BWXT Nuclear Energy Canada Inc.

Environmental Risk Assessment

Peterborough Nuclear Fuel Assembly Operations

May 2023

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Peterborough Nuclear Fuel Assembly Operations

May 2023

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Executive Summary

The Peterborough Nuclear Fuel Assembly Operations (NFAO) is a Class IB nuclear facility operated by BWXT Nuclear Energy Canada Inc. (BWXT NEC). The NFAO produces uranium fuel bundles and conducts services work on contaminated equipment. The NFAO is located within the General Electric (GE) complex between Monaghan Road and Park Street North in Peterborough.

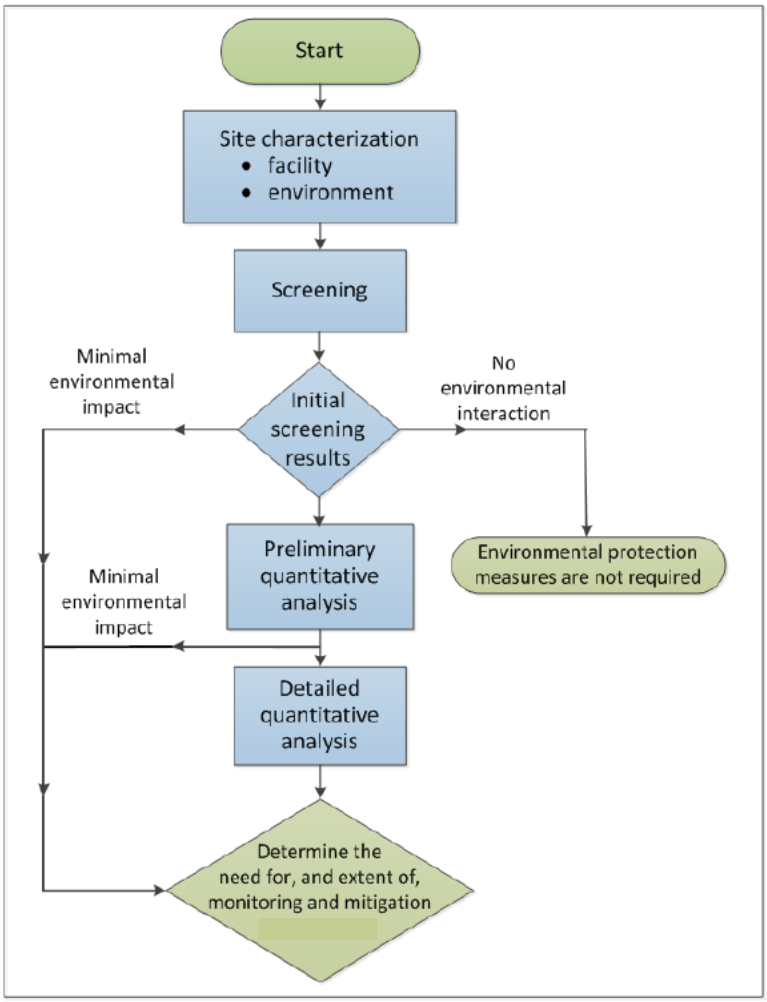
This report summarizes the Environmental Risk Assessment (ERA) for the facility required by the Canadian Nuclear Safety Commission (CNSC) *REGDOC-2.9.1: Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC, 2020).

REGDOC-2.9.1 outlines the requirements for a Class IB nuclear facility to conduct and update its ERA in accordance with CSA *N288.6:22, Environmental risk assessment at Class I nuclear facilities and uranium mines and mills* (CSA, 2022). CSA N288.6:22 requires an update to the ERA at least every five years and whenever significant change occurs in either the facility or activity. This ERA updates previous ERAs with current information, consistent with the CSA N288.6:22 requirement to review the ERA at least every five years to verify its applicability and update it, if the review indicates that an update is necessary.

An ERA is a systematic process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors in the environment associated with a facility (CSA, 2022). An ERA provides science-based information to support decision-making and to prioritize the implementation of mitigation measures. An ERA and its associated performance predictions serve as the basis for control and monitoring of releases, environmental monitoring, and any supplementary studies (CNSC, 2020).

Effectively, the ERA evaluates the contaminants that are released to the air and water from the facility to determine whether there is any potential for health effects to humans through a Human Health Risk Assessment (HHRA) or non-human biota through an Ecological Risk Assessment (EcoRA). The general methodology followed for both the human health and ecological risk assessments are defined by CSA *N288.6:22*. The iterative methodology outlined in CSA N288.6:22 and used in this ERA allows for the risk assessment to be refined in each iteration (or Tier) by removing conservatism. This methodology is illustrated in Figure ES-1.

Integral to this assessment is to understand how the contaminants from the NFAO enter the natural environment and interact with the Human and Ecological Receptors. Figure ES-2 and Figure ES-3 illustrate the potential pathways of contaminant exposure to humans and ecological receptors, respectively.



Source: (CNSC 2020)

