

Long-term Safety

NPD Closure Project

The nature of the materials at the Nuclear Power Demonstration (NPD) site, known collectively as the waste inventory, as well as the numerous safeguards to protect the environment and human health, make this reactor a particularly suitable candidate for in-situ disposal. The fundamental objective of in-situ disposal is to contain and isolate the remaining waste inventory to prevent a release of radioactivity to the environment. Doing so ensures that post-closure doses and environmental concentrations are acceptably low under all plausible conditions.

Six Key Safety Features

1. The majority of the radioactivity is present within the reactor components. The reactor components includes steel and zircaloy, which will corrode very slowly.
2. The reactor, which is already tens of metres below ground in the bedrock, is protected by the thick concrete vault walls, as well as the facility's structure walls.
3. The backfilled grouted vault will constrain the rates of groundwater flow and maintain an alkaline environment, which slows corrosion of radioactive components.
4. The isolation of radionuclides will be further achieved by filling much of NPD with grout.
5. A concrete cap will be constructed over the grouted facility above the reactor vault to provide a redundant layer of protection against inadvertent human intrusion.
6. An engineered cover will be placed over the entire facility to divert rain and melt water from the facility.

Natural Hazards

Through the Environmental Assessment, the project has examined how extreme weather, natural disruptive scenarios, like an earthquake, and long-term processes like climate change will impact the decommissioned NPD facility. Results have indicated that in all of these scenarios, human and environmental exposures to contaminants will remain below current regulatory limits. That is to say, people and the environment remain protected in any of the following "worst case" scenarios:

- Glaciation
- Tornado
- Flooding
- Earthquake
- Forest Fire
- Changes to the Ottawa River



Taking Care of Future Generations

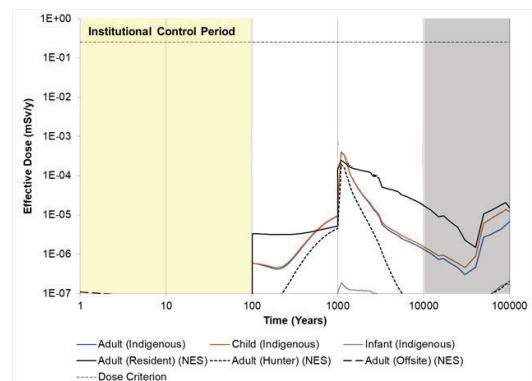
Human health is of particular interest to members of the public and is evaluated for all stages of the proposed project. The graphs below provide the predicted results of radiation doses that could be received by the public during future unrestricted uses of the site.

The Post-closure Safety Assessment considers three potential exposed groups:

- Site resident family: A highly conservative model that maximizes potential exposures. This is a small household (comprising two adults, a child and an infant) living on top of the disposal facility with a self-sufficient lifestyle. This assumes the use of potentially contaminated ground water for domestic and agricultural purposes.
- A hunting/recreational group, represented by a small number of adults and children making hunting and/or recreational use of the river and the area surrounding the NPD. This group gather and eat wild foods, is similar to the types of land use that might be exhibited by Indigenous people.
- An offsite group, represented by two households (two adults and two children) that live by the Ottawa River at Deep River and Ottawa/Gatineau. These households are assumed to use river water from the Ottawa River for domestic use and as drinking water, and to use the Ottawa River for recreational swimming.

The Post-closure Safety Assessment also assesses dose to an Indigenous receptor group. This is a self-sufficient receptor group that is intended to represent traditional Indigenous lifestyles.

As you can see, the highest radiation dose predicted to be received is more than 625 times lower than the regulatory limit. This is less than the radiation dose you would receive from a single dental x-ray, meaning the in-situ disposal approach effectively protects future generations.



Protecting the Ottawa River

NPD Closure Project

Continued protection of the Ottawa River is a key focus of CNL's work. Members of the local public have shared with us the ecological importance of the Ottawa River and its use as a source of drinking water. For Indigenous communities, the Ottawa River, known as the Kichi-Sibi, is a revered waterway with immeasurable value.

