Submissions of Lake Ontario Waterkeeper and Ottawa Riverkeeper

Re: 2018 CNSC Staff Regulatory Oversight Report Meeting concerning Canadian Nuclear Laboratories Sites

Notice of Public Meeting: Ref 2019-M24

October 7, 2019

Submitted to:
Participant Funding Program Administrators cnsc.pfp.ccsn@canada.ca ad the CNSC Secretariat cnsc.interventions.ccsn@canada.ca

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Executive Summary

Ottawa Riverkeeper (ORK) is a charity that seeks to inspire action and collaboration in order to achieve a healthy Ottawa River in which every person can safely swim, drink, and fish. We work to encourage responsible decision making, to hold polluters accountable, and to recommend alternative practices and policies to safeguard our local waterways. We are also first responders on the river to investigate spills and harmful pollution that may impact aquatic life and public health.

Lake Ontario Waterkeeper (LOW) is a Canadian charity working for a day when every person in our watershed can safely touch the water, when the water is pure enough to drink, and when the lake is clean and wild enough that you could toss in a line anywhere and pull out a fish. Our work connects and empowers people in order to stop pollution, protect human health, and restore habitat. Our programs bring together law, science, culture, digital media and public education to achieve our goals, and we regularly assist in environmental decision-making processes as members of stakeholder advisory committees and through legal interventions.

ORK and LOW are collaborating jointly on this intervention and have retained two external experts to assist in the preparation of these submissions:

1. **Pippa Feinstein, JD, LLM** as case manager, legal counsel, and expert on public information-sharing policies and practices; and
2. **Dr. Ekaterina Markelova,** an expert on environmental modelling and biogeochemistry who provided the qualitative assessment of environmental contamination at the Chalk River complex with regard to the natural water bodies (wetlands, surface and groundwater).

These submissions begin by addressing certain concerns relating to intervention procedures and make several recommendations for immediate and longer-term solutions.

These submissions are also drafted to provide Commissioners with:

1) An evaluation of deficits in public information disclosure by CNL at Chalk River;
2) An overview of some potential environmental concerns from ORK's perspective concerning CRL impacts to local waterways and the need for more specific disclosures related to these identified concerns;
3) Associated recommendations for improvement at Chalk River; and
4) Recommendations concerning potential improvements to emergency/incident public alerts in Port Hope.

Finally, this intervention has been drafted to provide members of the public with:

5) A better understanding of how existing and still functioning facilities at the site operate;
6) A better understanding of the extent to which operating and retired facilities and current waste sites are contained; and
7) A better understanding of an event last year in which the west wall of the Port Hope Harbour collapsed, including the event's potential impacts to water quality in the area and the efficacy of subsequent mitigation measures.

About the intervenors

Ottawa Riverkeeper (ORK) is a charity that seeks to inspire action and collaboration in order to achieve a healthy Ottawa River in which every person can safely swim, drink, and fish. We work to encourage responsible decision making, to hold polluters accountable, and to recommend alternative practices and policies to safeguard our local waterways. We are also first responders on the river to investigate spills and harmful pollution that may impact aquatic life and public health.

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Current intervention opportunity

ORK and LOW have examined two sites and projects administered by Canadian Nuclear Laboratories (CNL): the Chalk River Laboratories (CRL) complex, and the Port Hope Area Initiative (PHAI).

Chalk River Laboratories

ORK was granted funding to examine the Chalk River site with a particular focus on its information sharing mechanisms and its impact to local ground and surface water.

The organization is a member of Chalk Nuclear Laboratories' (CNL) Environmental Stewardship Council (ESC). The ESC was started by Atomic Energy Canada Limited – Chalk River in 2006 in response to a recommendation of the Canadian Nuclear Safety Commission (CNSC). Through participation in the ESC, ORK has developed considerable knowledge of operations at CRL and the wastes that have accumulated at the site over its lifetime. This experience has highlighted the importance and urgency of dealing with all wastes at this site in a responsible and safe manner.

ORK submitted an intervention in last year's licence renewal process, however it did not retain experts at that time. The main objective for this current intervention is to better understand the Chalk River site – and in turn, assist members of the public to do the same. Unfortunately, due to several interrelated factors, including the complexity and age of the site and its facilities, there is a considerable lack of transparency concerning its exact make up and specific impacts on surrounding surface and groundwater.

More specifically, this intervention seeks to provide Commissioners with:

1) An evaluation of deficits in public information disclosure by CNL;

2) An overview of some potential environmental concerns from ORK's perspective concerning CRL impacts to local waterways and the need for more specific disclosures related to these identified concerns; and
3) Associated recommendations for improvement.

It has also been drafted to provide members of the public with:
4) A better understanding of how existing and still functioning facilities at the site operate; and
5) A better understanding of the extent to which operating and retired facilities and current waste sites are contained.

Port Hope Area Initiative

LOW was granted funding to examine an unplanned release event resulting from the collapse of the West Harbour Wall of Port Hope Harbour in October 2018.

LOW has been involved with decision-making processes for the PHAI for over a decade. The organization has also enjoyed long-standing relationships with many Port Hope residents since its founding in 2001. The organization intervened in 2009 during the Environmental Assessment (EA) for the PHAI, in 2012 during its licence hearing which ultimately granted a 10-year licence for remediation work, and again in October and November 2016 during a Commission meeting to review the PHAI.

This intervention seeks to provide members of the public with:
1) A better understanding the event, its potential impacts to water quality in the area, and the efficacy of subsequent mitigation measures;

It has also been drafted to provide Commissioners and CNSC staff with:
2) recommendations concerning the improvement of emergency/incident public alerts and subsequent messaging related to this and any other unplanned events.

However, before discussing these issues, certain concerns relating to intervention procedures must be briefly outlined.

Concerns with current Commission Meeting intervention processes

The Waterkeeper and Riverkeeper organizations have long expressed concerns with significant shortcomings involved with CNSC intervention proceedings, whether they be Commission meetings or hearings. These concerns should not surprise Commissioners or CNSC staff as they have been repeatedly expressed by both LOW and ORK in almost all past Commission hearings and meetings. Similar concerns have also been expressed by other public interest organizations and environmental non-government organizations who regularly intervene in meetings and hearings.

Ultimately, intervening in CNSC meetings and hearings is an unnecessarily fraught process that can at times disrespect the time and expertise of members of the public and public interest organizations who are deeply concerned about nuclear industrial operations and their regulation. Procedural deficits in the intervention regime compromise the CNSC's regulatory transparency and strain the relationship between the regulator and civil society. Immediate concerns apply to timelines for public interventions, and associated challenges with access to information (especially environmental data). However, there is an urgent need to more formally review CNSC intervention procedures in consultation with public stakeholders.

Timelines

Just under three months were provided as notice for funding applications, with the notice published on February 25, and funding applications due May 17, 2019. Once applications were submitted, it took another three months to render a funding decision, which was received by ORK and LOW on August 9, 2019. This left only two months for LOW and ORK to: secure third-party expert consultants; revise the scope of study to reflect actual funding amounts offered; obtain information from CNSC staff, CNL, and other government agencies responsible for overseeing the subjects of study; not to mention understanding, synthesizing, analysing information received, and drafting legal arguments and scientific/technical findings. Further, the CNSC staff Commission Member Document (CMD) that forms the basis for the current intervention opportunity was only made available on September 5, effectively providing a month for its review.

At least three months should be afforded by the CNSC to intervenors for their reviews. This period would span from the date on which organizations are notified of the actual granted funding amounts until the date on which written submissions are due. The release of CNSC staff CMDs should be made as soon as possible to the funding announcement date to further assist intervenors in preparing their written submissions.

In this current intervention opportunity, the CNSC staff CMD was completed August 16, and released September 6, 2019. Had the report been completed only two weeks earlier, and released immediately, it would have doubled the time over which it would have been available to intervenors. Making such amendments to CNSC staff CMD release times should not be considered too onerous to be applied by the Commission

Recommendation 1: that the CNSC ensure intervenors have at least three months to prepare written interventions for future public meetings. This time period would span from date on which organizations are notified of the actual granted funding amounts until the date on which written submissions are due.

Recommendation 2: that CNSC Staff ensure their CMD is available at least two months in advance of due dates for written interventions.

Access to information

Current timelines often mean that interventions focus mainly on obtaining information, and often have to be drafted without having received sufficient responses to requests. Further, there is also insufficient time left for actual synthesis and analysis of information received.

In the case of this intervention, formal Access to Information requests were demanded by two agencies to respond to ORK information requests. Under the applicable federal and provincial access to information legislation, agencies have 30 days to initially respond to requests for information and then several weeks to refine and understand requests. It can ultimately take several weeks or months for agencies to actually provide requested records. In the current case, no records (requested pursuant to legislated Access to Information processes) have been provided to date to ORK, and limited information has been provided to LOW from provincial, federal, and municipal bodies. Further, it took three weeks (four emails, two phone calls, and a request for assistance to the CNSC Secretariat) to receive acknowledgement from CNL of our initial information requests and subsequent partial responses to these requests. Ultimately, much information required to provide the analysis we were funded to undertake in this intervention has still not been provided to date.[1]

[1] See Appendix A to these submissions for a more detailed account of information requests made by LOW and ORK.

This not only a waste of Waterkeeper's and Riverkeeper's experts' time and expertise. It also constitutes a waste of the Commission's time and participant funding. These experts are already donating much of their time to supplement these intervention processes and contribute what they can to assist LOW and ORK in their important public interest work. More formalized information request procedures, spread over longer timeframes would better support intervenors and ensure experts could provide more value-added information.

Recommendation 3: The CNSC should immediately initiate a comprehensive review of access to information or interrogatory processes for future Commission meetings and hearings in consultation with stakeholders.

Recommendation 4: In the meantime, the CNSC should immediately institute the following changes concerning access to information by intervenors for future Commission meetings:

- *a. When notifying organizations of their funding grants, Participant Funding Program officers should also provide contact information for designated individuals representing the industrial facilities that are subject to the meeting reviews. These representatives should be prepared to field questions and should be made aware of intervenors' timeframes and deadlines; and*
- *b. Some CNSC staff time, and industry/proponent staff time must be designated to provide intervenor-requested information and engage in follow-up information requests and/or site visits.*

ORK REVIEW: CHALK RIVER LABORATORIES

<u>Chalk River's Ecological Context</u>

The Chalk River Laboratories (CRL) are located in several clusters in the municipality of Deep River. The largest facilities sit on banks of the Ottawa River, at the river's deepest point.

Facilities are located in the Canadian shield, predominantly on eroded bedrock,[2] in a rift valley. Actually, it is through this valley that the Ottawa River flows. This effectively means that the Chalk River complex was sited not merely 'adjacent to the Ottawa River' but perhaps more accurately, deeply embedded within the river system. Several Chalk River facilities directly border the shores of the river and several lakes - the largest of which are Perch Lake and Sturgeon Lake. Many of the facilities are also surrounded by wetlands intimately connected to the ecology of the flowing river. As such, Dr. Markelova explains in her report, there are numerous pathways for contaminant migration from the site to the river, either by direct discharge into the river, or else via contaminated wetlands, bogs, streams, and lakes which ultimately flush out into the river. This also means that biota and fauna along contaminant pathways are at risk of long-term exposure.[3]

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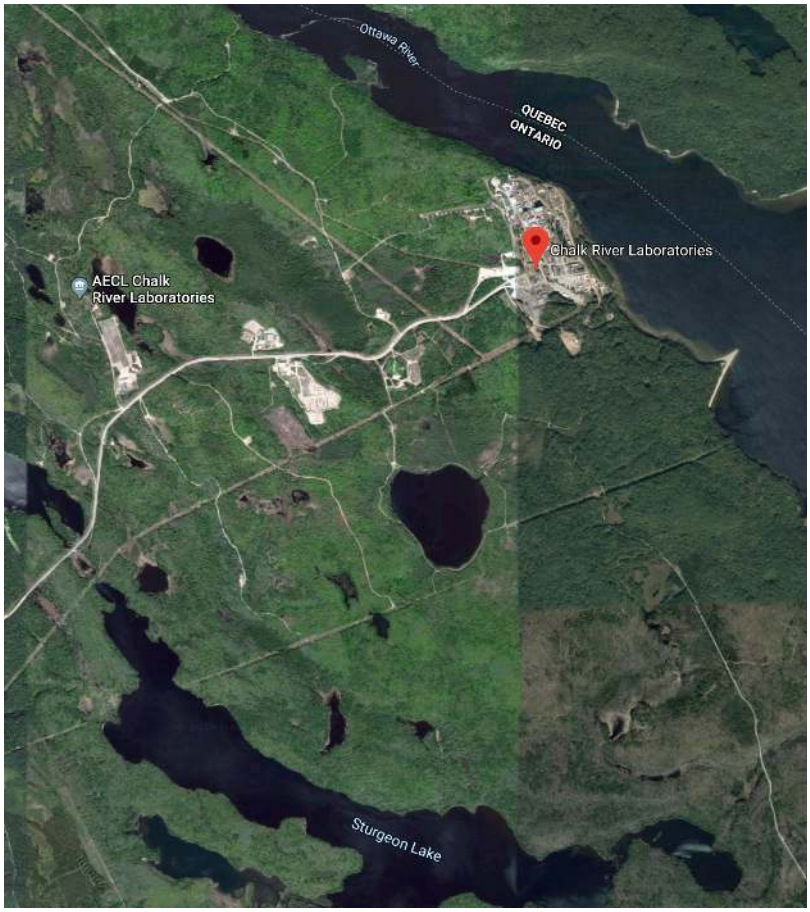
[2] See: Wilf Ruland, "Initial Indpendent Review of Hydrological Issues Pertaining to the draft Environmental Impact Statement for the Proposed Near Surface Disposal Facility (NSDF) at the Chalk River Nuclear Site", prepared for Ottawa Riverkeeper and the Algonquin Anishnabeg Nation Tribal Council, July 31 2017, online: <https://www.ottawariverkeeper.ca/wp-content/uploads/2017/08/Ottawa-Riverkeeper-Submission-EIS-Review_AUG16.pdf>.

[3] Dr. Markelova Expert Report at p. 3, Appendix B to these submissions.



Source: Google Maps, retrieved September 10, 2019

The CRL facilities were built within the Boreal Forest Biozone, thus forestry is an important industry in the area. Much of the CRL property is forested with white, red, and jack pine; white and yellow birch; hemlock; white, red, and black spruce; beech; sugar and red maple; red oak; and poplar. The Canadian Forest Service established 30 research plantations around the Chalk River complex which are managed and monitored by the Petawawa Research Forest.[4]

The area hosts several hydroelectric generating facilities as well, which constitutes another ecological stressor on local waterways, in addition to expected municipal and agricultural runoff associated with local towns and farmland.

Wildlife species in the area include moose, deer, black bear, ruffed grouse, hare, beaver, mink, fisher, marten, otter, muskrat, fox, and raccoon. Numerous wetlands provide a suitable nesting habitat for waterfowl.[5]

Recreation and tourism is popular in the area. The Ottawa River is an important source of sport fishing. Fish found in local waters within and surrounding the CRL property includes pike, bass, walleye, muskie, and sturgeon.[6] Paddling and boating in the region is also popular amongst locals and visitors.

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[4] Written submission from Canadian Nuclear Laboratories in the matter of the Chalk River Laboratories Application for the renewal of the Nuclear Research and Test Establishment Operating Licence", January 24-25, 2018, online: <http://www.cnl.ca/site/media/Parent/CMD(1).PDF> [CMD 18-H2.1] at p. 4.
[5] *Ibid* at p. 4.
[6] *Ibid* at p. 5.

Chalk River's Historical Context

Chalk River was established, and the first facilities there were built, during the Second World War. The nearby town of Deep River was built to house those working at the laboratories. During the war, Canadian and European physicists and engineers worked on nuclear weapon development for the Allied powers. When the war ended, many of the Canadian scientists stayed there and transitioned their work to focus on peaceful uses of the atom: namely designing and building the first CANDU nuclear energy generating reactors as well as research reactors to produce a variety of medical isotopes for the global market.

The licensing challenges posed by such a complex and dynamic site are immense, especially when understandings of nuclear substances and the environment have evolved so much over its 80-year lifespan. The capacity and attitudes of government regulators have also shifted significantly over this time. Chalk River predates the establishment of the *Nuclear Safety and Control Act* (and its predecessor the *Atomic Energy and Control Act*) and the CNSC (and its predecessor the Atomic Energy and Control Board). The historical legacies of the site are difficult to separate from current conditions as they continue to be felt, both in the surrounding ecology as well as well as governing licenses and permits.