Figure ES-1 ERA Methodology

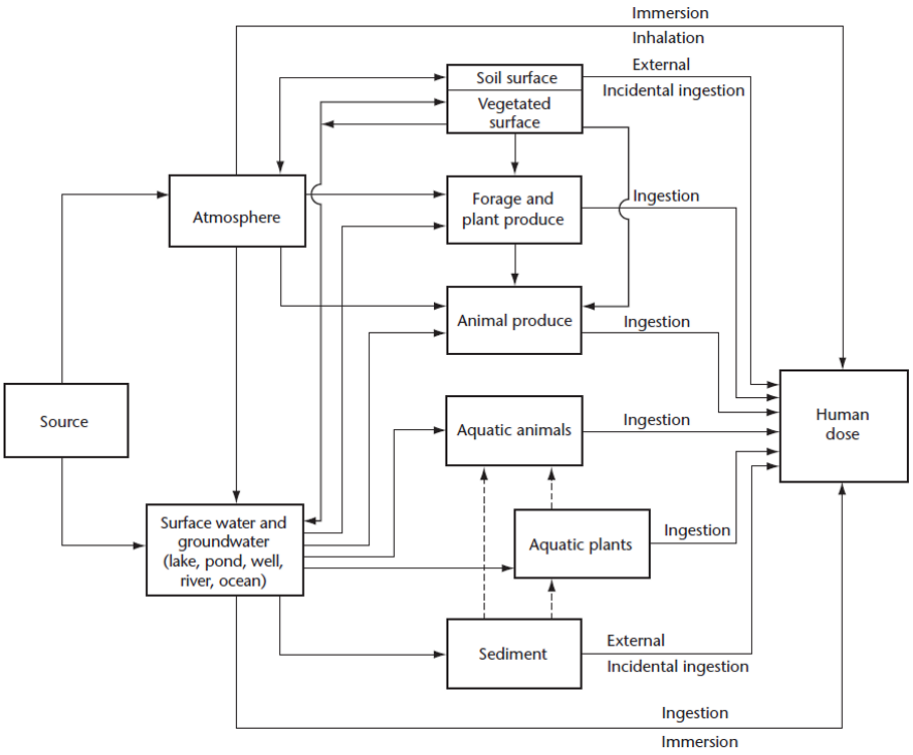
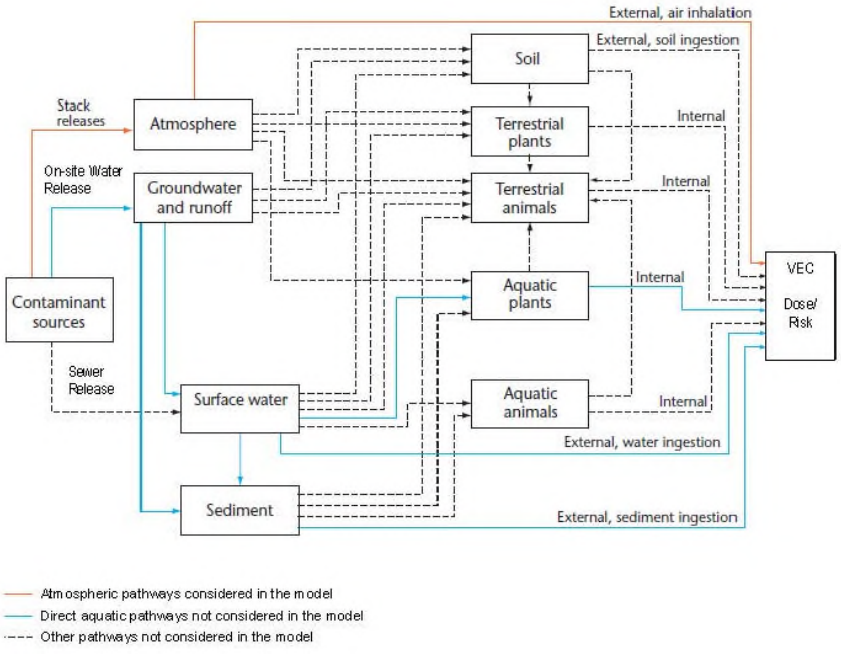


Figure ES-2 Sample Human Pathway Model (CSA 2022)



Source: (CSA 2022)

Figure ES-3 Sample Ecological Exposure Pathway Model

Once these pathways are understood, the Contaminants of Potential Concern (COPCs) need to be determined. COPCs is a list of all radiological and non-radiological contaminants released to air and water from facility operations. When contaminants are released in very small quantities, they are removed from further consideration. Also, if it is determined that the contaminants are not a concern from a human or ecological health perspective, they are removed from further consideration.

Emissions to Air

The principle radiological contaminant emissions of BWXT NEC operations are uranium and beryllium.

70% of non-negligible airborne non-radiological contaminants emitted from the NFAO had modelled air concentrations 10% or less of the applicable screening criteria and only 2 had modelled concentrations of 50% or more of the applicable screening criteria at 50% and 65%. Other than uranium, beryllium, and combustion sources, all other airborne sources were from low use, intermittent operations which were very conservatively modelled as operating continuously and are therefore highly overestimated. Furthermore, all non-radiological substances with CNSC licence limits, BWXT NEC *Action Levels* and BWXT NEC *Internal Control Levels* are currently and expected to remain well below these limits. Therefore, airborne emissions are expected to be negligible.

Emissions to Water

There are no surface water bodies present in the vicinity of the NFAO and there is minimal liquid effluent from the facility, therefore no measurable effects on surface water and sediment components are expected. For discharges to sewer, after passing through the municipal wastewater treatment plant, concentrations of uranium and beryllium attributable to plant operations are orders of magnitude below the Ontario Interim Provincial Water Quality Objective, the Canadian Environmental Quality Guideline for freshwater and the Ontario and Health Canada drinking water quality guideline for uranium and the Ontario Provincial Water Quality Objective and World Health Organization drinking water quality guideline for beryllium.

Human Health Risk Assessment

Since airborne contaminant emissions are well below applicable limits, no non-radiological airborne substances have been identified as COPCs for further assessment in the HHRA. Similarly, because contaminant emissions are well below applicable guidelines and criteria, no non-radiological waterborne substances have been identified as COPCs for further assessment.

The maximium estimated annual effective dose as a result of air releases and direct gamma exposure radiation from the BWXT NEC operation is expected to be on the order of 12 µSv/year. This dose represents 1.2% of the 1 mSv (1,000 µSv) per year effective dose limit to a member of the public and 5.8% of the 0.2 mSv (200 µSv) per year effective dose screening criterion for radiological releases to air and water. Therefore, it can be concluded that there will be no radiological effects to human health due to the operation of BWXT NEC, and no further assessment is required.