Members of the NPD Closure Project team live with their families in communities along the Ottawa River. Several members of the team grew up in the area. Caring for the river and ensuring it remains a healthy, safe place where we can continue to live, work and play is essential to us.

Why we are confident in our protection of the Ottawa River

Scientific modelling and analysis

CNL has updated the Post-closure Safety Assessment, which evaluates the potential long-term effects of the project on the public and environment. This update includes the final grout formula, results from the geological site characterization and the new, more detailed earthquake assessment.

In the last two years, to further demonstrate CNL's alignment with the public and Indigenous communities' care for the Ottawa River, CNL has undertaken additional detailed modeling to determine how potential releases from the grouted NPD facility could affect the river after closure is complete. This new analysis supports CNL's conclusion that the Ottawa River will remain protected considering all potential releases after closure.

Results of our modelling and analysis

The only non-radioactive element that is present in significant quantities in the NPD facility is lead, and the behaviour of lead over time was modelled. The peak concentration of lead in surface water is estimated to be very small indeed at 7×10^{-11} mg/L (another way of saying this is 0.07 parts per trillion), and is well under the maximum permissible concentrations in the Provincial Water Quality Objectives (PWQO), adopted from Ministry of the Environment (Ontario), which is 0.001 mg/L. The resulting concentration is approximately 100 million times lower than this guideline.

The main radioactive element in the facility is tritium. The peak level of tritium in the river water resulting from the closed NPD facility is projected to be 0.04 Bq/L. This is 100,000 times lower than Health Canada's limit of 7000 Bq/L of tritium in drinking water.

Concentrations of the Five Dominant Radionuclides in River Water

Time (y)	Radionuclides (Bq l ⁻¹)					Total
	H3	C14	Ca41	Ni59	Cl36	
100	7E-05	9E-08	2E-10	<1E-10	2E-09	7E-05
300	7E-10	1E-07	6E-10	<1E-10	2E-09	1E-07
1000	<1E-10	9E-08	5E-09	<1E-10	3E-09	1E-07
3000	<1E-10	3E-06	8E-07	<1E-10	8E-07	4E-06
10000	<1E-10	6E-07	1E-06	1E-09	5E-07	2E-06
30000	<1E-10	7E-08	7E-08	2E-07	2E-07	6E-07
50000	<1E-10	8E-09	8E-09	1E-06	2E-07	1E-06
Maximum	4E-02	5E-06	2E-06	4E-06	9E-07	4E-02
Time of Max.	1*	1300	5500	90000	3750	1*



Monitoring

Finally, the project team has developed draft follow-up monitoring plans which describe how all aspects of the environment including the Ottawa River will be monitored to ensure that the impact from the NPD Closure Project is minimal. We have received comments on these plans from the public and Indigenous communities and will continue to seek and listen to feedback to ensure that the follow-up monitoring program for the NPD site is optimal.



What We've Heard - 2

NPD Closure Project

Over the last few years, we've learned from the public and Indigenous communities. At meetings, public information sessions and community events, on the telephone and by email, we've heard a variety of perspectives on the closure of the first power reactor in Canada.

Knowing what aspects of the environment that are valued by the public and Indigenous Peoples has helped us identify what to take into account when planning the project and ensures appropriate mitigations are in place to protect our environment.

The public and Indigenous Peoples also had the opportunity to submit formal comments on the 2017 Environmental Impact Statement (EIS) for the NPD Closure Project to the Canadian Nuclear Safety Commission (CNSC). These comments are posted to the web page for the NPD Closure Project's Environmental Assessment (reference number: 80121). Based on feedback from stakeholders and Indigenous communities, including previous engagements and these submitted comments, eight main themes have been identified and incorporated into our plans for the project.



5. IAEA Guidance on the In-situ Decommissioning

CNL received questions about the International Atomic Energy Agency's (IAEA) guidance in their safety standard for decommissioning which states that in-situ decommissioning is not a suitable option for all nuclear facilities and should be considered only under certain conditions. CNL agrees with this assessment and considers that NPD has features which make it suitable for long-term disposal such as its location 80 feet below grade into bedrock and the thick concrete basement structure. The NPDDF project is creating a disposal facility by decommissioning the existing reactor and then utilising the remaining below grade structure to create a new disposal facility. In this case decommissioning of the NPD reactor ends following partial removal of the structure, and does not involve entombment of the facility. The decommissioned waste is then placed into the disposal facility which when complete undergoes closure. The strategy used is therefore not entombment but partial removal, which is acceptable according to GSR-6, (IAEA 2014).