Review of Selected CRL Facilities and Associated Ecological Concerns

As of 2018, the Chalk River complex housed 12 Class I nuclear facilities in operation; several fuel manufacturing and processing facilities; hot cells; 13 waste management areas, four Class II nuclear facilities (including accelerators and irradiators), over 60 radioisotope laboratories; and various support facilities and offices.[7] A description of some of the larger facilities and associated ecological impacts of concern are as follows:

The **National Research Experimental (NRX) Reactor** was built just after the Second World War, and operated between 1947 and 1993. The NRX suffered a serious accident in 1952 when the reactor core suffered a melt-down, the first ever serious nuclear reactor accident in the world – requiring hundreds of Canadian and US technicians and military personnel to mitigate the damage over the course of a whole year. During that incident, a million gallons of water was pumped in (presumably from the Ottawa River or nearby lakes) to cool the reactor. This lead to a significant amount of contaminated water penetrating the ground below the facility. Contaminated water was also pumped into adjacent 'holding ponds' which were not effectively lined, thus likely responsible for further groundwater contamination. Given the limited understanding of radioactive contamination in the environment at the time, and coupled with an absence of environmental legislation or regulations concerning this issue for many years, the severity of that incident's full impacts remain unclear.[8] However, Waste Areas A and B in the Perch Lake Basin (discussed more below) are likely in their currently compromised state due to their being the primary receiving areas for NRX contaminants.

In addition to this historic accident, there has been a decades-long leak of Strontium (Sr-90) from the NRX fuel bays into the environment. The Sr-90 plume was first detected in 1959, and only in 2006 was the source of the contamination finally removed (i.e. the last fuel bay). While the source of this leak may have been stopped at that time, Sr-90 has a long half-life (almost 30 years), meaning that historic releases of the substance will persist in the environment for decades to come. Groundwater wells at the Chalk River complex have measured Sr-90 at levels five times higher than established benchmarks as recently as 2017.[9] Sr-90 contamination of soil around the NRX facility is also highly likely. However, soil contamination (as opposed to groundwater contamination) does not appear to have been assessed by CNL to date. This is a

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[7] *Ibid* at p. 3.
[8] Peter Jedicke, "The NRX Incident", online: <https://www.cns-snc.ca/media/history/nrx.html>.
[9] Dr. Markelova Expert Report at p. 6.

concern as contaminated soil can ultimately end up in surrounding wetlands, lakes and rivers via stormwater runoff during precipitation events. Thus, while NRX facility is currently sitting in a storage state, the adequacy of its containment remains difficult to assess.

Recommendation 5: that CNL and CNSC staff characterize Sr-90 contamination of the soil around the NRX facility and that that soil contaminant runoff be regularly monitored and taken into account in the CRL's stormwater management plan.

The **National Research Universal (NRU) Reactor** was built and operated for almost 70 years. It generated medical radioisotopes as well as early fuels and materials for future CANDU reactors until this past year. In 1958, it also became the site of another significant reactor accident when a fuel rod caught fire while being removed from the core. This incident constituted the second largest nuclear accident in the world at that time, after the NRX incident (discussed above). The NRU accident required months of remediation efforts, and likely resulted in significant contamination below and around the site.

Operations at the NRU from that point continued with periodic difficulties until the CNSC shut it down in 2007 due to non-compliance with safety requirements contained in its licence. The Commission's decision to do so led the federal government to pass emergency legislation to allow the NRU to continue operations despite the CNSC's order (as it was a globally-significant source of medical isotopes). The government subsequently fired the Commission president over her decision to stop operations, which constituted an episode of unprecedented political interference with the federal agency.[10] In 2008 and 2009 the facility experienced a significant heavy water leak which demanded the closure of operations for a year in order to attempt to contain and repair the damage.

The NRU ceased its operations on March 31, 2018 and was permanently shut down. By late May 2018, the reactor was defueled and all rod bays had been moved into wet storage. In September of 2018, all heavy water was drained from the reactor vessel and temporarily stored awaiting further processing and storing in metal drums. As such, the majority of the reactor and its parts are currently sitting in a storage state. It will be decommissioned starting in 2028.

Dr. Markelova has noted there is a tritium plume in groundwater at the Chalk River complex originating from the NRU reactor. Much of this plume may be attributable to ongoing leaks from the spent fuel rod bays stored at the facility. The highest measured concentration of tritium in a nearby groundwater monitoring well was 109kBq/L, though the dose acceptance criteria is 17400 kBq/L. However, as tritium cannot be removed from groundwater and treated, the only available course of action is for it to be diluted over the next several decades. As the tritium plume in groundwater below the Chalk River complex remains one of the key environmental concerns for CRL, the proper management and containment of NRU's tritium plume will be crucial.

Recommendation 6: CNL and CNSC staff should conduct further investigations and release additional publicly accessible information concerning the migration of the tritium plume originating in the groundwater below the NRU facility.

Recommendation 7: CNL and CNSC staff should conduct further investigation and release additional publicly accessible information concerning airborne emissions of tritium from the NRU facility, and their migration to the Ottawa River via contaminated soil carried by stormwater.

a) this review should inform the development of CNL's stormwater management plan.

[10] Voices-Voix, "Linda Keen", online: <http://voices-voix.ca/en/facts/profile/linda-keen>.

In addition to tritium releases from the NRU, organics, heavy metals, and chlorinated organic compounds have also been released over time. With the shutdown of the facility, releases will be significantly curbed if not ceased completely and some substances may cease to give cause for concern such as total residual chlorine. However, other substances such as PCBs and mercury will likely persist in the environment for a long time if not made the subject of considerable and specific remediation efforts.[11]

Recommendation 9: CNL and CNSC staff should conduct further investigation and release additional publicly accessible information concerning the quantity and concentration of PCBs and mercury released by NRU facility into the surrounding environment (especially groundwater and soil).

The NRU was also the major source of radioactive emissions to the air at the Chalk River complex. In fact, emissions of tritium to the atmosphere have been higher than those to groundwater directly. Once released into the air, emitted contaminants eventually fall to the ground where they contaminate soil and further contaminate already compromised groundwater quality which can migrate to the Ottawa River as stormwater runoff during precipitation events and snow melts. These NRU releases to the air do not only contain tritium, but also noble gasses including Ar-41.[12] The stormwater management plan for CRL is currently being amended, and it is impossible to predict its contents and how effectively it will account for stormwater containment and treatment to mitigate this runoff.

Recommendation 9: CNL and CNSC staff should ensure airborne emissions of tritium and noble gases from the NRU to surrounding soil is addressed in the new stormwater management plan for CRL.

Recommendation 10: CNL should ensure timely public disclosure of the new stormwater management plan as soon as it is finalized.

Finally, Dr. Markelova makes an important note of the direction of wind at the CRL which is responsible for much of the NRU's airborne emissions being carried upstream from the CRL.[13] As such, it is crucial to re-evaluate the baseline conditions that are often taken from the upstream values in the estimation of contaminant levels from Chalk River emissions downstream of the complex. In other words, CNL must ensure that upstream contamination is considered when measuring any upstream conditions so that this contamination can be substituted from any measurements of upstream conditions used to constitute baseline values against which Chalk River emissions limits are compared.

Recommendation 11: CNL and CNSC staff must demonstrate that upstream contamination is being taken into account in the calculation of upstream (i.e. baseline) conditions against which the impacts of Chalk River facilities are measured.

The **Molybdenum-99 Production Facility (MPF)** began producing the important medical radioisotope Mo-99 in 1984. It ceased to operate in October 2016, and CNL kept it in a standby state for two years ready to be returned to operation should it be required over that time. With the more recent cessation in NRU operations, CNSC staff have confirmed that the MPF will also now be permanently retired (as it was dependent solely on the NRU reactor for its production process). Waterborne releases of contaminants from the facility are treated at the CRL's Waste Treatment Centre, and airborne emissions of Ar-41 and I-131 (which exhibit more elevated levels of contaminant release than waterborne pathways) are being mitigated by absorption filters on certain tile holes. With the cessation of the facilities' operations, it remains to be seen how effective existing treatment and mitigation activities will be.[14]

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[11] Dr. Markelova Expert Report at p. 5.
[12] *Ibid*.
[13] *Ibid*.
[14] *Ibid* at p. 6.

Additional facilities at the Chalk River Site include:

- **ZEEP Reactor**, which was the first reactor built at the site during the war as a precursor to the NRX reactor. The ZEEP produced plutonium to fuel nuclear weapons and research until it was decommissioned in 1973 and dismantled in 1997;
- **Pool Test Reactor (PTR)** which operated between 1957 and 1990 when it was shut down and defueled. It had been responsible for measuring the reactivity effects of materials at the site;
- **Zero Energy Deuterium (ZED-2)** research reactor was the successor to the ZEEP, and has operated at the site since 1960 mainly for research concerning reactor and fuel design;
- The NRU also contained a **Canadian Neutron Beam Centre**;
- **SLOWPOKE reactors** were built at the site before being transferred for use at the University of Toronto in the early 1970s;
- **Tandem Accelerator Superconducting Cyclotron (TASCC)** was the world's first accelerator, and operated at the site between 1986 and 1996 when it began to be decommissioned;
- Two **Multipurpose Applied Physics Lattice Experiment (MAPLE)** reactors were built in the early 2000s at the site, however, due to a series of design and construction flaws, never functioned as intended and their project was terminated in 2008. They were meant to produce medical isotopes, fueled by enriched uranium;
- The **Combined Electrolysis Catalytic Exchange Upgrading/Detritiation (CECEUD)** which processed heavy water until its operations ceased a few years ago. It is currently being relocated, though that process is ongoing;
- A **Health Physics Neutron Generator** which houses a Texas Nuclear Neutron Generator (150 1H) linear accelerator that was recently shut down and is currently pending decommissioning and removal;
- **The Pool Test Reactor** which is in the process of being decommissioned;
- A **Plutonium Tower** and **Plutonium Recovery Reactor** the first of which has been decommissioned, the latter is currently being decommissioned;
- A **Heavy Water Upgrading Plant** which was decommissioned, which involved retrieving and demolishing Under Ground Heavy Water Storage tanks; and a
- **Cosmic Ray Inspection and Passive Tomography (CRIPT)** unit.

With these units, and other waste storage and treatment facilities, there are approximately 100 major buildings and an additional 60 smaller structures at Chalk River.

As discussed above, the legacy waste challenges at the Chalk River sites are considerable. Part of the plan to address this issue is **the proposed Near Surface Disposal Facility (NSDF)**: a new waste site for permanent low-level waste storage. The proposal was the subject of an Environmental Impact Statement (EIS).[15] ORK has reviewed the EIS document for its assessment of risks to the Ottawa River with several technical experts, and is waiting to continue its review of the site, once the regulatory review process is resumed – however, it remains unclear when this will be exactly.[16]

The facility was at one point proposed to hold high and intermediate-level radioactive waste. However, due to strong concerns expressed by ORK and several other organizations and Indigenous nations, the proposal to store high- and intermediate-level waste at the facility has since been withdrawn.[17] Should the NSDF

[15] See: Canadian Nuclear Laboratories, "The Environmental Impact Statement (EIS) for the Near Surface Disposal Facility (NSDF)", online: <https://www.cnl.ca/en/home/environmental-stewardship/nsdf/eis.aspx>.

[16] *Supra* note 2.

[17] Ottawa Riverkeeper, "CNL backs down from proposal to include intermediate-level radioactive waste", October 27, 2017, online: <https://www.ottawariverkeeper.ca/breaking-news-cnl-backs-down-from-proposal-to-include-intermediate-level-radioactive-waste/>.

ultimately be approved, it will be added to the existing Chalk River Laboratories' licence, rather than being issued a separate licence.[18]

The NSDF project is mostly meant to store and contain legacy waste at the Chalk River site (though low-level waste from other locations in Ontario may be housed there as well). Approximately 70% of the waste at Chalk River, generated over the last 80 years, would be stored in the NSDF and would constitute a tremendous volume of waste requiring storage. And still, while the NSDF is being relied on by the CNL to address much of its legacy waste challenges, the truth is that the exact nature and extent of legacy wastes at Chalk River remains unclear. Even Natural Resources Canada has noted that legacy waste issues at Chalk River are poorly documented and generally misunderstood.[19]

There are 13 waste sites at the Chalk River complex, five of which are in operation and eight of which are legacy sites no longer in use. Some of these sites and their ecological footprints are discussed in greater detail below.

For decades, Chalk River 's contaminated water was directed via the area's sandy soil to the Perch Lake Basin which is a depressed area in the underlying bedrock. Over this time, highly radioactive waste was also buried there beginning with the 1952 accident at the NRX reactor, but continuing throughout the 1960s and 1970s when highly radioactive liquid waste was brought to the area and stored in unlined trenches from fuel repurposing experiments conducted at the site. The Perch Lake Basin was also used to store contaminated but reusable equipment from around the CRL site over this time. As the Basin was one of the earliest waste repositories for the site, it constitutes one of the most severely contaminated sites at Chalk River. This whole site is referred to as **Waste Management Area A** and waterborne contaminants ultimately flow from it into the Maskinonge Lake Basin and Ottawa River via Perch creek. The area boasts a considerable Sr-90 plume as well as gross beta and chloride contamination. While 3m of cover material was put over the site a number of years ago, and a permeable reactive barrier was installed across the plume in 2013, the extent of their efficacy remains to be seen.

Waste Management Area B spans 14 hectares and contains a decade's worth of buried waste with only a cap of sandy fill, and no lining below. Due to its size and contents, it poses a greater ecological risk than Waste Management Area A. Apparently, this site has two reactor vessels buried in it from the NRU and NRX reactors from early 1970s, and it still receives waste from elsewhere at the CRL site. Waste Management Area B has at least two significant contaminant plumes: one comprised of tritium, the other of Sr-90. Their migration has been studied and characterized, and upgraded groundwater treatment facilities at the site are minimizing releases of Sr-90 from the area. Tritium contamination, however, cannot be treated and mitigation can only attempt to control the substance's dilution into the environment. Since the installation of the groundwater treatment facilities, there has been at least one extended outage event which appears to have further aggravated Sr-90 releases to the environment – an outage event that merits more investigation and publicly available information. Further, trichloroethane, 1,1-dichloroethane, trichloroethylene (TCE), 1,1-dichloroethylene and tetrachloroethylene (PCE)), and 1,1,1-TCA and chloroform compounds have been measured at Waste Management Area B in concentrations and volumes that may constitute cause for concern, as the adequacy of treatment to date is unknown.[20]

Waste Management Area B also holds irradiated uranium and thorium from over 50 years of nuclear reactor fuel and related substances (e.g. hot cell waste, experimental fuel bundles, unusable radioisotopes, active exhaust system filters, fission products from medical isotope production). They are kept in 750 tiled

[18] For CNSC staff response to Riverkeeper information request, see Appendix A to these submissions.
[19] Ian McLeod, "Chalk River's toxic legacy", *Ottawa Citizen*, December 29, 2011, online: <https://ottawacitizen.com/news/chalk-rivers-toxic-legacy/wcm/12a1f5e3-9b71-4448-9414-1e4416fbacfc>.
[20] Dr. Markelova Expert Report at p. 9.

concrete cylindrical holes, each 4.9m deep. The CNSC has expressed concerns in the past about the structural integrity of these holes, as 100 of them hold 175 highly radioactive old prototype fuel rods encased in aluminium – the structural integrity of which is threatened as they are submerged in water. Another 600 rods are also submerged but since they are encased with zircaloy and stainless steel, the concern is not as urgent. All of these fuel rods are awaiting relocation to a new above-ground facility which is required to help ensure their containment.[21]

Recommendation 12: that CNL and CNSC staff provide more publicly-accessible information concerning the recent failure of Waste Management Area B's Sr-90 groundwater treatment facility in order to assist further public review.

Recommendation 13: that CNL and CNSC staff provide more publicly-accessible information concerning the monitoring and management of tritium dilution in groundwater around Waste Management Area B to assist further public review.

The South Swamp at the CRL site is the recipient of much of the contamination at Waste Management Areas A and B. As such, the swamp exhibits high levels of Sr-90, Ba, Cl, Li, Sr, Cu, Fe, PCBs, phenolics, TCE, TCFM, Cl, and solvent extractables. Further, there are numerous non-radiological contaminants which have been measured in water and sediments at Spring B Forest and the West Swamp. The main source of contamination of those wetland areas is contaminated groundwater discharges from Waste Management Area B which include chlorinated solvents, Hg, lithium (Li), uranium (U), phenolics, arsenic (As), Cl, Fe, Ni, (lead) Pb, strontium (Sr), zinc (Zn), barium (Ba), Al, Cu, solvent extractable (oil and grease), TCFM, V, TCE and chloroform.[22] The contamination of these wetlands and swamps may pose a threat to the flora growing in those spaces. It may also adversely impact the wellbeing of wildlife, should those locations provide habitat for fauna.

There are four species of turtle listed as species at risk under the *Species at Risk Act* that have been identified at the Chalk River complex.[23] There is not currently sufficient publicly available information concerning which parts of the complex are currently constituting habitat for these species. As such, the extent of their exposure to contaminants in the site's wetlands are unknown. While exact locations of at risk species is not always publicly disclosed for their own safety, more information concerning their potential exposure to contaminants at the site as well as any existing efforts to mitigate exposure should be publicly disclosed.