Noise was identified as a potential physical stressor for human health. The BWXT NEC operations comply with the Ministry of the Environment, Conservation and Parks (MECP) *Environmental Noise Guideline - Stationary and*

Transportation Sources - Approval and Planning (NPC-300) noise criteria, therefore, it is expected that noise levels from the facility pose no adverse effects to human health.

Ecological Risk Assessment

As for human health, because airborne and waterborne contaminant emissions are well below applicable guidelines and limits, no non-radiological substances have been identified as COPCs for further assessment in the EcoRA.

Radiation (external and internal) exposure due to uranium air emissions and water effluent are trivial. Only 0.002 to 0.004 g of uranium per year are emitted to air and 0.01 to 0.4 g of uranium per year are discharged to sewer from the NFAO. As a result, direct external exposure to gamma radiation is the only pathway for radiation exposure to Value Components (VCs). The resulting hazard quotient (HQ) of approximately 0.0019 (assuming continuous exposure at the maximum annual gamma radiation level measured, inclusive of background) is well below one, the value at which no adverse effects are likely as levels are below those that are known to cause adverse effects. Therefore, it can be concluded that there are no radiological effects to VCs due to the NFAO and no further assessment is required.

The NFAO is located in a highly urbanized area which limits the site-specific potential for physical stressors (road kill, heat, artificial night lighting or noise) to impact on VCs. As such, none of these stressors are particularly relevant to the NFAO and no further assessment is required.

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1 Introduction

1.1 Background

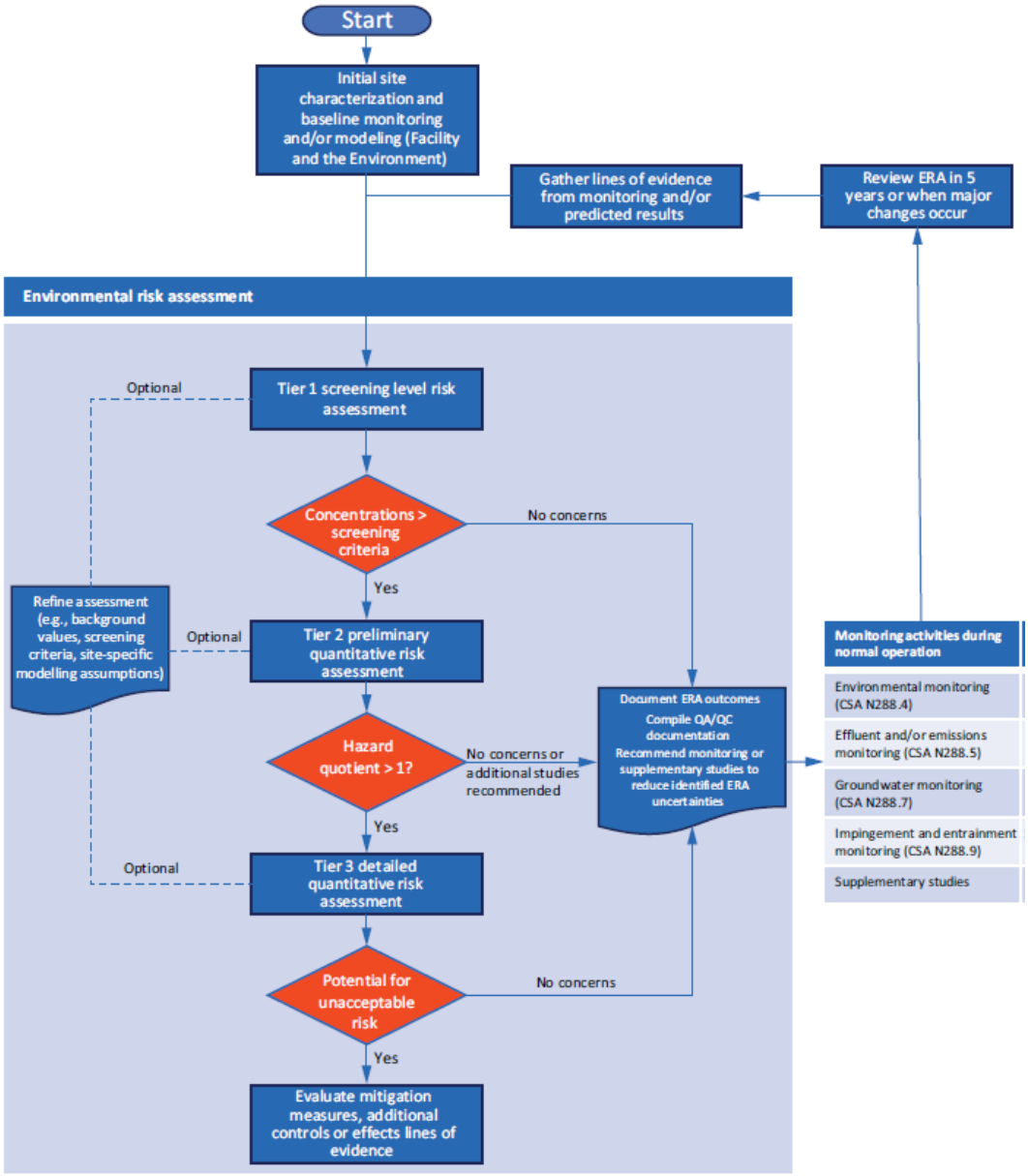
An Environmental Risk Assessment (ERA) is a systematic process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors (e.g., noise, artificial light) in the environment associated with a facility (CSA 2022). An ERA provides science-based information to support decision-making and to prioritize the implementation of mitigation measures. An ERA and its associated performance predictions serve as the basis for control and monitoring of releases, environmental monitoring, and any supplementary studies (CNSC 2020).

The Canadian Nuclear Safety Commission (CNSC) *REGDOC-2.9.1: Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC, 2020) outlines the requirements for a Class IB nuclear facility to complete and update an ERA. REGDOC-2.9.1 requires BWXT to conduct and update its ERA in accordance with *CSA N288.6:22, Environmental risk assessment at Class I nuclear facilities and uranium mines and mills* (CSA 2022).