CNL is considering IAEA guidance in their safety standards for the closure of the facility, and more importantly is also considering IAEA guidance in their safety standards for waste disposal, since the facility – in its end state – would be classified as a disposal site.

It is important to note that CNL is licensed by and is accountable to the Canadian nuclear regulator, the Canadian Nuclear Safety Commission (CNSC). CNL is following Canadian standards and regulatory requirements for decommissioning the NPD facility and Canadian regulations for the creation of a disposal facility.

6. Radiologic Inventory

CNL received several requests for information on the exact radiological content of the NPD facility that will be on-site for disposal. CNL has updated the Environmental Impact Statement to include recently completed neutron flux modeling using modern 3-dimensional codes and libraries, to improve the certainty of the radiologic inventory of the reactor components. CNL has also completed a full building characterization, including all remaining nuclear systems, to verify the total radiologic inventory. Since the reactor contains most of the remaining radiologic inventory (the fuel was removed in 1988), the completion of these additional analyses, incorporating field sampling measurements, allows CNL to better conservatively define the total radiologic inventory proposed for disposal.



7. Design and Engineering Details

At the time of the submission of the 2017 draft Environmental Impact Statement, CNL had completed only a preliminary design of the disposal facility. Now that CNL has a more detailed design of the disposal facility, including the engineered barrier and the finalized grout formulation, an update has been incorporated in the revised draft Environmental Impact Statement (EIS), submitted to the CNSC in 2020.

8. Indigenous Engagement

CNL, as a steward of the NPD property on behalf of Atomic Energy of Canada Limited (AECL), is committed to meaningful engagement with local Indigenous communities and is working to establish long term agreements with them. These interactions are on-going and allow CNL to learn how the Project could impact the rights and interests of Indigenous groups, and to identify actions to be taken. At the same time, Canada's nuclear regulator, the Canadian Nuclear Safety Commission, is also undertaking consultation activities with Indigenous communities, to ensure the Crown's duty to consult is upheld.

What is the duty to consult?

The Crown's unique relationship with Indigenous Peoples gives rise to the duty to consult, and where appropriate accommodate Indigenous peoples when the Crown contemplates conduct that might adversely impact potential or established Indigenous and/or treaty rights.

As an agent of the Crown, the CNSC has responsibility for fulfilling its legal duty to consult, and where appropriate accommodate Indigenous Peoples when its decisions may have an adverse impact on potential or established Indigenous and/or treaty rights.

As proponent, CNL engages with Indigenous communities and seeks to build long-term and meaningful relationships with those communities that have traditional territory and/or modern interests where we operate.

What We've Heard - 1

NPD Closure Project

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Knowing what aspects of the environment that are valued by the public and Indigenous Peoples has helped us identify what to take into account when planning the project and ensures appropriate mitigations are in place to protect our environment.

The public and Indigenous Peoples also had the opportunity to submit formal comments on the 2017 Environmental Impact Statement (EIS) for the NPD Closure Project to the Canadian Nuclear Safety Commission (CNSC). These comments are posted to the web page for the NPD Closure Project's Environmental Assessment (reference number: 80121). Based on feedback from stakeholders and Indigenous communities, including previous engagements and these submitted comments, eight main themes have been identified and incorporated into our plans for the project.



1. Alternative Means & Approaches

In selecting disposal for the NPD reactor, CNL has considered several alternatives, including continued storage with surveillance, partial dismantling and removal, and full dismantling and removal of the reactor and components. Through its various engagements, CNL was asked to provide more detail in the EIS on how it chose the in-situ disposal method for the NPD Closure Project. CNL has added quantitative assessments of the options considered to the EIS, and also updated the scenarios to include a new disposal facility becoming available during the institutional control period. Overall, the in-situ disposal method is still considered the safest and preferred option.