Recommendation 14: that CNL and CNSC staff publicly disclose more information concerning the interaction of flora and fauna exposed to contaminants in swamp and wetland areas (including South, West, East, and Duke Swamps) in the Perch Lake and Masinonge Lake basins, with special mention included of interactions between contaminants and the four at risk species of turtle that have been identified at the Chalk River complex.

In addition to the two waste management areas discussed above, there are a variety of **Liquid Dispersal Areas (LDAs) and a historical laundry pit** as well as six additional **Waste Management Areas (C, D, H, F, G, and J)** and three **Acid, Chemical, and Solvent (ACS) Pits** at the Chalk River complex which release numerous contaminants into the environment. The LDAs contain cobalt (Co-60) and cesium (Cs-137), which are sources of gamma radiation that require unique and specific measures to ensure against their spread of radiation through the surface and near-surface environment. The LDAs are also possibly responsible for elevated levels of Al, cadmium (Cd), Cu, Fe, PCBs, TCE, TCFM, V, Ni, tetrachloroethylene (PCE), Sr, Al, Ba, Hg, Pb, and U in the East Swamp, as well as elevated concentrations of phosphorous (P)

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[21] *Supra* note 19.
[22] Dr. Markelova Expert Report at p. 9.
[23] *Supra* note 4 at p. 91.

and PO4, which along with bioavailable organics may cause an increased rate of eutrophication of local water bodies.[24] The ACS Pits are not the subject of any specific recovery efforts. Instead, they are awaiting approval of the proposed NSDF which would receive their waste.[25]

There is a **Thorium Pit** which contains liquid waste from an on-site Nitrate Plant including natural thorium, thorium nitrate, ammonium nitrate, Ce-144, Cs-137, Sr-90 and U-233. Its Sr-90 plume appears to be contaminating Duke Swamp. Gross beta radiation as well as Al, As, Cd, Cl, Fe, Li, Ni, Pb, Sr, TCFM and V have also all been detected along the length of the plume from the Pit to the Duke Swamp. While there is a 'Wall and Curtain' passive water treatment system that mitigates the runoff from the Plant to the Pit, there is currently no specific recovery plan for the pit to address the identified plume, though contaminated soils are being monitored.[26]

Recommendation 15: that CNL and CNSC staff develop and publicly release a site-specific recovery plan for the Thorium Pit, as well as remediation activities to address resulting contamination of Duke Swamp. Should such a plan not be deemed necessary, reasons outlining such a decision should be made publicly available.

Waste areas and facilities at the Chalk River complex also include the following:

- A **Dilute Effluent Disposal System** which was recently shut down permanently;
- As was a **Waste Water Evaporator** which was shut down in 2012 and is currently being decommissioned;
- Construction of the **Bulk Material Landfill** was completed in 2018 after its capacity was doubled to store dewatered sludge produced by the on-site Sewage Treatment Plant;[27]
- Low-level waste is also stored in an above-ground **Modular Above-Ground Storage (MAGS)**;
- two **Shielded Modular Above-Ground Storage (SMAGS)** bunkers, both of which have some form of leachate collection systems. Some of the waste in these last two facilities has been shipped for treatment or permanent storage in the US; and
- **Grey Crescent**, a collection of mostly historic landfills at the CRL complex which contain a variety of radiological and non-radiological contaminants. Uranium has been detected in soil in the area at extremely high concentrations: up to 430,000 µg/g, which is about a thousand times higher than the Canadian Soil Quality Guideline of 300 µg/g for industrial sites. Other contaminants include Al, Ba, Cl, Cu, Li, Zn, and Sr.[28]

Recommendation 16: that CNL and CNSC staff prepare and publicly release a better characterization of contaminants in and around Grey Crescent so that their interaction with the local ecology can be better understood.

Despite the fact that most of the Chalk River facilities are either awaiting decommissioning or in decline, there is a 10-year **Chalk River Revitalization** project which began in 2016, expected to end in 2026. It aims to renovate essential site infrastructure, decommission aging infrastructure, and build new facilities. The project will cost approximately 1.2 billion in federal funds. The NSDF is a part of this plan.

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[24] Dr. Markelova Expert Report at p. 11.
[25] *Ibid* at p. 9.
[26] *Ibid* at pp. 12-13.
[27] *Supra* note 4 at p.10.
[28] Dr. Markelova Expert Report at p. 7.

Finally, a **Small Modular Reactor (SMR)** is a currently proposed for the Chalk River site.[29] No SMRs have yet been built in Canada, and the approval process for this technology is still in early development with public consultations underway as of July 2019 via the Canadian Environmental Assessment Agency's website.[30] If the unit is ultimately approved, it will hold its own licence separately from the larger Chalk River complex in which it will be located.[31]

As the discussions above illustrate, Chalk River is a complex site that poses several significant challenges in terms of oversight. Over its 80-year history, the character and activities at this site have continuously developed and changed. Nuclear regulation has similarly developed considerably over this time as well. Even over the course of the last 10-year licence term, Chalk River has been shown to exist in a constant state of flux with the retirement and decommissioning or several large facilities, as well as the construction of new ones. The current 10-year licence is guaranteed to govern a similarly dynamic period for the site. The challenges inherent in regulating such a complex site help to inform the discussion on licences and permits below.

Chalk River Regulation: Licences and Permits

Public access to the Chalk River Laboratories licence

The CNSC online licence database on its website is very limited, frustrating regulator transparency. Copies of actual licences are not available online, and must rather be specially requested from the Commission. Further, licences on the database are arranged according to type of licence and licence-holder, but the locations and names of the facilities to which the licenses apply are not included anywhere in the database. This makes it virtually impossible to match up licences listed on the database with specific CNSC-regulated facilities. Further, CNSC staff have explained that only Class II licences are included in the database. This means no Class I licenses or any other licence types are searchable online. In the context of this current intervention, it is impossible to say with any certainty whether the Chalk River Licence is included in this online database – a concerning prospect as it governs the largest nuclear complex in the country. This is a cause for concern as greater licence disclosure would be in the public interest.

Ontario's Environmental Compliance Approval (ECA) database may serve as an example of a better platform for public regulatory licence/permit disclosure as it includes copies of licences, their addresses, the companies to which the ECAs have been provided to, as well as the facilities' locations on an online interactive GIS map. While there are significant gaps in the ECA database as well, it would still serve as a helpful starting point for future improvements to the CNSC equivalent.

Recommendation 17: that the CNSC licence database on its website include all CNSC-granted licences in Canada, regardless of their Class.

Recommendation 18: that the CNSC licence database on its website include the addresses and facility names associated with all catalogued licences.

[29] Canadian Nuclear Safety Commission, "Micro Modular Reactor Project", online: <http://www.nuclearsafety.gc.ca/eng/resources/environmental-assessments/ongoing/ontario/EA_80182.cfm>; and Canadian Nuclear Laboratories, "Small Modular Reactor Technology: What's New", online: <https://www.cnl.ca/en/home/facilities-and-expertise/smr/default.aspx>.
[30] CNSC Staff CMD, "Annual Program Report, Canadian Nuclear Laboratories Regulatory Oversight Report for Canadian Nuclear Laboratories Sites: 2018", August 16, 2019, at p. 44.
[31] CNSC staff response to Riverkeeper information request, see Appendix A to these submissions.

Recommendation 19: that actual copies of all licences be posted to the CNSC licence database on its website so that they can be made permanently available to the public on a continuous basis that does not require CNSC staff intervention.

The current Chalk River licence does not specify the individual pieces of infrastructure to which it applies, nor do CNL or the CNSC provide a permanently available online map of the site and its buildings, waste areas, or environmental management infrastructure. This further impedes public transparency by denying a reliable and comprehensive description of the Chalk River complex.

Recommendation 20: that CNL permanently post on its website a map of the Chalk River complex with labels indicating all facilities (operational and in storage), waste areas, groundwater monitoring locations, and stormwater infrastructure.

Chalk River Laboratories licence and licence control handbook

At the moment, Chalk River Laboratories (all waste areas and 170+ structures) are subject to a single and very generalized 'blanket licence'. The licence does not name any specific facilities. Rather, it provides CNL with extremely broad authority to:

(a) prepare a site for, construct, operate, modify, decommission or abandon a nuclear facility;

(b) possess, transfer, use or abandon a nuclear substance, prescribed equipment or prescribed information;

(c) produce, refine, convert, process, package, manage, store or dispose of a nuclear substance; and

(d) produce or service prescribed equipment.

The licence requires CNL to have some kind of environmental management program that includes reference to selected action levels for emissions. It also includes brief mention of the requirement that CNL have a waste management plan that includes decommissioning activities. For such a complex site, its licence is extremely broad.

The lack of specificity in the current license is concerning as it effectively provides CNL with a considerable amount of discretion in the management of its facilities. It further inhibits CNSC and CNL transparency as the legal reach of the licence is ill-defined for the public. ORK alluded to this issue in its submission in last year's licence renewal proceeding when it advocated for the licence to include more specific information concerning the management of legacy wastes at the site.[32] At that time, ORK also raised concerns with the licence's 10-year term, which it argued was too long and would effectively exclude the public from important conversations concerning potentially significant developments planned for the site over the next decade.[33] One such development would be the NSDF, which if approved would be included as a potential amendment to the existing licence rather than subject to a new and separate licence. If the currently proposed SMR is approved at Chalk River, it would receive its own separate licence – making it the only facility at the site that would be subject to a facility-specific licence.

The Canadian Environmental Law Association (CELA) and Northwatch also expressed several concerns with the licence at last year's licence renewal hearings. Of significance to this current intervention are their arguments concerning the 2018 changes to the Licence Conditions Handbook (LCH) in which 56 licence conditions from the previous version of the LCH were deleted, many of which had contained important particulars about licence conditions for specific sites or aspects of operations. Unfortunately, the proposed

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[32] Ottawa Riverkeeper, "Submission from Ottawa Riverkeeper/Garde-Riviere des Outaouais Intervening in the Operating Licence Renewal Hearing for Chalk River Nuclear Laboratories (CNL) Ref. 2018-H-01", December 11, 2017, online: <https://www.ottawariverkeeper.ca/wp-content/uploads/2018/01/ORK-Submission_CNL-Licence-Renewal-2018.pdf>.

[33] *Ibid.*

Licence Conditions Handbook appears to have been adopted by the Commissioners, despite concerns and recommendations for improvement by ORK, CELA, Northwatch, and others.

It is worth noting that CELA and Northwatch also noted that the majority of CNSC-drafted compliance verification criteria were replaced by criteria developed by the Canadian Standards Association (CSA), a less transparent non-government (i.e. more industry-focused) body. The CSA verification criteria were less rigorous, and not generally subject to public comments processes concerning their contents.[34] This issue of compliance verification is a significant one in Canada as the federal Commissioner of the Environment and Sustainable Development already issued a report in 2016 in which it expressed concerns with several identified shortcomings in CNSC's compliance inspections.[35]

In her review, Dr. Markelova has also identified a potentially worrying bias in the LCH. While the Chalk River Basin is the focus of action levels and derived release limits specified in the document, the other two basins are almost entirely neglected – only one control area in the Maskinonge Lake Basin is included in the LCH and none in the Perch Lake Basin.[36] As such, it appears as though the Perch Lake Basin and Maskinonge Lake Basin are not being regulated as closely as the Ottawa River Basin, despite the fact that these other two basins exhibit especially high levels of radiological and non-radiological contamination – and despite the fact that both basins ultimately feed into the Ottawa River.

Recommendation 21: that Commissioners and CNSC staff include additional LCH Action Levels and Derived Release Limits for the Perch Lake Basin and Maskinonge Lake Basin in addition to those specified the LCH for facilities in the Chalk River Basin.

Recommendation 22: as a starting point, that Commissioners and CNSC staff include Action Levels and Derived Release Limits in CNL's LCH for the following substances in the Perch Lake and Maskinonge Lake Basins:

a) waterborne releases of Sr-90, Cs-137, Cl, and Co-60, tritium, phosphate, mercury, Ba, V, uranium, and Pb solvents, chloroform, toxic elements and heavy metals; and

b) airborne emissions of Ar-41

Further, the contaminants identified in the last Environmental Risk Assessments (ERA) for the Chalk River complex are considerably more comprehensive than contaminants included in the site's LCH. As these contaminants of concern have already been identified by CNL and are already periodically monitored, it should not be considered unduly demanding for them to be included as parameters in the LCH itself.

Recommendation 23: that Commissioners and CNSC staff amend the current LCH to include Action Levels and Derived Release Levels for all contaminants of concern identified in the 2019 ERA for CRL.

Recommendation 24: In particular, that additional ground water and effluent streams and outfalls monitored in the 2019 ERA be included in the LCH.

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[34] Canadian Environmental Law Association, submissions to the Canadian Nuclear Safety Commission, December 11, 2017, online: <https://www.cela.ca/sites/default/files/1164-CELASubmissionsCanadianNuclearSafetyCommission_0.pdf: and Northwatch, "Comment on application from Canadian Nuclear Laboratories (CNL) for the Renewal of its Nuclear Research and Test Establishment Operating Licence for Chalk River Laboratories", December 11, 2017, online: <https://www.cela.ca/sites/cela.ca/files/1157-CommentsOnApplicationFromCNL.pdf>.

[35] 2016 Fall Reports of the Commissioner of the Environment and Sustainable Development, "Report 1 – Inspection of Nuclear Power Plants – Canadian Nuclear Safety Commission", online: <http://www.oag-bvg.gc.ca/internet/English/parl_cesd_201610_01_e_41671.html>.

[36] Dr. Markelova Expert Report at pp. 16 – 17.

Finally, upon reviewing existing controls in the LCH, it is unclear whether contaminant parameters have been calculated and defined with ecological, as well as human-dose, considerations taken into account. After reviewing all references made to Action Levels and Derived Release Limits in CNSC staff submissions at last year's licence renewal hearing, CNSC staff's CMD in the current meeting process, and the current LCH for DRL itself, it appears as though only a one-year cumulative dose to humans was considered when setting existing release limits.

Recommendation 25: that CNSC staff confirm and explain whether LCH controls were established keeping in mind exposure to varied ecological components in addition to human exposure.

<u>*Fisheries Act* permits for Chalk River Laboratories</u>

As several reactors have been in operation at the Chalk River complex for decades, fish impingement and entrainment by reactor once-through cooling water systems has been identified as an environmentally adverse impact of the site's operations. However, publicly accessible documents do not seem to indicate which facilities exactly have been responsible for this ecological impact, making it difficult to conceptualize and assess.

Impingement monitoring of lake sturgeon is conducted annually,[37] though there does not appear to be any publicly available data concerning monitoring results. The Great Lakes and Upper St. Lawrence population of lake sturgeon is considered to be endangered under Ontario's *Species at Risk Act* and is the subject of a specific recovery strategy.[38]

Recommendation 26: that CNL make its monitoring results concerning the impingement of lake sturgeon publicly available.

Impingement monitoring of other species of fish was conducted in 2011, 2012, 2014, and to a lesser extent in 2015 and 2016. Entrainment monitoring appears to have only been conducted for a single year (June 2016 – June 2017), which is insufficient to understand longer-term trends.

Recommendation 27: that CNL make its monitoring results from other monitoring programs concerning both impingement and entrainment of fish publicly available.

Recommendation 28: that if any entrainment is continuing at the site, CNL should conduct additional monitoring to better understand longer-term trends in the entrainment of fish.

The *Fisheries Act* specifies in section 35(1) that:

> No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery.[39]

Such activity is strictly prohibited by the Act and any contravention of this provision can result in fines of up to $100.000 or $500,000 and/or a prison sentence of up to one or two years.[40] Further, the Act specifies that for any contravention lasting longer than a single day, each subsequent day on which the offence

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[37] *Supra* note 4 at p. 86.

[38] Committee on the Status of Species at Risk in Ontario, "Ontario Sepcies at Risk Evaluation Report for Lake Sturgeon (*Acipenser fulvescens*)", November 2017, online: <http://cossaroagency.ca/wp-content/uploads/2018/06/Accessible_COSSARO_Evaluation_LakeSturgeon_FINAL_20FEB2018_SP.pdf>.

[39] *Fisheries Act*, RSC 1985, c F-14, at s 35.

[40] *Ibid* at s 78.

continues constitutes a separate offence.[41] Of course, this section does not apply to facilities that receive a special permit by the DFO to undertake activities that would result in serious harm to fish. When such permits are granted, they generally contain provisions for the mitigation or offsetting of harm caused by the licensed activity.

However, it is unclear whether CNL has been granted a permit by the federal Department of Fisheries and Oceans (DFO). DFO policy prevents the ministry from posting its licenses online, or providing them to the public upon request via informal mechanisms. Rather, they must be requested of the DFO via a formal federal Access to Information (ATIP) request, which ORK has filed. A request was also made of CNL for a copy of any permits issued for CRL under the *Fisheries Act*. To date no responses have been received by the DFO or CNL either confirming or denying the existence of any permits for Chalk River.