In accordance with CSA N288.6:22, this ERA follows a tiered approach where risks that require more detailed consideration are identified and assessed in greater detail. CSA N288.6:22 recommends that the following tiers of assessment be conducted for the nuclear facilities, as appropriate:

- Tier 1 - Screening level risk assessment (SLRA): Within the context of a tiered approach to ERA, SLRA represents the less detailed lower tier and serves as the most conservative and broadest form of risk assessment. This first tier of assessment is broad in scope and serves to identify potential issues (receptors and stressors), using qualitative or quantitative methods (singly or in combination) that require further quantitative evaluation at a higher tier. If no such issues are identified, no further assessment is needed.
- Tier 2 - Preliminary quantitative risk assessment (PQRA): This second tier addresses the identified potential issues quantitatively, generally using available site data. A PQRA can be sufficient to eliminate some risk issues (receptors and stressors) as being of no concern, while others might require further investigation. The decision on whether to progress from a PQRA to a detailed quantitative risk assessment (DQRA) is based on the severity of estimated risks as well as the spatial and temporal extent of the risks. If minimal environmental effects have been identified through the PQRA process, refining risk further through the DQRA process is not necessary.
- Tier 3 - Detailed quantitative risk assessment (DQRA): This third tier addresses any issues that are still of concern after the PQRA. A DQRA focuses on risk issues that have been found through PQRA to require further investigation based on severity of estimated risks as well as the spatial and temporal extent of the risks. A DQRA can involve a refined (more realistic) exposure assessment and risk characterization, or can consider other lines of evidence (e.g., epidemiology or field studies of toxicity or population/community condition). It can use additional site-specific monitoring data or more sophisticated modelling to estimate more realistic exposure concentrations (CSA 2022).

This progression is illustrated at a high level in Figure 1-1. Specifically, the tasks identified in Table 1-1, as appropriate, should be performed in each tier.



(CSA 2022)

Figure 1-1 ERA Progression through Tiers of Assessment

Table 1-1 ERA Tasks by Tier

SLRA — Tier 1	PQRA — Tier 2	DQRA — Tier 3
Problem formulation • summarize site characterization results • select contaminants and physical stressors • select receptors and exposure pathways • define assessment and measurement endpoints (EcoRA) • develop conceptual model • compare screening levels to screening criteria		
Refine assessment (optional) • i.e., comparison to upper range of background values, use of alternate screening criteria	Exposure assessment • estimate exposure/dose for receptors at relevant locations for each COPC or physical stressor Toxicity/effects assessment • select TRVs/benchmarks for each receptor and COPC or physical stressor (if possible) Risk characterization • calculate HQs for each COPC or physical stressor (if possible) at relevant locations • calculate cancer risk for non-radiological carcinogens for human receptors (HHRA)	
	Refine assessment (optional) • i.e., use of more site-specific modelling assumptions • recommend additional studies, and/or continued monitoring for inclusion in next iteration of ERA	• refine exposure assessment and risk characterization • consider other available lines of evidence (e.g., epidemiology, field studies of toxicity or of population/community effects) • recommend further uncertainty reduction (e.g., supplementary studies), effects monitoring, and/or risk management (e.g., additional controls, mitigation measures) if applicable

Note: *Only issues (receptors or stressors) that remain of concern at the end of each assessment tier need to be considered further in the next assessment tier. Progression from Tier 2 to Tier 3 should be based on severity of estimated risks as well as the spatial and temporal extent of the risks.*

Source (CSA 2022)

1.2 Goals, Objectives, and Scope

As per CNSC's REGDOC-2.9.1, every Class IB nuclear facility applicant or licensee must have an ERA, commensurate with the scale and complexity of the environmental risks associated with the facility or activity. REGDOC-2.9.1 requires a licensee to review and revise the ERA in accordance with CSA N288.6:22, taking into consideration whether there has been:

- a significant change in the facility or activity that could alter the nature (type or magnitude) of the interactions with the environment (such as modification, expansion or refurbishment of the facility) within the ERA predictions; and
- any transition to a new phase in the lifecycle (such as a transition to licence to operate, decommission or abandon) where the application for the new licensing phase includes any interactions with the environment that were not previously captured in the ERA (CNSC 2020).

CSA N288.6:22 require an update to the ERA at least every five years and whenever significant change occurs in either the facility or activity.

This five year update to the 2018 ERA is being completed to update the ERA with current information, consistent with the CSA N288.6:22 requirement to review the ERA at least every five years to verify its applicability and update it, if the review indicates that an update it is necessary.

As per CSA N3288.6:22, the objectives of the ERA are to:

- evaluate the risk to relevant human and non-human biota receptors resulting from exposure to contaminants and stressors related to a site and its activities, and
- to recommend further action or assessment based on the results.

The scope of the ERA covers both human health risk assessment and ecological risk assessment. Human receptors are addressed through a human health risk assessment (HHRA) and non-human biota are addressed through an ecological risk assessment (EcoRA).

CSA N288.6:22, clause 0.2 notes that the nature and complexity of ERAs will vary according to the nature and complexity of the subject (site, scenario, magnitude, facility, etc.) and provides for a tiered approach to ERA. Where concerns are below a screening criteria, a Screening Level Risk Assessment (SLRA) is deemed adequate. Where concerns are noted, a Preliminary Quantitative Risk Assessment (PQRA) is required. If the PQRA identifies a hazard quotient[1], as defined in the Standard, greater than 1, a Detailed Quantitative Risk Assessment (DQRA) is required. Within the context of this tiered approach, compared to other nuclear fuel cycles facilities, the NFAO presents a relatively low human health and environmental risk profile.

