-54	Solid	Metal (mainly)	27.8 MBq	1.4 GBq
Type A (B-25-16594), Upper reactor components, irradiation tubes, PPE&C, excavated concrete	Co-60, Zn-65, Mn-54, Eu-152, Eu-154, Sc-46, Fe-59	Solid	Metal (mainly)	430 MBq	692.6 MBq

SRC characterized the decommissioning wastes as they were packaged for transportation. The characterization included monitoring for fixed and removable contamination and radiochemical analyses for major radionuclides. The information on radionuclide concentrations were combined with the weight of the materials, in order to generate an estimate of the radionuclide inventories in each shipping container.

Table 8: Estimates vs Actual Quantity of Radioactive Materials

Radioactive Materials	Estimated Quantity	Actual Quantity	Shipped to
Irradiation Tubes	10	10	Canadian Nuclear Laboratories, Chalk River
Upper Reactor Container	1	1	
Lower Reactor Container	1	1	
Beryllium shims	10	10	
Beryllium annulus	1	1	
Beryllium base	1	1	
Ion Exchange Columns	3	3	
Concrete	0.08 m^3	0.7 m^3	

As part of the SRCSF decommissioning process, SRC prepared 147-01622-REPT-002, *SRC SLOWPOKE-2 Decommissioning Waste Management Plan* [16] describing the strategy for managing the wastes generated during decommissioning. This document also contained estimates of the waste quantities and radionuclide content expected in each category of waste.

As can be seen from table 7, the estimated radioactivity values of wastes are much higher than the actual measurements, due to conservative impurity assumptions and decay time. Calculations assumed a minimum decay time of 2 weeks, when in reality, the components were removed months later.

Table 9: Estimates vs Actual Quantity of Non-Radioactive Non-Hazardous Materials

Non-Radioactive Items	Estimated Quantity	Actual Quantity	Shipped to
Capsule Receiver	1	1	IAEA
Irradiation controller	1	1	
Uranium analysis system	1	1	
Capsule Receiver	1	1	Royal Military College SLOWPOKE-2 Facility
Irradiation controller	2	2	
Pool water purification system	1	1	Ecole Polytechnique SLOWPOKE-2 Facility
Service Box	1	1	Landfill disposal
SRC SLOWPOKE cooling coil	1	1	
Control rod motor cover	1	1	
Concrete Shielding Blocks (9000 lbs)	6	6	
Frame of water purification system	1	1	
Radiation detector	1	1	
Attached readout unit with cables	1	1	
Support brackets	4	4	
Tier rack	4	4	
Wood and wooden stand	1	1	
Wheeled side attachments and handles	2	2	
Radiation wall mount detectors	2	2	
Electric Box	1	1	
Desk	1	1	
Cable Trays	8	8	
Monitor	1	1	
Control Console	1	1	
RML-200 Detector	1	1	Repurposed within SRC EAL

The actual quantity of active waste generated from the decommissioning was consistent with the planned estimates in the DDP and Waste Management Plan, with the exception of an increase in the concrete waste, as shown in tables 8 and 9. This increase, from 0.08 to 0.7 m^3, was due to the removal of additional concrete that was removed from the reactor pool in order to meet the requirements as stipulated in SOR/2000-207 [10].

SRC categorized and characterized the waste before shipping out of SRCSF according to 147-01622, *SRC SLOWPOKE-2 Decommissioning Waste Management Plan*, providing the radiochemical and physical properties in order to ensure safety of public, workers and environment.

The waste characterization undertaken by SRC met CNSC staff's expectations.

2.8 Indigenous Consultation

The common law duty to consult with Indigenous groups applies when the Crown contemplates actions that may adversely affect established or potential Indigenous and treaty rights. Based on the information provided, CNSC staff have determined that the activities to be conducted will not cause an adverse impact on potential or established Indigenous or treaty rights, therefore, the duty to consult does not arise in relation to this project.

2.9 Public Information

SRC's public information program provides the framework to communicate key information about the decommissioning project to stakeholders, employees and the public.

Since 2017, SRC has conducted both internal and external communications activities in support of the decommissioning project. SRC posted a news release and facilitated discussions with the public. A factsheet and Frequently Asked Questions were posted along with contact information on the SRC SLOWPOKE-2 webpage. In December 2018, SRC hosted a public meeting regarding the decommissioning of the SRCSF. There has been very low level of public interest regarding the facility in general. Responses received have been either neutral or positive. In 2020, the SRC announced that they have submitted an application to the CNSC for a licence to abandon, which removes the operating licence that SRC originally held for the SLOWPOKE-2 research reactor. There was little interest in the news. Generally, public and media interest in the reactor has been dwindling [17, 18].

2.10 Cost Recovery

SRC is not subject to cost recovery fees in accordance with subsection 2(a) of the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*.

2.11 Financial Guarantee

SRC holds a financial guarantee in the amount of C$5.76 million in the form of Trust and Financial Security and Access Agreements.

SRC's Board of Directors approved the decommissioning of the SRCSF and authorized the President/CEO to negotiate and execute the contracts required for decommissioning. In March 2020, SRC made a request [19] for the release of financial guarantee funds, due to the completion of the major milestones in decommissioning, and recovering the payments made from the operating cash. The path forward chosen at the time was for SRC to wait until the completion of the decommissioning and apply for a licence to abandon, granting of which the financial guarantee would be released.

No decommissioning activities remain; therefore, a financial guarantee is no longer required. CNSC staff recommend the release of the financial guarantee funds.

2.12 Nuclear Liability and Compensation Act

The SRCSF is subject to the *Nuclear Liability and Compensation Act* and is designated as a nuclear installation under the *Nuclear Liability and Compensation Regulations*.