Recommendation 29: that CNL confirm whether it has been granted a s.35 permit from the DFO, and provide a copy of the permit and the assessment used to inform it. If no permit has been granted, CNL should still provide the assessment conducted to support any decision not to issue a permit.

Environmental Compliance Approvals

From a search of the Ontario Ministry of Environment Conservation, and Parks (MECP) online database of environmental approvals, it does not appear as though any ECAs have been issued for Chalk River. This was tentatively confirmed with the local MECP office for CRL, but is more formally being confirmed via a provincial Freedom of Information (FOIP) request to the ministry. This query has also been submitted to CNL. To date, no response has been received by either the MECP or CNL.

Recommendation 30: that CNL confirm whether it has been granted any ECAs from the MECP and provide a copy of any ECA(s). If no ECA has been granted, CNL should still provide the assessment conducted to support any decision not to issue an ECA.

Public access to environmental information concerning Chalk River

The federal government has been developing an open data strategy for almost a decade. The most recent Plan on Open Government notes:

> Openness and transparency are fundamental to ensuring Canadians' trust in their government and in democracy overall. Citizens expect their government to be open, transparent, and accountable... The Government of Canada's commitment to openness is intended to foster greater transparency and accountability, and to help create a more cost-effective, efficient, and responsive government for all Canadians.[42]

Several Commitments from this plan are especially relevant to the current intervention process, including Commitment 3 to expand and improve open data across the country. The commitment recognizes:

> Open data has the potential to transform how government officials make decisions and how citizens interact with government… The Government of Canada is committed to ensuring that its data is open by default. Data must be discoverable, accessible, and reusable without restriction so as to enhance transparency, enable better services to Canadians, facilitate innovation, and inform public participation.

[41] *Ibid* at s 78.1.
[42] Government of Canada, Canada's New Plan on Open Government 2016-2018, online: < https://open.canada.ca/en/content/canadas-new-plan-open-government-2016-2018>.

Commitment 6 requires all federal public servants to change how they design and deliver programs to support Canada's commitments to transparency and public engagement. It asserts "an openness mindset needs to be integrated into their day-to-day business activities". Further, Commitment 13 undertakes to increase the availability and usability of geospatial data, and Commitment 14 undertakes to make the science performed in support of Government of Canada programs and decision-making open and transparent to Canadians.

The CNSC recently amended its own internal regulatory document concerning public information and disclosure requirements for all regulated facilities. This policy (and its predecessor released in 2012) state the "primary goal of a public information and disclosure program… is to ensure that information related to health, safety and security of persons and the environment, and other issues associated with the lifecycle of the nuclear facilities are effectively communicated to the public."[43]

<u>Proactive Disclosure by CNL</u>

The Chalk River licence requires CNL to have a public disclosure protocol, however the LCH fails to provide substantive guidance concerning required contents of CNL's protocol.[44] The Commission's REGDOC-3.2.1 *Public Information and Disclosure* similarly fails to include mandatory requirements for specific content in licensee information and disclosure protocols.

Currently, CNL has prepared and publicly released the following environmental information to its website:

- an environmental performance report for its facilities in June 2019;[45]
- an Annual Safety Report for its environmental monitoring programs in 2017;[46]
- a one-page executive summary of its 2017 Annual Compliance Report for the NPD Waste Facility;[47]
- a summary of its 2017 environmental monitoring of the NPD Waste Facility;[48] and
- an Environmental Risk Assessment for Chalk River Laboratories from January 2019.[49]

Wherever possible, ORK advises against the publication of executive summaries of reports to the exclusion of the reports themselves. While broad assurances of the safety of facilities may be correct, if they are to be believed and understood, the information and data used to support such assertions must be made public.

Recommendation 31: that CNL post all Environmental Monitoring Reports, Annual Safety Reviews, Environmental Risk Assessments, and Annual Compliance Reports from this point onward to its website.

There are several other potential sources of information and data concerning nuclear facilities prepared independently from the CNSC. However, none of these sources has proven especially accessible or helpful during the current intervention opportunity:

- CNL reports to the National Pollutant Release Inventory (NPRI) for Chalk River Laboratories. Reports are for releases of lead and lead compounds, particulate matter, nitrogen oxides, and

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[43] REGDOC-3.2.1 *Public Information and Disclosure*, s 2.1, online: <http://nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc3-2-1/index.cfm>. Note, this was the same in the previous *Public Information and Disclosure*, Regulatory Document 99.3, March 2012, s 2.1.
[44] Canadian Nuclear Safety Commission, Canadian Nuclear Laboratories' Licence Conditions Handbook, at p. 10.
[45] Online: <https://www.cnl.ca/site/media/Parent/CRL-Performance-2019-June.pdf>.
[46] Online: <https://www.cnl.ca/site/media/Parent/CRL-509243-ASR-2017(2).pdf>.
[47] Online: <https://www.cnl.ca/site/media/Parent/2017-Annual-Compliance-Report-NPD.pdf>.
[48] Online: <https://www.cnl.ca/site/media/Parent/2018-NPD_Environmenta-performance2.pdf>.
[49] Online: <https://www.cnl.ca/site/media/Parent/Env_Risk_Assessment_2019_Full_REV_0.pdf>.

sulphur dioxide to air and water. However, all amounts are expressed as annual averages, preventing an understanding of seasonal trends or peak releases.[50]

- When the *Wastewater Systems Effluent Regulations* (*WSER*) came into effect in 2013, the CRL Sewage Treatment Plant was required to report to Environment and Climate Change Canada under the *Fisheries Act*. However, this data can only be obtained via a formal information request.
- The Ontario provincial Nuclear Reactor Surveillance Program does not appear to sample the Chalk River site.[51] A search of the Ontario provincial Drinking Water Surveillance Program does not include references to Chalk River or Deep River.[52]
- The Town of Deep River makes some of its water quality reports available online – including drinking water and sewage treatment. However, it remains unclear to what extent these reports reflect conditions at or nearer to the Chalk River sites.[53]
- The Canadian Radiological Monitoring Network shares online open-access data pages, however they are exceedingly difficult to navigate, especially as search functions do not clearly indicate specific facilities or geographic regions.[54]
- The Independent Environmental Monitoring Program (IEMP) for Chalk River includes air, water, sediment, soil, and vegetation monitoring data collected at several points around the Chalk River complex. However, data is averaged, and the locations of sampling points used for the IEMP have been a subject of concern in the past for several Waterkeeper experts, often because they are situated far from the polluting facilities and thus can effectively only measure highly diluted areas.[55]
- Past Environmental Assessments, licence decisions, and compliance reports for facilities at Chalk River are not consistently available online.

The shortcomings of these additional resources and databases highlight the need for CNSC staff and CNL to ensure they are publicly disclosing important information and data concerning environmental conditions and activities Chalk River.

Reportable Events

In 2018, there were 35 reportable events at the CRL site. Eight of these related to NRU operations. Three involved action level exceedances and radioisotope releases, though CNSC staff assert no regulatory limits were exceeded.[56] CNL's current LCH requires regulatory reporting for release events, however it does not contain detailed requirements concerning the contents of these reports. Instead, it provides CNL with considerable discretion to draft its own disclosure plan to determine the contents of these reports.[57]In CNL's

[50] For reports, see: <https://pollution-waste.canada.ca/national-release-inventory/archives/index.cfm?do=facility_substance_summary&lang=en&opt_npri_id=0000003147&opt_report_year=2017>.

[51] For the database, see: <https://www.labour.gov.on.ca/english/hs/pubs/rpms/report_water.php>, see more generally: <https://www.labour.gov.on.ca/english/hs/pubs/rpms/index.php>.

[52] For the database, see: <https://www.ontario.ca/data/drinking-water-surveillance-program?_ga=1.265290511.124848547.1486560529>.

[53] See: < http://www.deepriver.ca/departments/public-works/drinking-water-system-annual-reports/>.

[54] For the database, see: <https://open.canada.ca/data/en/dataset?portal_type=dataset&q=Canadian+Radiological+Monitoring+Network>.

[55] For monitoring results, see: <http://nuclearsafety.gc.ca/eng/resources/maps-of-nuclear-facilities/iemp/ch-river.cfm>.

[56] *Supra* note 30 at pp. 36 – 37.

[57] Canadian Nuclear Safety Commission, Canadian Nuclear Laboratories' Licence Conditions Handbook, at pp. 21-22.

Public Information Protocol, the company commits to posting incident reports to its website on a quarterly basis. It does not specify which information must be included in these reports.[58]

Recommendation 32: Each incident report reported by CNL should include at a minimum:

- *a) the incident date,*
- *b) reporting date,*
- *c) an exact description of the event including actual data of any measured releases, and*
- *d) any applicable Action Levels and/or Derived Release Limits so that members of the public can understand the severity of the reported incidents.*

Recommendation 33: Once posted, incident notices and reports should remain on the CNL website indefinitely and include subsequent event notices describing any follow-up remediation activity whenever it is undertaken.

LOW REVIEW: PORT HOPE AREA INITIATIVE

The intervention concerning the Port Hope Area Initiative has been scoped to follow up on an unplanned event last October, which Waterkeeper did not have the capacity at that time to examine in much detail.

This intervention seeks to provide members of the public with:

1) A better understanding the event, its potential impacts to water quality in the area, and the efficacy of subsequent mitigation measures;

It has also been drafted to provide Commissioners and CNSC staff with:

2) recommendations for the improvement of emergency/incident public alerts and subsequent messaging related to this and any other unplanned events.

Port Hope Harbour and the Port Hope Area Initiative

The Port Hope Area Initiative (PHAI) is an internationally significant undertaking. It is the biggest radioactive waste clean-up project in Canadian history, and involves one of the largest nuclear waste holding facilities in North America.

The PHAI is comprised of two distinct projects: the Port Hope waste relocation project ("Port Hope Project"), and the Port Granby waste relocation project ("Port Granby Project"). Together, both projects seek to clean up a combined two-million cubic meters (m^3) of low-level radioactive waste from various sites across Port Hope and Port Granby.

The Port Hope Project involves excavating 1,223,250 m^3 of historic radioactive waste from several sites around the town of Port Hope to a Long-term Waste Management Facility (PH LTWMF) just north of the community. The project was subject to an environmental assessment (EA) under the *Canadian Environmental Assessment Act, 1992* (CEAA, 1992) which was conducted from 2001 to 2007. In 2009, the CNSC granted a five-year Nuclear Waste Substance Licence to Atomic Energy Canada Limited (AECL) to implement the project. In 2012, AECL applied to have its licence extended for ten years. This was granted by the Canadian Nuclear Safety Commission (CNSC), making the current licence valid until December 31,

[58] Canadian Nuclear Laboratories, "Public Information Program for Canadian Nuclear Laboratories (CNL)" at Section 2.6.6.2, online: <https://www.cnl.ca/site/media/Parent/PIP-rev5.pdf>.

2022.

The Port Granby Project involves the removal of 450,000 m^3 of historic radioactive waste from the existing and poorly contained Port Granby waste management facility to a new above- ground waste management facility (the PG LTWMF) 700 meters north of the Lake Ontario shoreline. The Port Granby Project was also subject to a federal EA under CEAA, 1992 and the project was approved in 2009. After a public hearing in September 2010, the CNSC granted AECL a ten-year licence to implement this project.

Both Port Granby and Port Hope's new LTWMFs have their own Waste Water Treatment Plants (WWTPs) to treat the sites' stormwater and leachate before it is released into Lake Ontario.

AECL/CNL's licences for both projects authorize it to:

- Develop and construct new long-term waste facilities;
- Remediate historic waste sites;
- Transport waste to its facilities; and
- Conduct long-term maintenance and monitoring of its waste sites.

LOW has been involved with decision-making processes for the PHAI for almost a decade. The organization has also enjoyed long-standing relationships with many Port Hope residents since its founding in 2001. Waterkeeper is very aware of the beauty of the Port Hope and Port Granby areas: their preserved historical town buildings and houses; their active aquatic communities along the lake's shoreline, the Ganaraska River, and local creeks; their local beaches; and their stunning cycling and walking trails. The organization intervened in 2009 during the EA for the PAHI, and again in 2012 during its licence hearing which ultimately granted a 10-year licence for remediation work.

In October and November 2016, LOW intervened during a meeting to review the PHAI. At that time, Waterkeeper made a series of recommendations for improvements including remediation activities to address harbour water quality concerns while PHAI activities such as dredging and construction on other parts of the Harbour walls were being undertaken.[59] However, this does not appear to have been implemented.

<u>Port Hope Harbour incident last October</u>

On October 12 Waterkeeper saw a news story documenting the collapse of the west harbour wall in Port Hope Harbour.[60] The story noted that the collapse was not a surprise at it had been deteriorating for some time. It assured the public on behalf of the municipality that "there are no human or safety concerns related to this incident and that the area will continue to be monitored regularly". The following three follow-up actions were also shared:

- A new silt curtain was sourced and scheduled for installation that week. The barrier was to be installed along the length of the west harbour wall, from the north to the south end, and was designed to prevent suspended materials from migrating into the rest of the harbour.
- End-to-end investigation of the sanitary sewer line was completed using a closed-circuit camera. Municipal staff determined that the pipe is clear and stable.

[59] Lake Ontario Waterkeeper, "Submissions of Lake Ontario Waterkeeper Re: Reviewing Canadian Nuclear Safety Commission (CNSC) staff's status report on Canadian Nuclear Laboratories Limited's (CNL) Port Hope Area Initiative (PHAI)" at p. 12.
[60] Greg Davis, "Repairs underway following Port Hope harbour wall collapse", *Global News*, October 12, 2018, online: <https://globalnews.ca/news/4542149/repairs-underway-port-hope-harbour-wall-collapse/>.

- The municipality's regular water sampling schedule was enhanced and was being conducted by municipal staff daily. The Canadian Nuclear Safety Commission (CNSC) was also conducting water sampling to ensure water safety and compliance.[61]

A press release from the municipality of Port Hope had been published on October 9, 2019 with these same pieces of information.[62] As care and control of the west wall of the harbour is the primary responsibility of the municipality and not a CNSC licensee, the ability for LOW to make recommendations for improvements to incident reporting may be less applicable to the current intervention opportunity. However, since the CNSC has conducted water quality monitoring of the Harbour after the wall's collapse, and the municipality of Port Hope has not yet posted any links to raw data concerning water quality monitoring around the date of the incident, the CNSC may be well positioned to fill some of this public communication gap.

Recommendation 1: that CNSC staff make their sampling results of the Port Hope Harbour publicly accessible on the CNSC website.

Currently, no steps appear to have been undertaken to remediate harbour water quality. This had been recommended by LOW in its 2016 intervention for the duration of harbour remediation activities. Thus, it is worth reiterating that previous recommendation, in the hope that it be reconsidered by the Commissioners at this time.

Recommendation 2: that CNL and Cameco collaborate with the municipality of Port Hope to take positive steps towards remediating water quality in the Port Hope harbour to counteract activities and incidents that would further contaminate surface water in the harbour.

Recommendation 3: that CNSC staff, CNL, Cameco, and the municipality of Port Hope consider collaborating more on major incident communications to ensure the public knows in a timely way:

a) when the incident occurred;
b) measured environmental effects (including sharing available monitoring data); and
c) a description of any mitigation and/or remediation efforts undertaken to address incidents after they occur.

LOW prepared information requests for CNL as part of this intervention to obtain additional information and data concerning the incidents and its environmental impact. The organization is still waiting on some information, and as it only obtained monitoring data on October 3rd, cannot yet provide analysis.[63]

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[61] *Ibid.*
[62] Municipality of Port Hope, "Media Release: Port Hope West Harbour Wall", October 9, 2019, online: <http://www.porthope.ca/news/media-release-port-hope-west-harbour-wall>.
[63] See Appendix A for more detailed account of LOW's information requests.

APPENDIX A: Information requests and responses

CRL Information requests

Ms. Feinstein made a first round of information requests has been made on August 15th to the following parties:

For CNL and the CNSC:

1) "Can you confirm the current number of CNSC licences for facilities on the Chalk River sites?
   a. Please provide copies of all existing licences.
2) Can you confirm the current number of CNSC licences currently being sought for the Chalk River sites and the names of these facilities?
3) Can you provide the groundwater management plan for the Chalk River site?
   a. Can you also provide the last three years of groundwater monitoring program reports?
4) Can you provide the stormwater management plan for the Chalk River site?
   a. Can you also provide the last three years of stormwater monitoring program reports?
5) Can you provide the last three years of CNSC Annual Compliance Reports for the Chalk River sites?

These requests concern copies of original documents, rather than summaries."

For the MOECP:

1) "Can you confirm whether there are any Environmental Compliance Approvals (ECAs) for any facilities at the Chalk River sites?
   a. If there are, can you please share them?
   b. If there are, can you also please share the last three years of compliance reports for the/each ECA?"

For the DFO:

1) "Can you confirm whether there are any *Fisheries Act* approvals for any facilities at the Chalk River sites?
   a. If there are, can you please share them?
   b. If there are, can you also please share the last three years of compliance reports for the/each permit?"