[1] Hazard Quotient (HQ) is a numerical representation of the potential for effects due to exposure to a non-carcinogenic (threshold acting) contaminant or stressor. To calculate an HQ, some estimated exposure value (EV, usually a concentration or dose) is divided by a toxicological reference value (TRV) or benchmark value (BV) in the same units (CSA 2022).

1.3 Organization of Report

The ERA has been structured for consistency with Annex A of CSA N288.6:22. The report is structured as follows:

- Section 2.0: Site Characterization;
- Section 3.0: Human Health Risk Assessment;
- Section 4.0: Ecological Risk Assessment;
- Section 5.0: Conclusions and Recommendations;
- Section 6.0: Quality Assurance; and,
- Section 7.0: References.

2 Site Characterization

2.1 Engineered Site Facilities

NFAO is operated by BWXT NEC and is located on the General Electric (GE) plant complex between Monaghan Road and Park Street North in west-central Peterborough (See Figure 2-1 and Figure 2-2). The business address for BWXT NEC is 1160 Monaghan Road, Peterborough, Ontario K9J 0A8. The total plant complex is registered as Lots 14 to 17 and Lots 6 to 30 inclusive, of plan 30 North side of Albert Street, registered September 3, 1892.

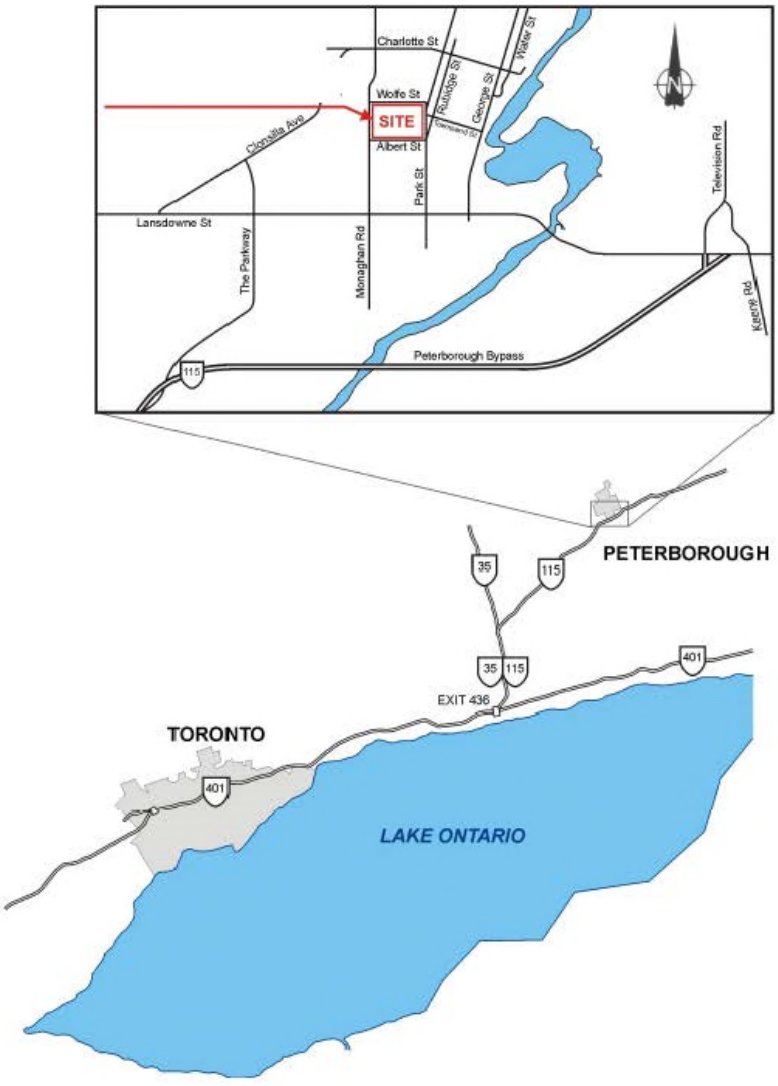


Figure 2-1 Location of the NFAO

2.1.1 BWXT NEC Buildings

Within the larger GE complex, NFAO occupies Buildings 21, 24, 26 and 28, which are leased from GE (see Figure 2-2 and, Figure 2-3). Other buildings in the GE complex are vacant or used as office space.