2. Grout and Concrete Degradation

The NPD building structure will be filled with custom grout formulations to help contain and isolate contaminants, ensure stability, and reduce corrosion rates of the reactor components. CNL started with a specially-formulated grout used in other in-situ disposal projects and adapted it to the unique requirements of the NPD facility. Extensive research was conducted on the use of grout in similar circumstances. We have also conducted a test program using locally-sourced materials to verify that the grout formula requirements can be met. The test included fresh properties, such as determining the ability of the grout to flow around piping and tanks, and cured properties, such as strength and hydraulic conductivity. Combined with the existing robust construction of the underground facility, the proposed grouting process will enhance protection of people and the environment. CNL has added details on grout and grout formulations to the revised draft EIS that has recently been submitted to the CNSC.



3. Impacts from Earthquakes

CNL has conducted additional detailed quantitative analysis to assess how a catastrophic earthquake – one that might occur once every ten thousand years – would affect the facility. Results show that cracks would develop mainly in the areas of the NPD facility which are above the bedrock level. The grouted reactor vault would not be affected as it is well below this depth, with the grout providing increased protection against the stresses of the earthquake. Modelling updates show that any impacts to the public or environment from such an earthquake would be well below the regulatory limits.

CNL also conducted additional geological site characterization work to strengthen our understanding of the geology around the NPD site. This characterization work strengthened our confidence in bedrock elevations and characteristics, including quality and rates of water flow. It also confirmed the soundness of the bedrock at the site. That is, nothing was encountered that would preclude this location as a disposal site. This information was important to confirm assumptions made in seismic modeling and to demonstrate the suitability of the site for long-term stability.

4. Proximity to the Ottawa River

Ensuring the continued protection of the Ottawa River is a key focus of CNL's work and is reflected in the EIS. CNL has undertaken additional detailed modeling of potential releases from the facility to assess how they could affect the river. This new analysis supports the conclusion of the EIS that the Ottawa River will continue to be protected. CNL has also updated the Post Closure Safety Assessment, which evaluates the potential long-term effects of the project on the public and environment. The update included the final grout design, results from the geological site characterization and the new, more detailed earthquake assessment. Finally, the project team has developed draft follow-up monitoring plans, which are available for review by interested parties. CNL held a workshop to discuss the draft effluent monitoring plans in 2019 that included members of the public. Additional workshops will be held for the environmental and groundwater plans in the near future and CNL looks forward to input from the public and Indigenous communities.



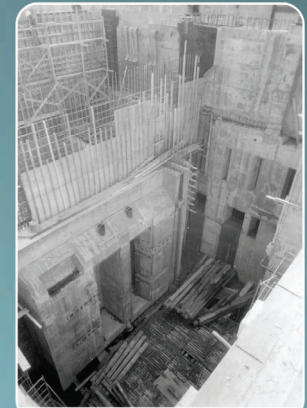
Closing the NPD Facility

Grout



Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

The Nuclear Power Demonstration (NPD) reactor structure will be filled with a custom grout formulation to help contain and isolate contaminants, ensure stability, and to reduce corrosion.



NPD construction – Fall 1959



GROUT — FACTS

1

What is it?

- Grout is a robust filler similar to concrete, typically using sand instead of gravel and more water making it flowable into congested areas.
- It is specifically formulated for the NPD structure using locally-sourced material – this is NOT what you would use for a DIY project.
- Used to fill entire concrete structure.

2

Grout is time-tested

- More than 30 years of research and development support the use of grout in nuclear decommissioning and waste disposal.
- Grout has been used for more than 100 years for infill applications in the environmental remediation of mines and other industrial sites.
- CNL consulted experts across North America on the use of grout and the verification of formulations.

3

Grout safety

- Grout infill will minimize radiological risks to workers and the environment.
- Grout will be placed into voids in the concrete structure to further slow the movement of any groundwater entering the facility.
- Combined with the existing concrete structure, grout will further provide contaminant containment.
- Grout properties are extensively tested and measured.

4

Public and Indigenous Engagement

- CNL has regularly briefed and hosted local stakeholders, local municipalities, and Indigenous communities.