On August 16th, Ms. Feinstein received responses for first two questions above from CNSC staff, and sent the following clarification questions on August 22nd:

Follow up to question #1

a) Would it be possible for you to provide a copy of the licence conditions handbook? If it is too large to send electronically, mail is fine and can be left at the door of the address I provided in case I am not home.
b) The licence you provided does not seem to contain a list of facilities to which it applies, so can CNSC staff confirm all facilities at the Chalk River sites are meant to be included in the 2018 licence provided?
c) I was not able to find any reference to this 2018 licence on the CNSC's online licence database. Can CNSC staff verify whether the licence has been included in the lists provided by that database?

Follow up to question #2

a) I understand the NSDF will also require a new licence at the Chalk River site (https://www.cnsc-ccsn.gc.ca/eng/reactors/research-reactors/nuclear-facilities/chalk-river/near-surface-disposal-facility-project.cfm), thus at least two additional licences seem to be being pursued (the SMR and

NSDF). Can you confirm whether there are any additional licences being sought (by CNL or any other applicant) in addition to the SMR and NSDF?

Ms. Feinstein sent follow-up emails to CNL on August 22nd, called CNL on August 22nd and 26th. Ms. Feinstein also sent a follow-up email to CNSC staff on September 4 inquiring about responses to follow-up questions for staff, and requesting assistance with contacting CNL.

On September 4th, CNSC provided responses to follow-up questions (in red):
Follow up to question #1
a) Would it be possible for you to provide a copy of the licence conditions handbook? If it is too large to send electronically, mail is fine and can be left at the door of the address I provided in case I am not home. (The LCH was sent separately).
b) The licence you provided does not seem to contain a list of facilities to which it applies, so can CNSC staff confirm all facilities at the Chalk River sites are meant to be included in the 2018 licence provided? (Yes. All facilities on the CRL site are included and the list of Class I and Class II facilities are in the licence conditions handbook)
c) I was not able to find any reference to this 2018 licence on the CNSC's online licence database. Can CNSC staff verify whether the licence has been included in the lists provided by that database? (The "online licence database" on the website does not include Class I licences. None of the Class I facility licences are in this list.)
Follow up to question #2
a) I understand the NSDF will also require a new licence at the Chalk River site (https://www.cnsc-ccsn.gc.ca/eng/reactors/research-reactors/nuclear-facilities/chalk-river/near-surface-disposal-facility-project.cfm), thus at least two additional licences seem to be being pursued (the SMR and NSDF). Can you confirm whether there are any additional licences being sought (by CNL or any other applicant) in addition to the SMR and NSDF? (We are not aware of anything else – the NSDF, if approved by the commission will be an amendment to the site licence for CRL, not a new separate licence. The SMR, if approved will be a separate licence)

On September 6th, ORK received the following documents from CNL:
- Effluent Monitoring Reports from 2016, 2017, and 2018;
- Annual Safety Reports from 2015, 2016, and 2017;
- Groundwater Monitoring Reports from 2016 and 2017; and
- Annual Compliance Reports from 2018.

On October 3rd, the following requests were submitted to CNL:
1) Has Chalk River has been granted any Environmental Compliance Approvals (ECAs) by the Provincial Ministry of Environment, Conservation, and Parks. If so, would you be able to share copies of it/them? and
2) Have any *Fisheries Act* permits for Chalk River issued by the federal Department of Fisheries and Oceans. If the site is also subject to such a permit, could you share a copy?

Confirmation of receipt of the requests were provided the same day, but no response has since been provided.

PHAI Information requests

Ms. Feinstein made the following information request to CNL on August 15th, 2019:
1) the identified cause for the wall collapse;
2) whether similar risk conditions exist for any remaining walls;

3) whether any water quality testing was conducted in the area after the collapse;
    a. if so, a list of contaminants that were tested for and the results of water quality sampling;
4) a description of mitigation and remediation measures taken since the incident;
5) A copy of the incident report for the event that was sent to the CNSC; and
6) A copy of the incident report which was sent to the MECP.

On August 29th, CNL informed Ms. Feinstein that information should be obtained from the Municipality of Port Hope as it had control over the west harbour wall:

> "It should be noted that Canadian Nuclear Laboratories (CNL) did not (and still does not) have care and control of the municipally owned west wall of the Port Hope Harbour during the collapse.
>
> The deteriorating condition of the aging harbour walls and the potential for their collapse was known and taken into account during the planning phase for the harbour remediation, as part of the Port Hope Area Initiative (PHAI). Although it was determined that the collapse was not related to PHAI work being undertaken on the Centre Pier and the east side of the harbour at the time, CNL worked closely with the Municipality and Cameco to provide technical assistance.
>
> The Municipality of Port Hope issued a media release about the incident (attached) that provides information on the collapse and is the point of contact for information on any testing done at the time and any reports submitted.
>
> CNL's rehabilitation of the remaining harbour walls began earlier this year to prepare the harbour for dredging. On the north and south side, (pipe) pilings were installed to protect the timber crib structure that is currently there. On the west wall, a section of which had collapsed prior to this event, a grout curtain is installed to prevent water seepage underneath the new combi wall when it is built. Installation of pilings on the Queen's Wharf also started this year, although completion of that work has been postponed as result of the high water levels experienced in the area. The shoring in that area will include drilling pipe piles against the existing wall along the wharf, which will continue once the waters recede to avoid underwater drilling.
>
> As CNL continues work in the harbour in preparation for dredging, the safety of our workers, the public and the environment remain our priority."

forwarded the information request to the Municipality of Port Hope on September 4th. She was contacted September 5th with a promise to provide a response to questions by the 18th.

Ms. Feinstein was contacted September 17th by the municipality noting it could only provide responses by the 19th or 20th.

The following responses (in red) were provided September 19th, in addition to a copy of a previously prepared briefing report from Golder Associates reviewing the incident and its effects for Cameco Corporation (dated July 4, 2019 – the contents are too extensive to be attached to this Appendix):

1) The identified cause for the wall collapse;

    a. the partial collapse of the west harbour wall concrete coping is believed to be a result of age, deterioration of sub grade cribbing, and erosion of soils surrounding the west wall. There has been incremental movement that has consistently been monitored since 2007 and the Municipality proactively installed a turbidity (otherwise known as silt) curtain in the spring of 2017 as a potential mitigation measure should the wall collapse as this area is within our drinking water intake protection zone. In advance of the west turning basin wall coping collapse in October 2018, Canadian Nuclear Laboratories (CNL) had also been operating a heavy duty turbidity curtain in the harbour approach channel in association with the Phase 1 wave attenuator placement and harbour remediation preparations. Subsequent to the partial west wall coping collapse in October 2018, the Municipality installed a second turbidity curtain across the full span of the turning basin west wall, with a north-south orientation. Moreover, Golder Associates was retained to design an engineered revetment to stabilize the wall. In consultation and cooperation with CNL and Cameco, the revetment was installed in December 2018.

2) Whether similar risk conditions exist for any remaining walls;
    a. it has been known there is Harbour wall movement had been documented at various locations across the harbour, however, monitoring points along the mid portion of the west turning basin wall associated with the October 2018 coping failure had by far shown the greatest rates of displacement. A 2019 third party geotechnical assessment of the remaining west turning basin wall coping identified a potential short term failure risk for the coping segment immediately north of the revetment zone. Remaining harbour wall segments are not at risk of failure in the short term. Cameco has provided and consented to the release of the enclosed Golder Associates Ltd. letter dated July 4, 2019.

3) Whether any water quality testing was conducted in the area after the collapse;
    a. the Municipality undertook a daily sampling program after the collapse commencing on October 10th through October 25, 2017. Both the MECP and CNSC were satisfied with the performance of the turbidity (silt) curtain and mitigative measures installed by the Municipality and our Water Treatment Plant Manager / Overall Responsible Operator for protection of our drinking water system intake Zone. b) if so, a list of contaminants that were tested for and the results of water quality sampling; the Municipality continues weekly sampling with raw samples off our low lift header tap in the lab and treated sample from the treated sample tap in our lab. Basically before and after filtration that includes, but not limited to contaminants of potential concern for low level radioactive waste, specifically arsenic and uranium in both the raw water and treated water samples. Results of the sampling may be provided upon request, and the sampling is on-going as part of a regulatory compliance regime the Municipality is required to do. The sampling frequency was increased to daily immediately after the collapse to ensure water quality, both inside the harbour, immediate proximity to the west wall both in front of and behind the silt curtain, and at the wave attenuator both inside the attenuator and out in the lakeside. The Water Keepers are invited to consult directly with the regulators if there are any questions regarding test results and compliance measures.

4) A description of mitigation and remediation measures taken since the incident;
    a. see Response to Q # 3. The Municipality continues to monitor water quality through its routine sampling regime. As with any other municipal construction activity where excavation work occurs the Construction Monitoring Program through CNL was engaged at the time of the west turning basin coping wall collapse to assess and manage LLRW contaminated soils excavated during the revetment construction period. CNL has care and control of the harbour and Centre Pier for remediation activities, EXCEPT for the west wall.

5) A copy of the incident report for the event that was sent to the CNSC;

   a. the harbour west wall is owned by the Municipality of Port Hope and outside of a Federally CNSC licensed facility, and therefore under jurisdiction of the Ministry of Environment, Conservation and Parks. There is no incident report to be shared as the protocol for reporting is to Spills Action Ontario by telephone.

6) A copy of the incident report which was sent to the MECP;
   a. see response to Question # 5 above.

Ms. Feinstein sent follow-up queries on September 25th:

1) You mention that the results of sampling could be made available upon request. Can I make that request to you or is another channel required? It would be helpful if we could see sampling results from between 9-10 months prior to the wall collapse up until the present.
2) You note primary contaminants of concern that were tested for were arsenic and uranium. Is this a comprehensive list? Were any other substances tested for?
3) I understand s.12 of OReg 675/98 requires written reports of all incidents reported to the Spills Action Centre, even if the report need only be made to the MECP officer over the phone. Would it be possible for you to share that report?

On October 3rd, the municipality sent sample results from the date of the collapse to October 24th as well as the results leading up to the collapse starting the previous August. A link to Port Hope's annual and summary reports was also provided.

Report

"Review of contamination pathways at the Chalk River Site: legacy contamination and future concerns"

Prepared for:
Lake Ontario Waterkeeper
Ottawa Riverkeeper

Prepared by:
Prof. Dr. Ekaterina Markelova
Markelova.phd@gmail.com

May 6, 2020

Executive summary

This report, prepared for Ottawa Riverkeeper and Ontario Waterkeeper, provides a review of the contaminant pathways from the Chalk River Laboratories (CRL) to natural waterbodies and atmosphere. The contaminant pathways have been assessed via data available from (1) Environmental Risk Assessment study (ERA 2019), (2) environmental monitoring program, (3) effluent releases, (4) groundwater monitoring. The contamination considered in the present study includes both radioactive and non-radioactive compounds, which are being released via waterborne and airborne pathways and could be potentially hazardous for the environment.

Over 70 years of historical operations at the CRL site, there have been gathered a great deal of information and monitoring data. At the present, available information does not facilitate public understanding of contaminant pathways. Therefore, the goal of this review was to focus on qualitative site description in order to identify the most critical contaminant pathways and hot-spots for further quantitative investigation. Based in the recent ERA 2019 [2], series of schematics have been created to depict contaminant pathways through groundwater, surface water and airborne emissions as a part of this review study. Such visualization helps to identify data gaps and locate hot-spots of contamination over a large-scale CRL site.

The major outcome of this study provides:
(1) Summary of the major contaminant facilities.
(2) Schematics of contaminant pathways through major facilities for three watersheds.
(3) List of identified hot-spots of contamination.
(4) Discussion on the importance of soil characterization and related information gap.
(5) Discussion on the relevance of storm water monitoring.
(6) Recommendations to the revision of the Licence Conditions with regard to the Environmental Protection section.

One of the striking conclusions of this study is that Operating Licence NRTEOL-01.00/2028 controls only 4 locations at the entire CRL site, which in turn includes more than 20 potential sources of contamination. Moreover, within 4 controlled locations, there is no any control location at the heavily contaminated site within the Perch Lake Basin, which fails to safely confine low-level and intermediate-level radioactive waste (legacy of nuclear accidents in the 1960th). Therefore, specific recommendations have been suggested for further consideration to supplement Licence.

Background and scale of study

Chalk River Laboratories (CRL) is located in Ontario and since 1944 is Canada's major nuclear science center. There is a very high diversity of nuclear-related activities and associated high volumes of radioactive waste. Over 80 years of historical site utilization, there have been numerous failures in operation that are causing serious concerns on the potential hazards to the environment. Out of all Canadian Nuclear Laboratories facilities, only the CRL site is classified as "high risk", which implies the most dangerous category of nuclear sites [CNSC Staff report 2018, page 4]. Although this classification does not imply that the facilities are currently posing any immediate environmental threat, there is a great concern towards the potential consequences of operational malfunctions.

The CRL site occupies area of about 40 km^2 and is spread over three watersheds: 1) the Ottawa River Direct Basin, 2) Perch Lake Basin, 3) Maskinonge Lake Basin. The area is located on a geological structural phenomenon (rift valley) that is generated by tension faulting and occupied by the Ottawa River. It implies high connectivity in the groundwater and surface systems within the site, which provides numerous pathways for contaminant migration to the Ottawa River, which in turn is an ultimate sink for contaminants. Groundwater flow is constrained by the geology and topography, which leads to water discharges to local wetlands, bogs, streams and lakes. Therefore, most of the contaminants are captured in the near-surface environment before reaching the Ottawa River. The amount and diversity of contaminants that are localized in small water bodies possesses long-term exposure of biota and fauna.

The CRL site is highly diverse and complex technological system that provides a great variety of contaminant pathways for both radiological and non-radiological contaminants to the environment. There are 79 operating facilities in 2018 including 13 of Class I and II Nuclear Facilities and about 20 Waste Management Areas (WMA) and pits. In 2016 and 2018, 2 of Class I Nuclear Facilities (Molybdenum-99 Production Facility and National Research Universal (NRU) Reactor) were shut down and are currently under a shutdown state. There are 9 more permanently shut down nuclear facilities, intended for decommissioning, or already partly decommissioned: NRX Reactor, Heavy Water Upgrading Plant, Plutonium Recovery Laboratory, Plutonium Tower, MAPLE 1 and MAPLE 2 Reactors, New Processing Facility, Pool Test Reactor, Waste Water Evaporator, and Nitrate Plant (buried).

The contamination pathways include waterborne and airborne releases to the environment via piped liquid effluents, airborne emissions and releases from waste management areas via groundwater (i.e., contaminant plumes). The monitoring of environmental impacts from CRL operations is carried out under the integrated Environmental Monitoring Program (EMP) on an annual base. Moreover, the most recent Environmental Risk Assessment (ERA) report became available in 2019. The report provides comprehensive assessment of contaminant releases, as well as summarizes the most complete site description. Therefore, the details on the history and description of CRL facilities with contaminant legacy are not repeated in this report. Rather, the goal of the study is to review the state of current environmental conditions at the CRL site in order to identify contaminant hot spots for future investigations. It should be stressed out that within the allocated timeframe (3 weeks) for this review, the report is focusing on the qualitative site characterization. Whereas, the quantitative assessment of monitoring data, release limits and soil retardation capacity could be performed at the next stages.

Review

There are two types of CRL site characterization with regard to its environmental impact. The first type is based on the grouping the facilities and discussing associated contamination per each watershed separately (i.e., 3 areas). This approach is implemented by the Canadian Nuclear Laboratories (CNL) to report the environmental performance review within the Annual Safety Report. The second type is more recent and detailed, which organizes the CRL site into 11 Management Units (MU) (i.e., 11 areas). In turn, this study aimed to supplement both approaches and provide detailed information on contaminant pathways through groundwater, surface water and atmosphere discussed in 11 MUs, while combined in 3 watershed areas. The schematics of all these approaches are given in Figure 1.

Below, the impact of CRL facilities is discussed in the following order:

(1) Ottawa River Direct Basin
(2) Perch Lake Basin
(3) Maskinonge Lake Basin

1.1 Ottawa River Direct Basin

Ottawa River Direct Basin	
Features of the basin	• The fastest contaminant migration pathway to the Ottawa River. • The highest radioactive contamination from entire CRL site to the environment: airborne emissions are more significant than waterborne emissions.
Facilities and key environmental concerns	1) NRU site: groundwater H-3, effluent outfall of phenolics and Hg, airborne Ar-41 and H-3. 2) NRX site: groundwater gross beta (Sr-90) 3) MPF: airborne Ar-41 and I-131 4) Grey Grescent: soil U and heavy metals 5) Power House: airborne SO2, NOx, CO, VOC
Schematics of contaminant pathways through major facilities	Figure 2 represents the schematics that was constructed within this review to visualize the contaminant pathways through major facilities of the Ottawa River Direct Basin.