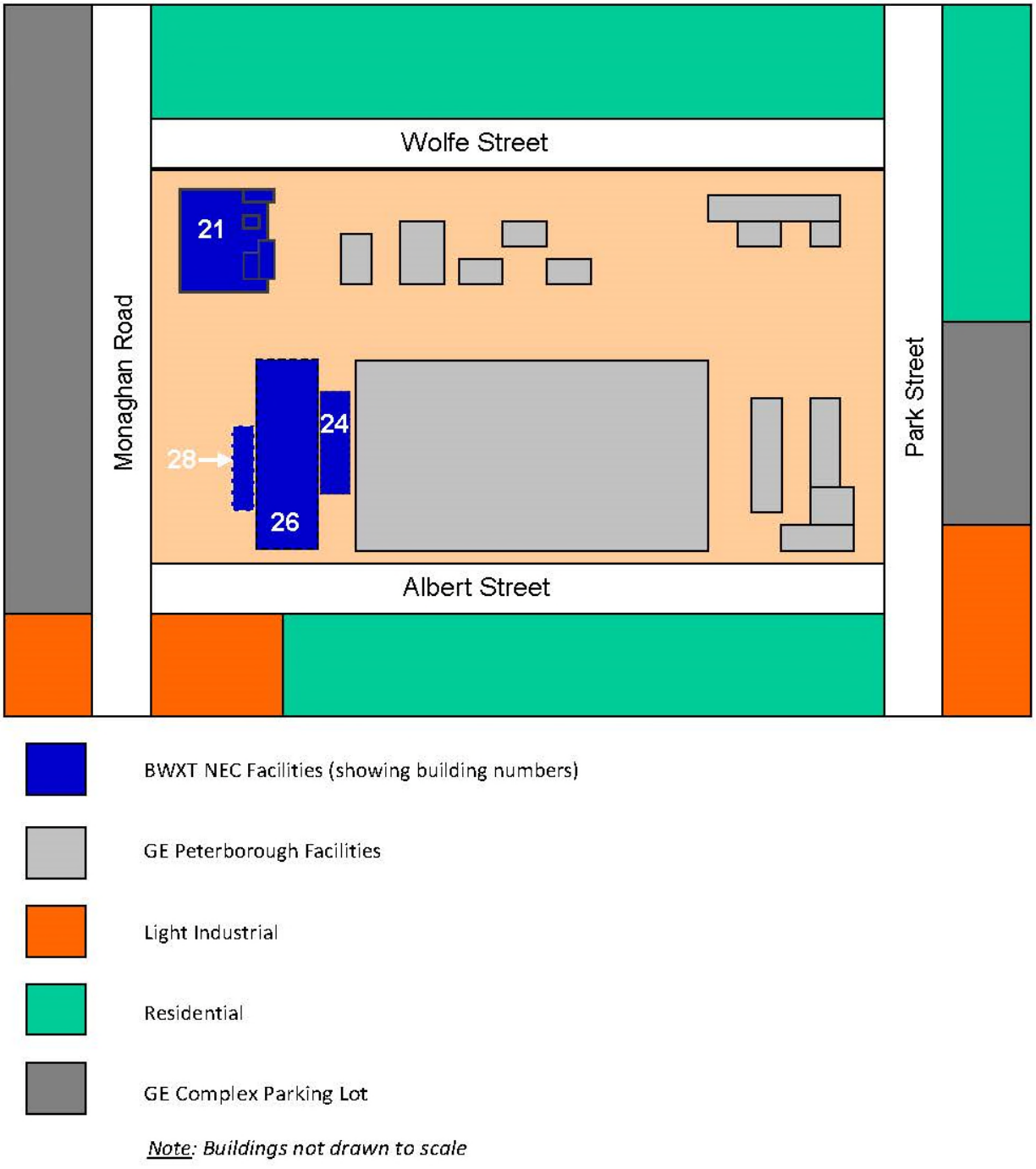


Figure 2-2 Site Plan of the NFAO

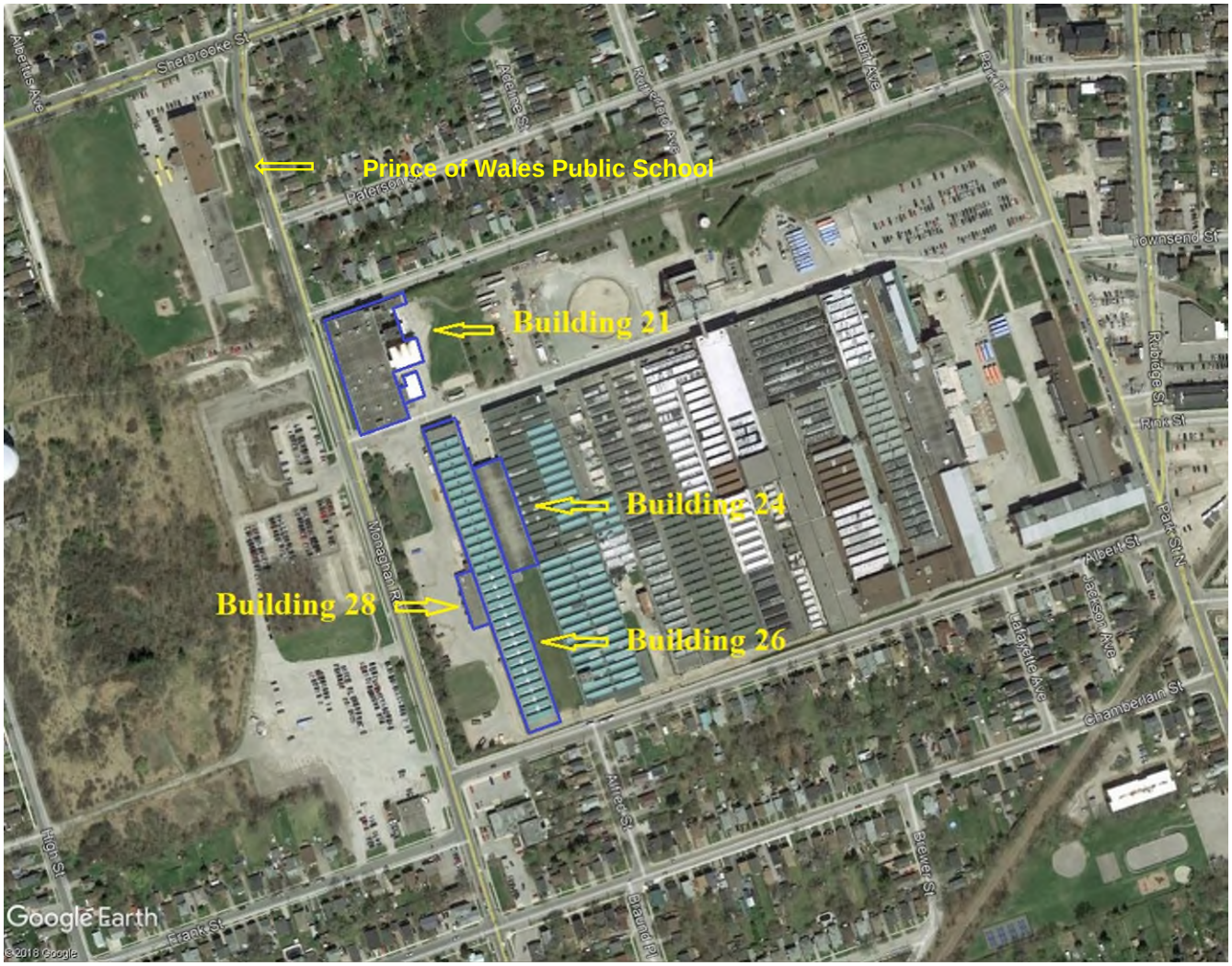


Figure 2-3 Aerial View of the NFAO and Surroundings

Building 21 is a two-floor brick and steel frame building. The first floor of Building 21 accommodates the fuel bundle ssembly which consists of uranium pellet storage, pellet sort & stack, pellet load, end cap weld, bundle assembly, test, inspection and pack. The second floor is occupied by offices.