EXISTING STRUCTURE IS SOUND

- The existing NPD structure sits roughly 25 metres below grade and is built into the Canadian Shield.
- Built with 8,000 cubic metres of concrete.
- Walls as thick as 2.7 metres.

Bedrock

Topsoil

Fill

Concrete cap

Reactor

GROUT FORMULA FOR SAFE CONTAINMENT
(PLACING 16,000 CUBIC METRES)

Key Properties of Grout

- Highly flowable
- Does not separate during placement
- Self-leveling

Bulk Fill

- Flowable to fill congested areas and to ensure stability

Learn More and Get Involved

CNL engages with local and Indigenous communities to provide opportunities for participation in the [Environmental Assessment process](#).

@CanadianNuclearLaboratories

@CNL_LNC

Participate in the Environmental Assessment process and learn more about NPD at www.cnl.ca/NPD or contact communications@cnl.ca.



Closure of the NPD Facility



A Canadian first

Nuclear Power Demonstration (NPD) made history in 1962 when it generated electricity from nuclear power for the first time in Canada. After 25 years of producing clean energy and serving as a training facility, NPD ceased operations in 1987.







The final stage

The Government of Canada and Atomic Energy of Canada Limited (AECL) are committed to the responsible management of Canada's nuclear liabilities. CNL's decommissioning of NPD is part of that commitment.

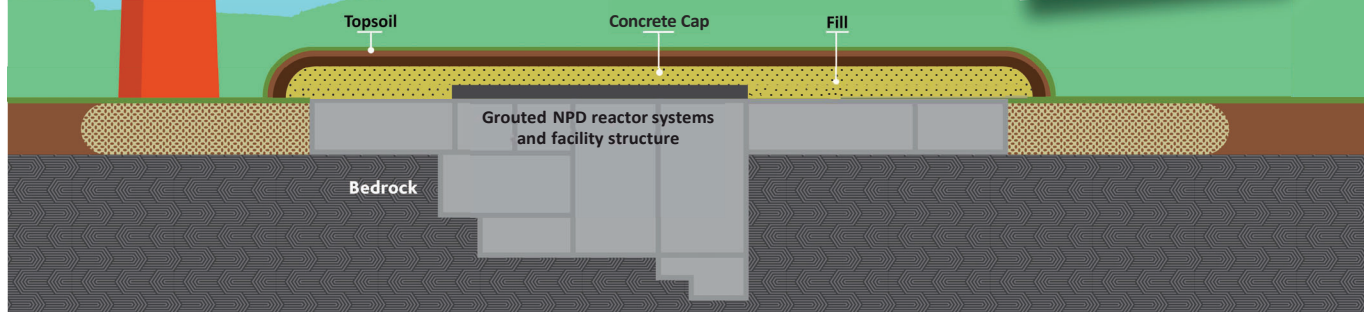


Protection of people and the environment

In-situ disposal is the preferred option to close the NPD site. Based on sound scientific and engineering principles, it involves filling the below-grade structure with a specially formulated grout to create a waste disposal facility on the site. The structure will then be capped with reinforced concrete and covered with an engineered barrier.

-  **Successfully demonstrated**
at many nuclear facilities worldwide
-  Reactor systems are located tens of metres underground **in bedrock**, with robust engineered safety barriers
-  Institutional controls will restrict access and confirm **environmental performance**
-  Reactor systems will be **isolated and contained**
-  **Protects** workers, the public and the environment
-  **Future generations** will not have to manage the waste

The iconic red and white stack will be kept to preserve the habitat of the largest known population of Chimney Swifts in Canada.



Decommissioning Timeline

EARLY 1990'S

All nuclear fuel removed from NPD and systems drained

FALL 2017

Public comment period on draft Environment Impact Statement

2021

Public hearing and regulatory decision on the project

2024

In-situ disposal complete and NPD site closed

Learn More and Get Involved

CNL engages with local communities and Indigenous groups to provide opportunities to participate in the Environmental Assessment process.

Participate in the Environmental Assessment process and learn more about NPD at www.cnl.ca/NPD or contact communications@cnl.ca.



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