1) NRU

Waterborne emissions

National Research Universal (NRU) reactor operated from 1957 to March 31, 2018 and is currently undergoing a stage of shutdown. This reactor was vital for both nuclear energy research and the production of medical isotopes. There is a spent fuel rods bays at the reactor site, which is leaking and causing a long-term groundwater contaminant plume of tritium (H-3). The water basins were used to store spent fuel for its radioactive decay prior the waste management. The rods have been removed, but the water is expected to remain in the rod bays for another 10 years or longer [Environmental Risk Assessment, page 4-53]. In contrast to other contaminants (e.g., Sr-90), there is no practical technology on an industrial scale to capture H-3 contamination. After the radioactive release from Fukushima nuclear power plant, the international scientists were searching for the appropriate technology to treat H-3 plume, but concluded that the environmental dilution is the best "decontamination" way. The half-life of radioactive decay of H-3 is 12.3 years, after which half of it will turn to non-toxic helium (He).

Currently, the main retardation mechanism of H-3 at the CRL site is its dilution along the pathway to the Ottawa River. According to the Environmental Risk Assessment, the concentration of H-3 in nearshore well was rather low in 2017 to cause an ecological effect. The maximum H-3 concentration was 109 kBq/L, while the dose acceptance criteria is 17.4 MBq/L (17400 kBq/L). It is expected by the CNL that tritium concentrations will continue to decrease over the next decade. Nevertheless, it is certain that the groundwater plume of H-3 remains one of the key environmental concerns of the CRL site and its migration warrants further investigations. Non-radiological contaminants originating from the NRU site include various organics, heavy metals and chlorines. With the shutdown of the facility, the Total Residual Chlorine (TRCl) should no longer be an issue of the Process Outfall effluent in the future. However, this does not solve the issue of **dioxin-like polychlorinated biphenyls (PCBs)** and **mercury (Hg)**. Further investigation should focus the fate of these contaminants.

Airborne emissions

It should be noted that besides the waterborne emissions of H-3, the NRU reactor stack remains to be the main source of H-3 to the air. There was an increase of airborne H-3 from 2012 to 2017, but in overall, the current levels are about 3 times lower than those in 2006 – 2008 [CRL ASR 201]. More importantly, the ventilation and cooling air from the NRU reactor also releases radioactive noble gases (primarily **Ar-41**). In contrast to waterborne emissions, airborne contaminants do not create hot-spot legacy as they spread away from the local source following the wind direction. The predominant wind direction at the CRL site is NW-SE, so that contaminant air plume is moving towards Balmer Bay, which is located 6.8-km northwest. This is another important issue that the radioactive air plume is moving upstream and not downstream of the site as in the case of aqueous contamination. Calculated doses that could be received by public of Balmer Bay are relatively low (0.084 mSv/year) and remain well below the accepted dose limit of 1 mSv/year [2]. With the shutdown of the NRU reactor in 2018, the airborne emissions are expected to decrease. However, the effect will not be immediate, since the radioactivity of Ar-41 decays with a half-life of 1.8 h, suggesting that the contamination will persist for another decade.

2) NRX Rod Bay leak

National Research Experimental (NRX) reactor was shut down in 1993. Since 1947, during its operation, there was a major accident 1952 (fuel melting and reactor explosion). This created the enormous amount of highly radioactive solid and liquid waste, which was buried at Waste Management Area A and B. These areas are outside of the NRX facility, which is located in the Direct Ottawa River Basin. So that the source of contamination was transferred to another basin (Perch Lake Basin), which is not currently under the Licence [3] control as discussed below. Meanwhile, at the NRX site, there is a long-term issue with leakage of contaminated water with **strontium (Sr-90)** from the NRX Rod Bays. The first plume of Sr-90 was detected in 1959. In September 2006, contaminated water remaining in the B204A Bays was removed supposing that contaminant source would be eliminated forever. However, the half-life of Sr-90 is relatively long ($t_{1/2}$=28.8 years), which would take decades for natural decrease of the contamination. It is evident that the contamination still persists nowadays. For example, in 2017, the concentration of Sr-90 in the RBP-7 well of the NRX plume was 3 times higher than the benchmark dose [Environmental Risk Assessment 2019, page E-1].

The near-surface and subsurface area of the NRX facility is being contaminated with Sr-90 over 60 years, which provides long-term interaction between the contaminant and the fractured bedrock. In this regard, natural capacity to absorb the contaminant plume is one of the major concerns. The soil is not routinely monitored, which implies a considerable gap in soil characterization for radiological and non-radiological contamination. Considering that the soil and sediments are the ultimate contaminants sinks of localized area, the corresponding capacity of these natural objects have to be assessed within the Environmental Monitoring Program. Once data become available on soil parameters (e.g., surface area of adsorbing minerals, water saturation, density, redox and pH conditions), numerical models can be used to predict the reactive transport of contaminants in time and space within the site. Such assessment would help to understand for how long and how much of the Sr-90 could be naturally retarded by the near-surface environment. It could turn out, that over decades of contamination, the soil and sediments have reached their maximum retardation capacities, which would indicate the emergency for immediate remediation actions.

3) Molybdenum-99 Production Facility (MPF)

Waterborne

Molybdenum-99 Production Facility (MPF) was launched in 1984 and shut down in October 2016. For decades, it was a world leader in radioisotope (Mo-99) production for diagnostic procedures in the field of nuclear medicine. MPF operation relied on the operation of the NRU reactor for irradiation of Mo-99 targets. After the closure of the NRU reactor, MPF is now transferred to a shutdown state. There are cooling water collection tanks still in place of the MPF site. The operation of these tanks is decreasing, but the facility remains a potential source of contamination. The effluent is being treated at the Waste Treatment Centre (WTC).

Airborne

The major concern of the whole MPF facility is in its airborne emissions. Over 30 years, the 61-metre stack of the MPF was releasing elevated concentrations of mixed noble gases (mainly **Ar-41**) and **I-131**. With the ceasing of the molybdenum (Mo) processing activities in 2016, the gaseous emissions are expected to significantly decrease. Firstly, due to the elimination of the major source, and secondly, due to the installation of the adsorbing filters (rings) on certain tile holes. The raw data has to be evaluated to assess whether the corresponding changes are in place.

4) Grey Crescent

The Grey Crescent site is a cumulative name to the area of historical landfills that were used to store conventional waste, construction debris and waste from operational activities. Most of the landfills are no longer accepting waste and only the Sanitary Landfill is currently in use for non-radioactive wastes. Although, there is no radiological contamination of the site, numerous non-radiological contaminants have been found at elevated concentrations. For example, uranium (U) is found in soils up to 430,000 μg/g, which is about a thousand times higher than the Canadian Soil Quality Guideline of 300 μg/g for industrial sites [Environmental Risk Assessment 2019, page xxix]. Other contaminants include Al, Ba, Cl, Cu, Li, Zn, Sr, which requires further assessment and better characterization of the areas where these contaminants are found.

5) Power House

The Power House is a non-radioactive facility. Its major contribution to the site contamination is by gaseous emissions of sulphur dioxide (SO2) Carbon Monoxide (CO), Nitrogen Oxides (NOx) and Volatile Organic Carbons (VOC). Although non-radioactive, these gases are toxic to biota. The area of contamination is estimated to be rather small and localized within the 300-m of the Power House. With the replacement of the oil burning to natural gas burning, the concentrations of SO2 are expected to decrease from 2018. However, the contamination trend for all these gases has to be further investigated.

6) ZED-2 reactor

The Zero Energy Deuterium (Lattice Testing Reactor) is the only operational reactor at the whole CRL site. There was no solid hazardous waste, no liquid radioactive waste and no effluents releases from ZED-2 in 2017 [8].

7) Maple 1 and Maple 2 reactors

As of 2019, the Maple 1 and Maple 2 Nuclear facilities are in Extended Shutdown State.

1.2 Perch Lake Basin

Perch Lake Basin	
Features of the basin	• It is one of the most contaminated areas of the CRL site with the long-term historical waste operations. • Groundwater treatment systems are effectively removing Sr-90 contamination, but there is a contamination legacy in the local wetlands (West Swamp, South Swamp, East Swamp). • Other radiological contaminants of concern are Cs-137 and Co-60. • The site is heavily contaminated by non-radiological waterborne emissions, such as Ba, Cd, Ni, Al, V, Li, Sr, As, U, Se, phenolics. Elevated concentrations are widespread and require further characterization. • The site is also a contribution to the atmospheric radiation by emitting Ar-41.
Facilities and key environmental concerns	1) WMA A: waterborne: Sr-90, Cs-137, Cl, Co-60 2) WMA B: waterborne: Sr-90, H-3, solvents, chloroform, toxic elements and heavy metals 3) LDAs: waterborne: Sr-90, Cs-137, H-3, phosphate, Hg, Ba, V, U, Pb
Schematics of contaminant pathways through major facilities	Figure 3 represents the schematics that was constructed within this review to visualize the contaminant pathways through major facilities of the Perch Lake Basin.

1) Waste Management Area A (WMA-A)

The Waste Management Area A is currently non-operational with a very long historical contamination since 1946. Natural receivers are local soil, vegetation and water bodies (e.g., South Swamp) within the Perch Lake Basin. Further, the Perch Lake Basin drains via Perch Lake and Perch Creek to the Ottawa River. The drainage system upstream of the outlet to the Ottawa River is effectively decreasing the gross beta (Sr-90) flux to the river. After the explosion of the NRX reactor core in 1952, highly contaminated radioactive waste was buried in the sand at the WMA A. Moreover, highly radioactive liquid waste from fuel reprocessing experiments was disposed at the same location in the unlined trenches without any environmental safety considerations. This resulted in the contaminant plumes of **Sr-90**.

The WMA-A stopped receiving the waste in 1955 and till the mid-1970s was used as a surface storage area for contaminated reusable equipment. Later on, the surface of WMA-A was cleaned-up and covered with approximately 3 m of cover material to limit surface water infiltration to the subsurface environment. In 2013, a permeable reactive barrier was installed across the Sr-90 plume extending from WMA-A to South Swamp, which is reducing the groundwater gross beta concentration to less than 10 Bq/L [2]. At the same time, the wetland receives groundwater from other contaminated areas (i.e., WMA B and LDAs) which are also being treated as discussed below. Overall, South Swamp has accumulated significant contamination legacy of Sr-90 over 70 years and the effectiveness of the barrier at the WMA-A is expected to become more evident over the next decades.

Besides the radiological contamination, the elevated concentrations of chloride are fairly widespread at the WMA-A site. Being a common natural receiver of polluted plumes from WMA-A, WMA-B and LDAs, the origin of the contamination within the South Swamp and its discharge area has to be further investigation with regard to Ba, Cl, Li, Sr, Cu, Fe, PCBs, phenolics, TCE, TCFM, Cl, and solvent extractables.

2) Waste Management Area B (WMA-B)

The Waste Management Area B is currently in operation. Currently operating facilities include a variety of **low-level and intermediate-level radioactive waste** including reactor components of NRU and NRX, as well as intermediate-level waste from Mo production up to 2018 [2, Table 4-11]. However, the major environmental concern relates to its past activities, when from 1953 to 1963 a lot of radioactive solid waste was disposed in the northwest corner of the site. The unlined sand trenches resulted in the contamination plume of **Sr-90**, which is currently discharging from groundwater to the surface at Spring B (a forested wetland area of West Swamp). In 1993, the Spring B Treatment (SBD) System was installed to treat a portion of the plume, whereas, the other portion remains untreated. The West Swamp is still receiving water contaminated by Sr-90 from WMA-B. Moreover, in 2009, there was an extended outage of the groundwater treatment facility, which resulted in the enhanced release of contaminated water.

From the wetland, the contamination is transported by surface water to Perch Lake via Perch Lake Inlet 1. The primary area of concern is the Spring B Forest that is heavily contaminated by Sr-90. It has been estimated by the ERA [2] that the highest environmental impact occurs at the groundwater discharge location. Although, the hot-spot of contamination is relatively small (about 0.1 ha), the mobility and bioavailability of Sr-90 should be investigated further in details. The relatively long half-life of Sr-90 of 28.8 years suggests that the contamination will persist for several decades in this area.

Additionally, to the plume of Sr-90, there is a **groundwater plume of H-3**, which is originating from the array of cylindrical bunkers at the southern end of the WMA-B site. It remains unclear for the review what remediation actions are taken at the site and should be further investigated in future.

A broad variety of waste types that was historically emplaced in the sand trenches of WMA-B results in high concentrations of organics (oil and solvents), so called **solvent plume**. Out of many contaminants found at the site (trichloroethane, 1,1-dichloroethane, trichloroethylene (TCE), 1,1-dichloroethylene and tetrachloroethylene (PCE)), **1,1,1-TCA and chloroform** compounds pose environmental concerns and require detailed investigation [2, Table 4-13].

Finally, there are numerous non-radiological contaminants have been found in water and sediments of Spring B Forest and West Swamp. Since the main source of contamination at the wetland area is the groundwater discharge from the WMA-B, further investigations are required to understand pathways and dynamics of chlorinated solvents, Hg, lithium (Li), uranium (U), phenolics, arsenic (As), Cl, Fe, Ni, (lead) Pb, strontium (Sr), zinc (Zn), barium (Ba), Al, Cu, solvent extractable (oil and grease), TCFM, V, TCE and chloroform.

3) **Liquid Dispersal Areas (LDAs)**

Liquid Dispersal Areas include Laundry Pit, Chemical Pit and Reactor Pits. All sites are currently non-operational, but have a long-term contamination history that makes them the most affected areas on the CRL site. Starting from the 1950^{th} and up to 2000, radioactive waste management practices with regard to the liquid waste were catastrophic to the environment. In particular, liquid wastes emitting beta/gamma activity, alpha activity and tritium were drained directly to the soil of these sites without preliminary treatment or encapsulation. The details of waste type present at the LDAs are available in ERA 2019 [2, Table 4-29] and briefly summarized below.

Reactor Pit #1: 1953 – 1956

Liquid waste with Sr-90 and alpha emitters was discharged to natural depression resulting in contaminated soil.

Reactor Pit #2: 1956 – 2000

Liquid waste with beta/gamma activity, alpha activity and tritium originating from lightly contaminated water from Rod Storage Bays and NRX with NRU operations was discharged resulting in contaminated soil.

Chemical Pit: 1956 – 1994

Low-level liquid waste with beta/gamma activity, alpha activity and tritium originating from laboratories and chemical operations was discharged to a gravel-filled pit resulting in contaminated soil.

Laundry Pit: 1956 – 1958

Liquid waste with beta/gamma activity and alpha activity originating from Decontamination Center and Laundry was discharged to engineered pit resulting in contaminated soil.

The important feature of the LDAs site is that its groundwater flow system discharging and releasing contaminants to two nearby wetlands. Currently, both wetlands are protected by groundwater treatment systems, which control **Sr-90** before contaminant plumes discharge to East Swamp and South Swamp.

In 2010, there was an extended outage in the treatment facility and the contamination was extensively spreading to the surface water. At the present, the contaminants of concern are of radiological and non-radiological origins. The striking difference of the LDAs contamination from other sites is that it contains **cobalt (Co-60)** and **cesium (Cs-137)**, which are the sources of **gamma radiation**. It implies, that this type of contamination can easily travel through surface and near-surface environment. It takes several inches of lead or several feet of concrete to effectively block gamma rays. Therefore, gamma rays are the most dangerous form of ionizing radiation and the effectiveness of the underground treatment systems should be investigated further. East Swamp is currently contaminated by Al, cadmium **(Cd), Cu, Fe, PCBs, TCE, TCFM, V, Ni, tetrachloroethylene (PCE), Sr, Al, Ba, Hg, Pb, U**. Additionally, the Laundry Pit was used to disperse wastewater from the active area Laundry and Decontamination Centre and therefore contains elevated concentrations of phosphorous (P) and PO4, which along with bioavailable organics may cause eutrophication of water bodies.

4) WMA-D, WMA-H, WMA-G

The WMA-D, WMA-H, WMA-G are above-ground waste storage facilities. WMA -D and -H are currently operating, while WMA-G has been a non-operating waste management area for several years. No contaminant releases to the environment due to spills or leaks are known to have occurred in the past. Since WMA-G is planned to be returned to an operating state in 2019, the routine monitoring should be investigated further.

1.3 Maskinonge Lake Basin

Maskinonge Lake Basin	
Features of the basin	• The most interconnected groundwater system between various contaminant facilities. • The contamination of soil and groundwater is represented by the historical legacy, whereas the currently operational WMA-J does not cause environmental concerns. • Contaminated soil is a subject for a removal program, which has not been evolved and depends on the NSDF progress.
Facilities and key environmental concerns	1) WMA C: groundwater H-3, VOC, Fe, redox conditions 2) WMA F: groundwater As, Ra, Th and U, airborne: Rn-222 3) Nitrate Plant: Sr-90 4) Thorium Pit: Sr-90
Schematics of contaminant pathways through major facilities	Figure 4 represents the schematics that was constructed within this review to visualize the contaminant pathways through major facilities of the Maskinonge Lake Basin.