Molybdenum (moly) targets are also manufactured in Building 21 for use in medical isotope production.

A Single Channel Hot Water Test Rig ("test rig") that simulates the hydraulic conditions of temperature, pressure, and flow in a single CANDU fuel channel is also located in Building 21.

Building 24 is a one floor warehouse used to store sealed radioactive materials including completed uranium fuel bundles, completed uranium fuel elements, drums of uranium dioxide (UO_2) powder, and contaminated equipment as required.

Building 26 is principally a conventional fabrication and assembly operation. It also houses manufacturing equipment and a facility for the repair of contaminated equipment. Contaminated equipment work can take place in any licenced area but typically takes place in Building 26.

Building 28 houses the main shipping and receiving docks for Building 26.

2.1.2 Basic Technical Characteristics

The NFAO is licensed to produce uranium fuel bundles and conduct services work on contaminated equipment from offsite nuclear facilities under Nuclear Fuel Facility Operating Licence FFOL-3620.00/2030. This facility can process both natural and depleted uranium dioxide pellets.

The fuel manufacturing operations involve the sorting & stacking of fuel pellets, loading of fuel pellets into Zircaloy tubes, sealing and welding of the tubes to produce fuel elements, and the assembly of the fuel elements into fuel bundles. The basic assembly process is described in Figure 2-4. Details of fuel bundle design vary by reactor. However, fuel bundles currently manufactured at BWXT NEC in Peterborough generally consist of 28 or 37 fuel elements.

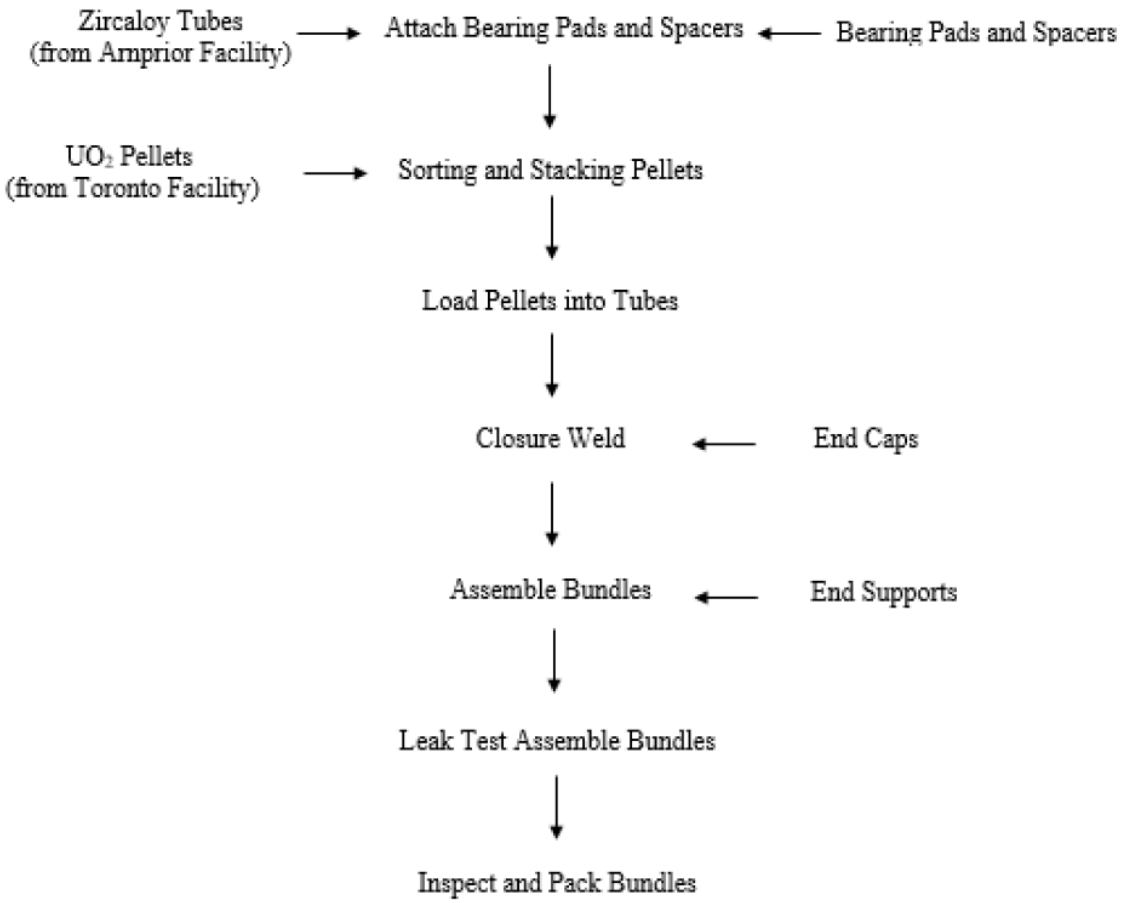


Figure 2-4 Natural Uranium Fuel Bundle Manufacturing Process (BWXT NEC 2022)

In addition, contaminated equipment from off-site nuclear facilities may be periodically received at the facility for repair and/or modification.

The facility is intended to operate over two, eight-hour shifts, five days per week, 47 weeks per year at a maximum monthly production rate 150 Megagrams (150 tonnes) of uranium, as specified in the Licence Condition Handbook. Effluent volumes and air emission rates are summarized in Section 2.2.10.