Accordingly, the SRCSF, during its operation, required nuclear liability insurance. Following the completion of decommissioning activities, this nuclear liability insurance is no longer required. The SRC intends to request the removal from the *Nuclear Liability and Compensation Regulations* effective the date of issuance of the Commission's decision, contingent on the Commission granting SRC's request for a licence to abandon.

2.13 Environmental Assessment

The abandonment of a decommissioned nuclear reactor facility does not trigger an IA under the *Impact Assessment Act*. It is not a project on federal lands or outside of Canada, and is not a designated project under that Act.

The CNSC conducts Environmental Protection Reviews (EPR) under the NSCA for all projects, in accordance with its mandate, to ensure the protection of the environment and health of persons. An EPR is a science-based environmental technical assessment by CNSC staff as set out in the NSCA. CNSC staff conducted an EPR [20] for SRC's decommissioning project. The EPR focused on items of regulatory oversight and on typical topics of public interest related to the decommissioning of a nuclear facility, such as releases to air and surface water and radiation protection. The information provided in the EPR supported the recommendation by CNSC staff to the Commission to authorize the decommissioning of SRCSF [6].

There will not be any activities that will affect the environment in or around the site occupied by the SRCSF.

3.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

CNSC staff conclude that the licensee:

1. Has fully decommissioned the SRCSF and has met CNSC regulatory requirements over the course of decommissioning activities.
2. Has left no nuclear substances in place and no activities are performed that would require an operating licence under the NSCA.

CNSC staff recommend that the Commission:

1. Revoke the current Saskatchewan Research Council Licence, NPROL-19.01/2023.
2. Issue a licence to abandon the SLOWPOKE-2 Reactor Facility.
3. Release the financial guarantee held for decommissioning of Saskatchewan Research Council SLOWPOKE-2 Reactor Facility.

REFERENCES

[1] *Record of Decision DEC 19-H100, Saskatchewan Research Council*, (e-Doc 6046494) December 6, 2019.

[2] *Application for the Licence to Abandon the Saskatchewan Research Council SLOWPOKE-2 Facility (SRCSF) NPROL-19.01/2023,* (e-Doc 6414793) October 27, 2020.

[3] *Non-Power Reactor Operating Licence SLOWPOKE-2 Reactor Saskatchewan Research Council*, NPROL-19.01/2023, (e-Doc 5905832) December 6, 2019.

[4] *Decommissioning inspection of the SRC SLOWPOKE-2 Facility, SRC-2020-01*, (e-Doc-6382152) September 22, 2020.

[5] 147-01600-ddp-002 *SRC Detailed Decommissioning Plan*, (e-Doc 5851109) March 4, 2019.

[6] Commission Member Document, *SRC Decommissioning CMD: 19-H100*, (e-Doc 5880419) July 10, 2019.

[7] Communication, P. Rees to I. Erdebil, Core Received at SRS, (e-Doc 6354902) September 11, 2019.

[8] 147-01600-ESDR-002 *SRC End State Decommissioning Report, SRC SLOWPOKE-2 Facility*, (e-Doc 6485798) February 4, 2021.

[9] SRC/Candu Report, 147-CECNSC-20-000L *Technical Letter*, (e-Doc 6324543) June 22, 2020.

[10] *Nuclear Substances and Radiation Devices Regulations* (SOR/2000-207).

[11] *Nuclear Substances and Radiation Devices Licence Application Guide: Nuclear Substances and Radiation Devices*, REGDOC-1.6.1 Version 2.

[12] Inspection at SRC SLOWPOKE-2 Reactor Facility, SRC-2019-01, (e-Doc 6030871) November 6, 2019.

[13] Correspondence, I. Ariani to I. Erdebil, Waste Data, (e-Doc 6554558) April 14, 2021

[14] Letter, I. Erdebil to P. Rees, *Saskatchewan Research Council Pool Water Analysis,* (e-Doc 6097275) January 20, 2020.

[15] CNSC Laboratory Services Report, LR-SA-2020-00006, (e-Doc 6361798) August 18, 2020.

[16] 147-01622-REPT-002 *SRC SLOWPOKE-2 Decommissioning Waste Management Plan*, (e-Doc 5928764) November 19, 2018.

[17] Correspondence, E. Taman-Atmar to I. Erdebil, Public Information Review, (e-Doc 6554564) March 11, 2021.

[18] SRC Report, *Public Information Update Report*, (e-Doc 6555640) May 4, 2021.

[19] Correspondence, P. Rees to P. Tanguay, Trust Withdrawal Request, (e-Doc 6541332) March 26, 2020.

[20] *Environmental Protection Review*, (e-Doc 5794571) June 2019.

GLOSSARY

CNSC	Canadian Nuclear Safety Commission
CNSCLS	CNSC Laboratory Services
CSA	Canadian Standards Association
DDP	Detailed Decommissioning Plan
DIQ	Design Information Questionnaire
DOE	Department of Energy (US)
EPR	Environmental Protection Review
ESDR	End State Decommissioning Report
HEU	High-enriched Uranium
IA	Impact Assessment
IAEA	International Atomic Energy Agency
NSCA	*Nuclear Safety and Control Act*
SCA	Safety and Control Area
SLOWPOKE	Safe LOW POwer Kritical Experiment
SRC	Saskatchewan Research Council
SRCSF	Saskatchewan Research Council SLOWPOKE-2 Reactor Facility
SRS	Savannah River Site
UCL	Unconditional Clearance Level

Proposed Licence

Word Ref.: e-Doc 6533222
PDF Ref: e-Doc 6586815

Current Licence

Word Ref: e-Doc 5899570
PDF Ref: e-Doc 5905832