1) Waste Management Area C (WMA-C)

From 1963 to 1987, WMA-C was used for the storage of small quantities of liquid sewage sludge from the CRL Sewage Treatment Plant. From 1982 to 1995, it was used for the low-level radioactive and chemically contaminated solid wastes. WMA-C has also been used for above ground storage of contaminated materials including sections of the NRX Reactor Stack, drums of liquid scintillation wastes (removed in 2008, now in WMA-H), suspect soils excavated from the Active Area, and steel containers filled with CRL sewage sludge filter cake (removed in 2011) [2]. The main contaminant of concern is **tritium (H-3)** and **volatile organic compounds (VOC)**. Other radiological contaminants include **Sr-90 and Co-60**. In 2013, an engineered cover consisting of three layers was placed over the top of both the original compound and the extension to reduce water infiltration through the waste at WMA-C. This should constrain contamination pathway of tritium, C-14 and Sr-90 from WMA-C towards Duke Swamp. Moreover, there is a second underground flow path from WMA-C to Bulk Storage Swamp. Although tritium concentrations at Duke Stream Weir showed a decrease in 2016, the gross beta activity (Sr-90) persists at the same level. This phenomenon should be investigated further.

With regard to non-radiological contaminants, the concentration of Fe is significantly elevated [2], which indicates highly reducing redox conditions. This may increase the mobility and bioavailability of many contaminants. Therefore, the fate of Fe, Al, Li, TCFM, V, As, Cd, Cl, Pb, Ni and Sr warrants further investigation.

2) Waste Management Area F

WMA-F was developed to store wastes from the remediation of contaminated sites at Port Hope, Ottawa, and Mono Mills (Ontario). The wastes contained contaminated soils, slags and building demolition debris resulting from uranium refining, niobium smelting and radium dial painting operations [2]. There is no data available on the radioactive contamination of groundwater since 2012, and there are no historical concerns neither. Whereas, airborne emissions are represented by radon, which requires further investigation. The major non-radiological contaminants are represented by As, Ra, Th and U.

3) Nitrate Plant

The Nitrate Plant operated from 1953 to 1954 and was used to decompose (chemically stabilize and volume-reduce) ammonium nitrate solutions containing fission products generated from spent fuel reprocessing in the Plutonium Extraction Plant. Groundwater contamination is a result of releases of fission product as well as the discharge of thorium nitrate waste solution into the ground near the Nitrate Plant via a small dispersal pit, later known as the Thorium Pit, between 1955 and 1960. The plume emits betta radiation, which is being controlled by installed Wall and Curtain passive water treatment system. The system helps to decrease Sr-90 levels before it reaches Duke Swamp. However, Duke Swamp still includes elevated concentrations of Al, As, Cd, Cl, Fe, Li, Ni, Pb, Sr, TCFM and V. Overall, Nitrate Plant Plume is under ongoing monitoring, which requires further investigation.

4) Thorium Pit

The Thorium Pit was operational from 1955 to 1960 for the dispersal of liquid waste solutions arising from thorium fuel cycle experiments conducted at CRL. The liquid waste contained natural thorium, thorium nitrate, ammonium nitrate, Ce-144, Cs-137, Sr-90 and U-233. The inventory released from the Thorium Pit is a small fraction of the inventory released to the Nitrate Plant Plume. Radionuclide releases from the Thorium Pit have resulted in a Sr-90 plume that extends to Duke Swamp. Gross beta activity in vegetation is elevated where the **Sr-90 plume** from the Thorium Pit discharges to the surface in the northwest portion of Duke Swamp. Retention of 90Sr by vegetation is low because there is a well-defined channel of only 80 m between the location of highest vegetation beta concentrations and the uppermost beaver dam on Lower Bass Creek, greatly reducing the opportunity for Sr-90 uptake [2]. Based on the groundwater flow path and contamination pattern, the Thorium Pit is believed to be the main source of beta contamination in Duke Swamp. Contaminated soils and other materials continue to be monitored and may require recovery plan.

5) Acid, Chemical, Solvent Pits

The ACS Pits are a series of three small pits operated from 1982 to 1987 and were used for the dispersal of miscellaneous laboratory and processing waste. The names of the pits are given corresponding to the waste type: inactive chemicals, acids and solvents. The groundwater that flow under these pits discharges to Duke Swamp along with Nitrate Plant discussed above. Therefore, the contaminant issues of Al, As, Cd, Cl, Fe, Li, Ni, Pb, Sr, TCFM and V could be investigated with regard to the ACS pits as well. The soil of the ACS Pits remains contaminated, however, there are no recovery plans are foreseen, waiting for the decision on disposal facility.

6) Waste Management Area J (WMA-J)

WMA-J (formerly the Bulk Materials Landfill) is an operating facility, which is located between WMA-C and the Plant Road. It is a relatively new waste storage facility that came into operation in early 2011 for the long-term management of dewatered sewage sludge from the CRL Sanitary Sewage Treatment Plant. No environmental concerns related to this site have yet been identified by the CNL within the scope of the ERA 2019 [2].

Future investigation

1) Schematics of contaminant pathways through major facilities

Over 70 years of historical operations at the CRL site, there have been gathered a great deal of information and monitoring data. At the present, available information does not facilitate public understanding of contaminant pathways. Therefore, series of schematics have been created to depict contaminant pathways through groundwater, surface water and airborne emissions as a part of this review study (Figure 1, 2, 3, 4). Schematics are mainly based on data available from the recent ERA 2019 [2] and are supplemented by information from other publically available documents. Most of the depicted contaminants have elevated concentration that are above ecological screening-levels. Therefore, they could cause adverse ecological effects and require further detailed assessment. It should be noted that the schematics are not claimed to represent a complete and most accurate information as of 2019, rather, they should be used as a “big-picture” to improve site understanding and guide further investigation as outlined below.

2) Further investigation of hot-spots contamination

A number of hot-spots locations with elevated contamination on the CRL site have been identified in the ERA [2]. The present study highlights uncertainties and predictions of the contaminant evolution in time, which requires further investigation. The detailed investigation could be directed by the following goals:

- To assess whether the shut-down of the NRU reactor resulted in the decrease of gaseous argon (Ar-41), liquid TRCl, dioxin-like polychlorinated biphenyls (PCBs), mercury (Hg) and heavy metals concentrations after 2018.
- To assess whether water that remains in the rod bays of the NRU site is properly confined and the concentration of tritium (H-3) in groundwater plume is decreasing due to natural radioactive decay over the next decade.
- To evaluate the change in Sr-90 concentrations in the RBP-7 well of the NRX plume from 2017 onwards.
- To assess whether the ceasing of the molybdenum (Mo) processing activities resulted in the decrease of noble gases (mainly Ar-41) and I-131 after 2016.
- To estimate the mobility and toxicity of U, Al, Ba, Cl, Cu, Li, Zn, and Sr present at elevated concentrations in the soil at the Grey Crescent site.
- To assess whether the replacement of oil burning with natural gas in the Power House resulted in the decrease of SO2 gaseous emissions from 2017 onwards.
- To verify that the installation of the permeable reactive barrier in 2013 at the discharge area from WMA-A to South Swamp is resulting in the decrease of gross beta (Sr-90) contamination in the wetland water.
- To assess the dynamics of contaminant plumes of Sr-90, H-3 and solvents (heavy metals and toxic elements) in the groundwater discharge location from WMA-B to the Spring B Forest and West Swamp.

- To investigate what actions are undertaken to treat H-3 plume leaching from the array of cylindrical bunkers at the southern end of the WMA-B site towards West Swamp.
- To assess the fate of cobalt (Co-60) and cesium (Cs-137), as well as of heavy and toxic metals in the East Swamp as a result of groundwater discharge from the LDAs (e.g., Chemical Pit).
- To assess the effectiveness of the engineered cover installed over WMA-C site in 2013 with regard to the fate of Sr-90 to Duke Stream Weir and radon emissions from the site. Moreover, non-radiological contaminants should be investigated in more details with the focus in Al, As, B, Ba, Cr, Li, Pb, V and redox conditions.
- To investigate gaseous and liquid emissions of the Zero Energy Deuterium-2 facility, which is the only facility hosting an operational reactor at the entire CRL site in 2019.
- To assess the fate of heavy and toxic metals in storm water discharge.

3) Soil characterization

The near-surface and subsurface area of the CRL site are being contaminated with radiological and non-radiological contaminants over 70 years. Such long-term interaction between contaminants and soil may significant alter natural capacity of contamination retardation. The capacity may become weaker by reaching its maximum and thus enhancing contaminant mobility within the site. However, there is a significant gap in soil characterization as a part of the waste legacy. Further investigation is required to better understand current conditions of soil capacity and predict contaminant migration in future. This could include the following:

- Detailed characterization of soil composition, depth profile and later distribution.
- Laboratory experiments on natural soil retardation capacity towards contaminants of concern.
- Numerical simulation of maximum retardation capacity of soil in time and space.

4) Storm water monitoring

Contaminated soil, which is spread at the CRL site (e.g., WMAs, Grey Crescent), creates a great environmental concern with regard to the storm water passing over the soil and washing out the contaminants down to the Ottawa River. There was a large-scale restructuring of storm water management at CRL during 2018. The major changes included the redirection of Storm Outfall 040 to the Process Outfall and Storm Outfall 030 to 010 Stream holding pond. Up to 2017, Storm Outfall 040 was directly discharging to the Ottawa River releasing gross beta (Sr-90) contamination from the NRX Rod Bays plume. After the restructuring storm water system, there are still 10 pathways for direct discharge of potentially contaminated water to the Ottawa River. All 10 pathways are under the effluent monitoring program, so that further investigation could focus on the following:

- Creation of a map for storm water system with depicted contaminants of concern.

- Detailed investigation of contaminant composition and migration pathways at each outflow: Perch Creek Weir, Process Outfall, Sanitary Outfall, Power House Discharge, 010, Storm Outfall (070 Storm Outfall is an up-gradient monitoring station), 030 Storm Outfall, 050 Storm Outfall, 080 Storm Outfall (new in 2018), and Manholes 4F6 and 4F7.
- Evaluation of new Sewage Treatment Facility: what effluent is received and how effectively it is treated.
- Creation of a map for the Perch Lake basin (the most contaminated area by non-radiological contaminants) routing to the WTC facility with depicted contaminants of concern.
- Creation of a map for operating facilities that send operational water to the WTC facility with depicted contaminants of concern.
- Identification of important outfalls that contain contaminated water and are not routed to the WTC for treatment. If it is a case, the corresponding outfalls should be included in the Licence Conditions additionally to WTC and PRO controls.
- Assessment of monitoring program with regard to the frequency of sampling and type of analysis in accordance with the identified hot-spots of contamination.

5) Licence Conditions: Environmental Protection

The section "Environmental Protection" of the Licence Conditions Handbook [3] is lacking clarity on the scale of area and the scope of facilities considered as potential sources of contamination. The structure of tables and description of controlled areas are rather misleading in the evaluation of the Licence application for such a large scale CRL site. Therefore, it is suggested that the Licence Conditions Handbook should be supplemented with detailed information regarding the list of facilities (or major contaminant pathways) included and excluded from the scope of the Licence. The reasoning for the exclusion of control areas should be supplemented with historical trends and present environmental conditions.

As of 2019, Licence NRTEOL-01.00/2028 covers 4 outflow locations, with 3 of them located at the Direct Basin Ottawa River (PRO, Storm Outfall 4F6, and WTC). The fourth effluent outflow under control is located in the Maskinonge Lake Basin (Duke Stream Weir), while no any outflow is controlled in the Perch Lake Basin. It is crucial to highlight that the Perch Lake Basin is hosting low-level and intermediate-level radioactive waste from nuclear accidents. This waste was disposed in a non-proper way back in the 1960th, which is currently causing significant environmental contamination. Although, the contamination area is rather localized, it seems rational to include the Perch Lake Basin into the Licence Conditions. Moreover, it is recommended that more control locations should be added to the Maskinonge Lake Basin, as results of the recent ERA 2019 demonstrate that both basins are heavily contaminated by radiological and non-radiological contaminants above benchmark values.

Below, Table 1 and Table 2 demonstrate important sources of waterborne (radiological and non-radiological) and airborne (radiological and non-radiological) emissions within their outflow areas as recommendations for potential control under the Licence. One of the suggested locations is the Groundwater discharge to Ottawa River (GW). Although, it is not a typical outflow path, it is considered as an effluent stream by the Environmental and Effluent Monitoring Programs. Most of the groundwater contamination in this area arises from radioactive plumes from the NRX and NRU rod bay systems discussed above. Additionally, this point is a discharge for contaminated groundwater from other facilities and operations. Therefore, these groundwater releases should be controlled by the Licence as other important effluent streams to the Ottawa River. Overall, it is suggested to extend the list of parameters for outflow locations that are already under control, as well as to add 5 more outflow locations with a number of specific parameters (Table 1). With respect to airborne emissions, besides 2 facilities included in the Licence, it is suggested to consider 4 more facilities for the operational control (Table 2).

Table 1. Radiological and non-radiological contaminants of concern that are included in Licence NRTEOL-01.00/2028 (text in black). The additional list of control pathways and parameters (text in red) is suggested within the present study. The type of facilities is included into the table for the clarification of contaminant sources.

	Effluent outflow	Facility	Radiological contaminants	Non-radiological contaminants
	Control points included in Licence NRTEOL-01.00/2028			
1	**Process Outfall (PRO)**	NRU WTC	Tritium oxide Gross alpha Gross betta *To be considered:* Cs-137 Co-60 C-14	pH *To be considered:* Hg TRCl PCBs Phenolics
2	**Storm Outfall 4F6**		Tritium oxide	*To be considered:* Al Cu P(tot) Cl Fe
3	**Duke Stream Weir (DSW)**	WMA C WMA F WMA J Nitrate Plant plume Acid, Chemical, Solvent Pit Thorium Pit plume	Tritium oxide *To be considered:* Gross betta Ra-226	*To be considered:* VOC U As
4	**WTC**			P(tot) TSS Oil/Grease

				Cr Cu Pb Hg Ni Zn *To be considered:* As U PCBs TRCl TCFM PCE TCE Chloroform Al Ba Li Sr Fe Cl V Ammonium Phenolics VOC
	Additional control points to be considered for the Licence			
5	**Groundwater to Ottawa River (GW)**	NRU NRX	Tritium oxide Gross alpha Gross betta	
6	**010 Storm Outfall**	Inactive landfill Grey crescent sites		U Al Ba Li Al Cu Zn Sr
7	**Perch Creek Weir (PCW) (groundwater and runoff)**	WMA A WMA B WMA D WMA E WMA G WMA H Laundry Pit Chemical Pit Reactor Pit 1 Reactor Pit 2 Waste Tank	Tritium oxide Gross betta Cs-137	P (tot) Hg Pb Ni Cd Se As Cu Al Zn Ba

		Farm Salt storage shed In prospects: Near Surface Disposal Facility (NSDF)		Li Sr Fe Cl V U PCBs TCFM TCE Oil/Grease Chloroform Phenolics
8	**Sanitary Sewer Outfall (IMH)**	Sewage Treatment Plant Active laundry		Cd Al Ni V TSS TRCl Cu P (tot) Ammonium Cu
9	**Bulk Storage Stream (BSW)**	WMA C	Tritium oxide Gross betta C-14 Co-60	Fe VOC

Table 2. Radiological and non-radiological contaminants of concern that are included in Licence NRTEOL-01.00/2028 (text in black). The additional list of control pathways and parameters (text in red) is suggested within the present study.

	Facility	Pathway	Radiological contaminant	Non-radiological contaminant
	Control points included in Licence NRTEOL-01.00/2028			
1	**NRU**		Tritium oxide *To be considered:* Ar-41	
2	**WTC**		Tritium oxide	
	Additional control points to be considered for the Licence			
3	**WMA B**		Ar-41	
4	**WMA F**		Rn-222	
5	**MPF**		I-131 Noble gases (including Ar-41)	
6	**Power House**			SO2 CO NOx VOC

List of abbreviations and chemical symbols

NRU – National Research Universal (research reactor)
NRX – National Research Experimental (research reactor)
PCB – Polychlorinated Biphenyl
Al – Aluminum
Ar – Argon
Ba – Barium
CO – Carbon Monoxide
Cs – Cesium
Cu – Copper
Fe – Iron
HCFC – Hydro chlorofluorocarbons
HFC – Hydrofluorocarbons
HT – Elemental Tritium
I – Iodine
Li – Lithium
Mo – Molybdenum
Ni – Nickel
NOX – mono-nitrogen oxides NO and NO_2
Pb – Lead
SO2 – Sulphur Dioxide
Sr – Strontium (e.g. Sr-90)
TDS – Total Dissolved Solids
TRCl – Total Residual Chlorine
V – Vanadium
VOC – Volatile Organic Compounds
Zn – Zinc
Cl – Chloride
Cu – Copper
Fe- Iron
TSS - Total Suspended Solids,
TCE - Trichloroethylene,
DCE - 1,1-Dichloroethylene,
Se – Selenium,
B – Boron,
As – Arsenic,
Cs –Cesium,
Sr – Strontium,
TCFM - Trichlorofluoromethane

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[7] Canadian Nuclear Laboratories, Annual Safety Report "Chalk River Laboratories Annual Safety Review for 2017" CRL-00583-ASR-2017, 2018, April

Annex

Figure 1. CRL site description indicating potential source facilities as given in (A) the Annual Safety Report 2016 by CNL, (B) Environmental Risk Assessment 2019 by CNL, and (C) this study by the author.

Figure 2. Schematic of potential source facilities of CRL within the Ottawa River Direct Basin prepared by the author of this study based on the Environmental Risk Assessment 2019.

Figure 3. Schematic of potential source facilities of CRL within the Maskinonge Lake Basin prepared by the author of this study based on the Environmental Risk Assessment 2019.

Figure 4. Schematic of potential source facilities of CRL within the Perch Lake Basin prepared by the author of this study based on the Environmental Risk Assessment 2019.

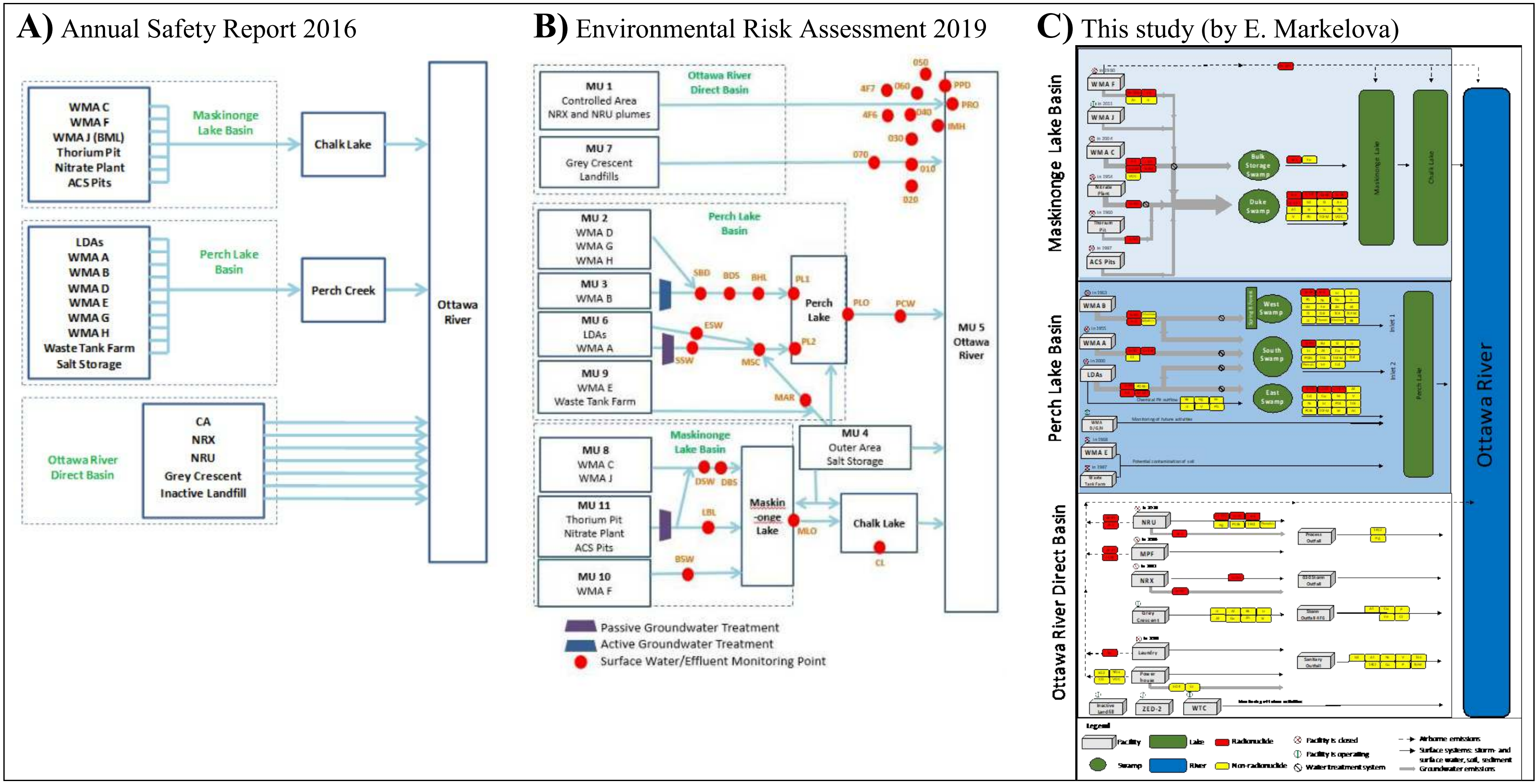

Figure 1. CRL site description indicating potential source facilities as given in (A) the Annual Safety Report 2016 by CNL, (B) Environmental Risk Assessment 2019 by CNL, and (C) this study by the author.

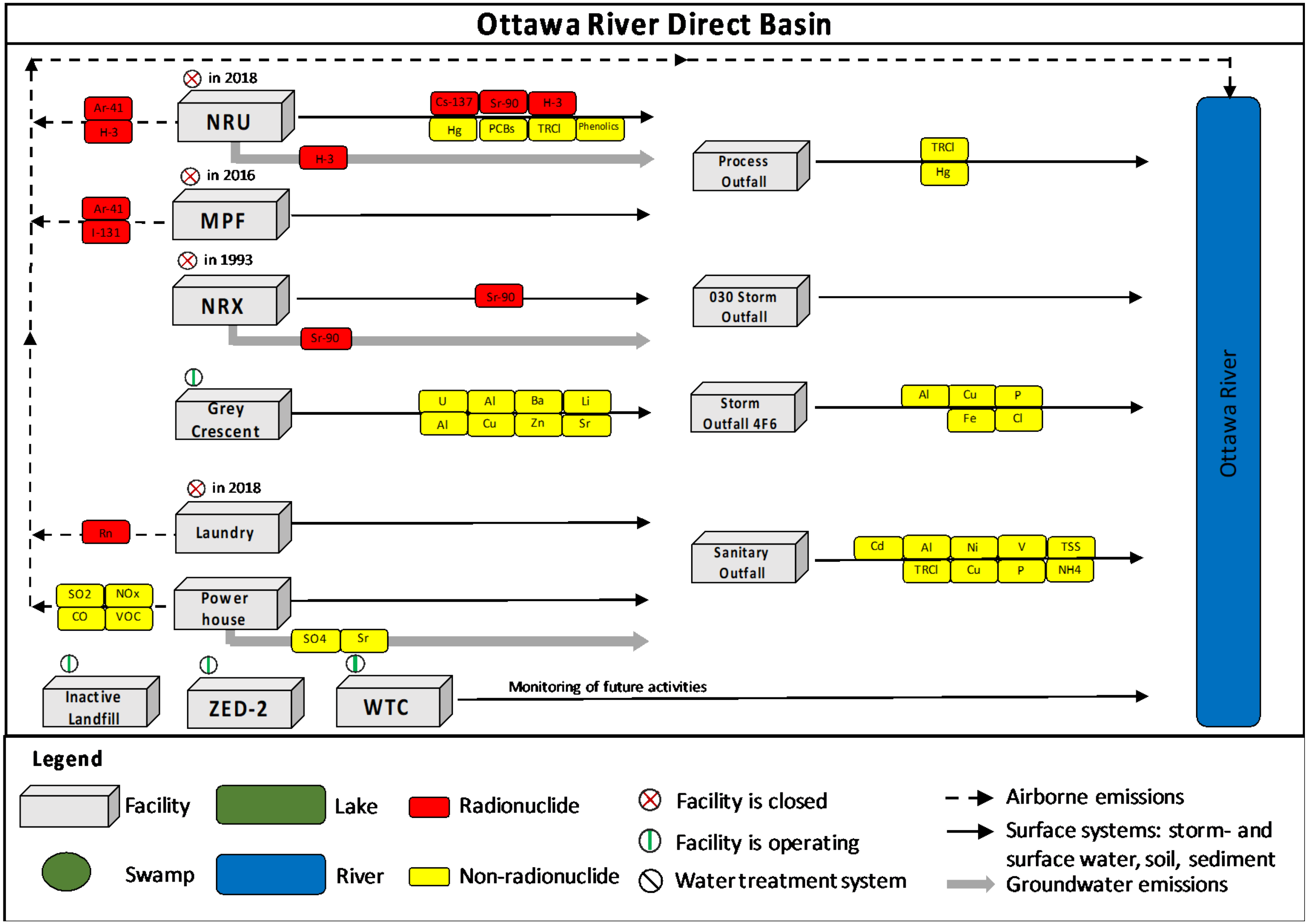

Figure 2. Schematic of potential source facilities of CRL within the Ottawa River Direct Basin prepared by the author of this study based on the Environmental Risk Assessment 2019.

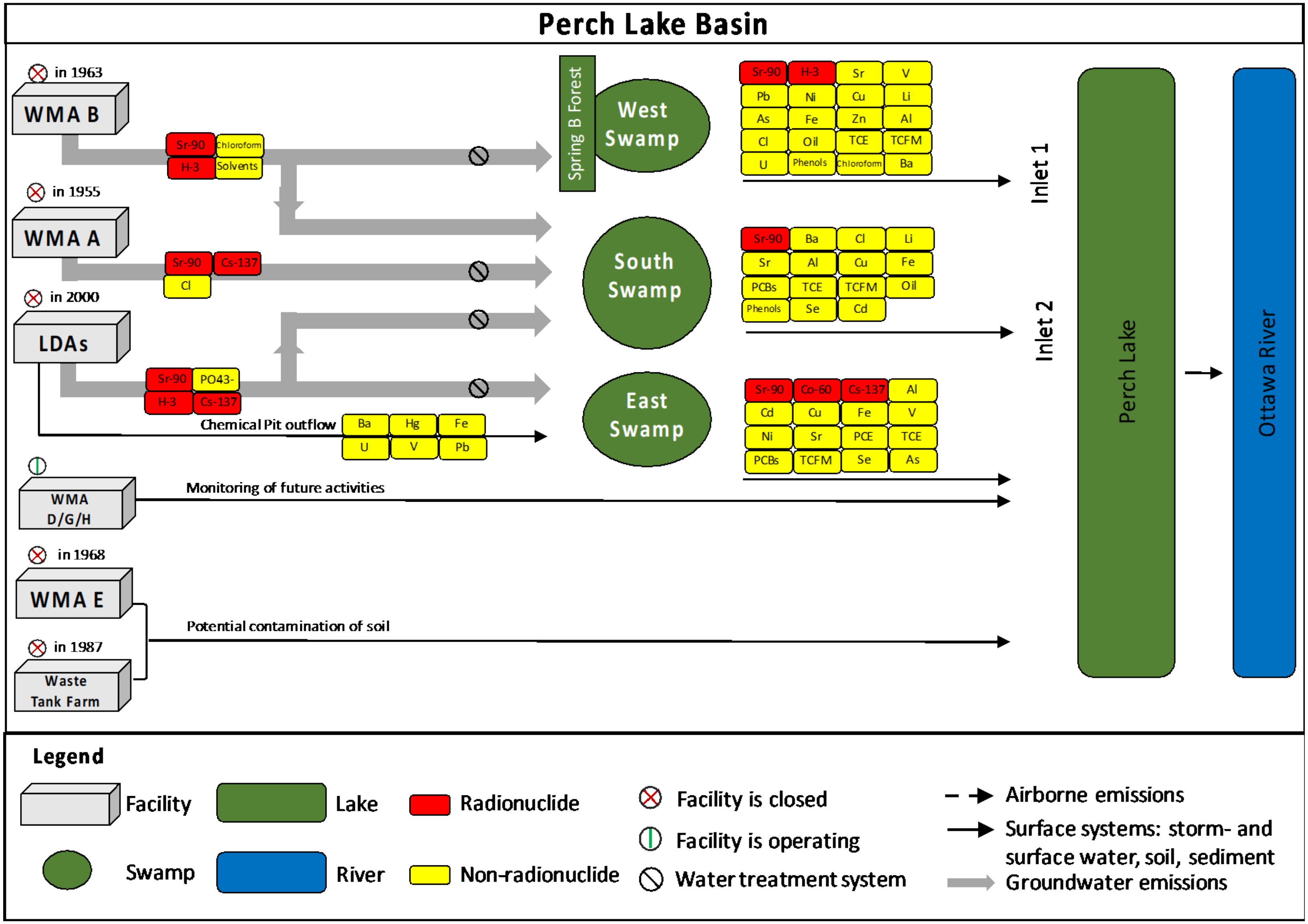

Figure 3. Schematic of potential source facilities of CRL within the Maskinonge Lake Basin prepared by the author of this study based on the Environmental Risk Assessment 2019.

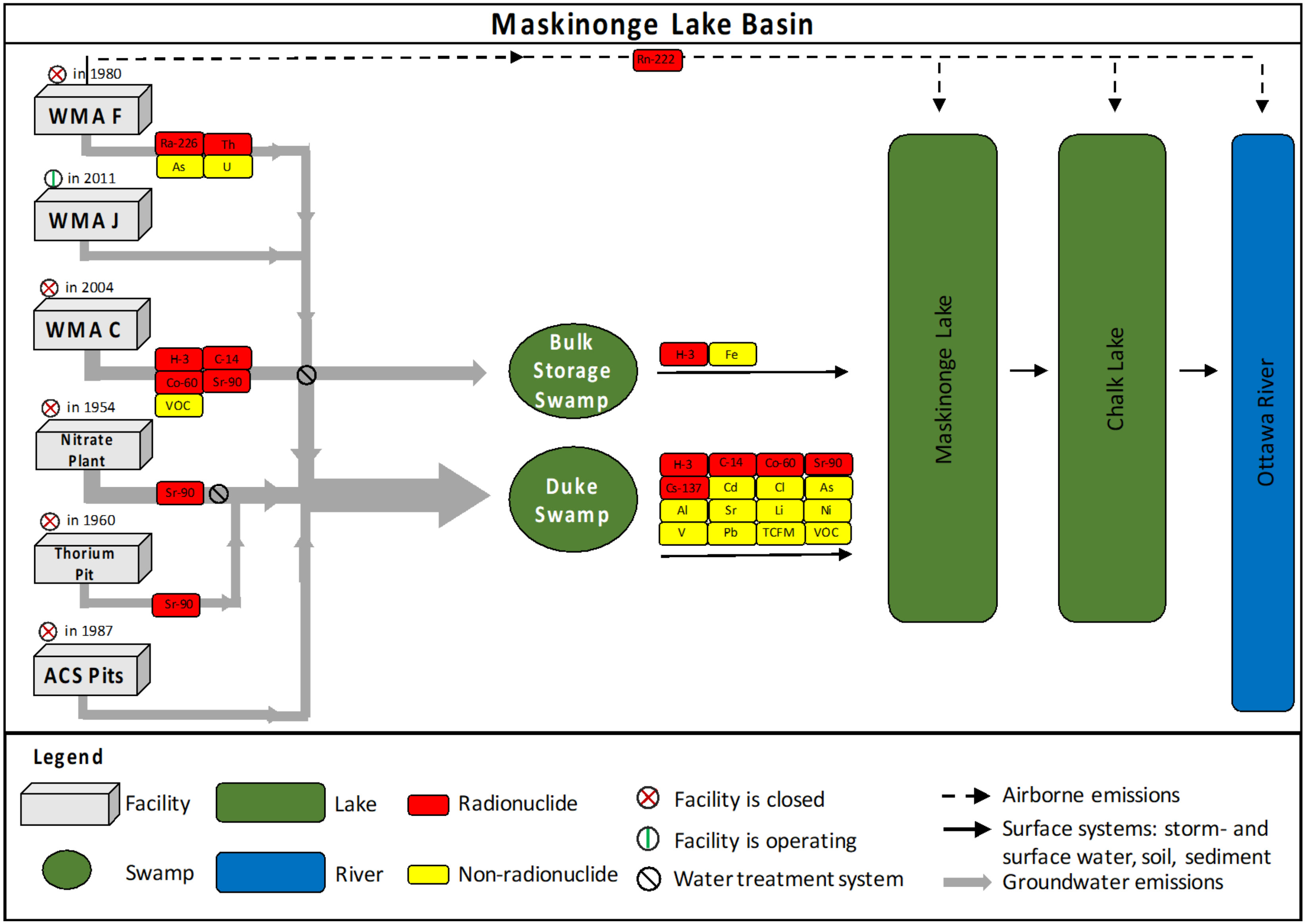

Figure 4. Schematic of potential source facilities of CRL within the Perch Lake Basin prepared by the author of this study based on the Environmental Risk Assessment 201