2.1.3 Uncertainties in Site Engineered Facilities

There are no substantive uncertainties in the understanding of the site engineered facilities. The fuel bundle manufacturing process and associated emissions are well established and understood.

2.2 Description of the Natural and Physical Environment

The natural and physical environment of NFAO and the surrounding area is described in this section.

2.2.1 General Description of Surrounding Area

NFAO is located within the GE Peterborough plant complex in west-central Peterborough. The facility is located in a mixed industrial, commercial and residential area. The nearest sensitive land uses are residences located on Residential (R) zoned land immediately north, south, and east of the Facility (see Figure 2-2 and Figure 2-3) and the Prince of Wales Public School located approximately 50 m to the northwest (see Figure 2-3).

2.2.2 Climate and Meteorology

Peterborough has a humid continental climate (according to the Köppen classification, Ontario Ministry of Agriculture, Food and Rural Affairs 2011) with large seasonal temperature differences, with warm to hot (and often humid) summers and cold (sometimes severely cold) winters. Further details are provided in section 2.2.2.2 below. Precipitation is usually well distributed through the year as discussed further in section 2.2.2.3 below. This climate is characterized by four different seasons and is greatly affected by the Great Lakes. Summers in Ontario are warm with several stretches of hot, humid and hazy weather. Fall brings mainly warm sun-filled days and cool temperatures at night. Winters can last anywhere from three to five months whereas spring is the shortest season of the year.

Ontario is located across one of North America's major storm tracks. As a result, when high and low-pressure systems move over the area they bring great variation in the day-to-day weather. The majority of weather systems travel through the province every two to five days during the year. Periods of active weather rarely last long.

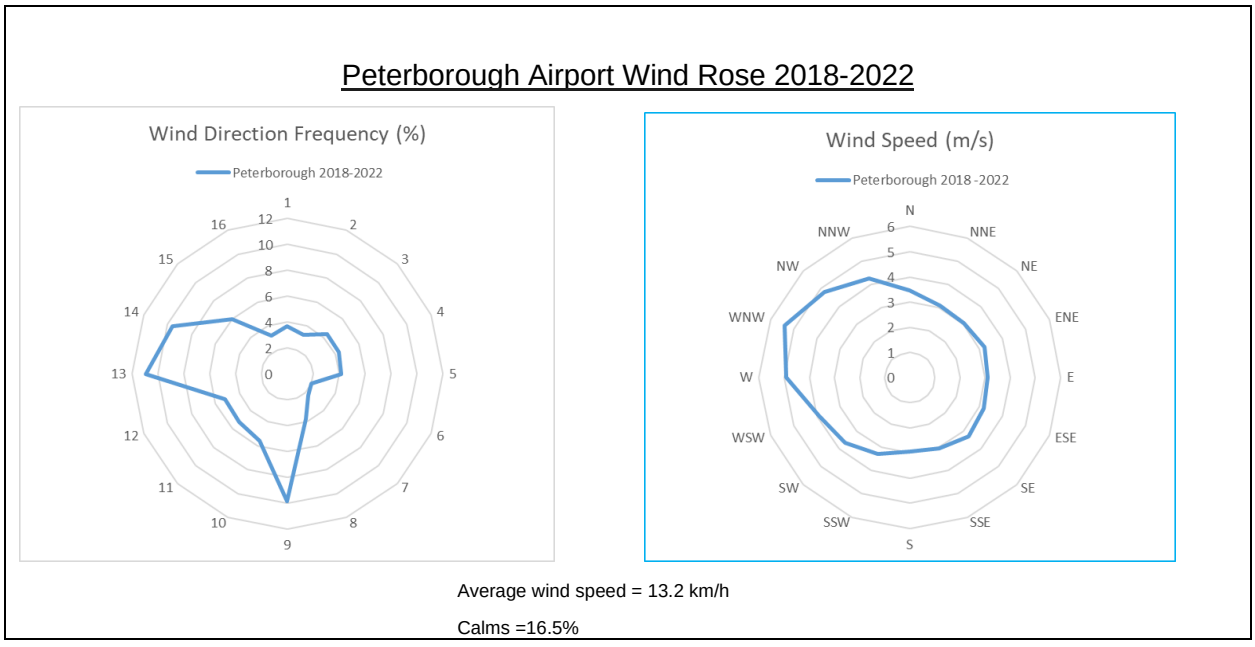
The long-term climate conditions in the region are described by the Environment and Climate Change Canada (ECCC) 30-year climate data normals from the Peterborough Airport climate station for the period from 1981 to 2010 (the most recent period available) (ECCC 2022a). The local meteorology near the NFAO, as described below, is characterized by the surface meteorological data collected from the ECCC Peterborough climate station, for the period from 2018 to 2022.

2.2.2.1 Wind

Table 2-1 summarizes the wind speed and wind direction for the 30-year period from 1981 to 2010 at the Peterborough Airport climate station. Wind direction is reported as the direction from which the wind blows and is based on surface (i.e. 10 m) observations. The most frequent wind recorded at Peterborough Airport climate station in the period 1981 to 2010 was from the west, with average annual wind speed of 10.6 km/h. The maximum hourly wind speed was in the range from 42 km/h (from the SE recorded in July) to 70 km/h (from the W recorded in April).

Figure 2-5 presents the frequency distribution of hourly surface wind speed and direction at the Peterborough station in the period from 2018 to 2022 in the form of a wind rose (ECCC 2022b). The prevailing annual wind direction was from the west (10.9% of the time), consistent with the dominant westerly wind in the climate normals. The average wind speed was 13.2 km/h. Calm wind conditions were observed 16.5% of the time.

Direction and speed of the wind dictates the location and distance from the source that a pollutant may travel.



Note: Wind directions shown are winds "blowing from".

Figure 2-5 Wind Rose

2.2.2.2 Temperature

Thirty-year temperature normals, which are normally updated by ECCC every ten years, are provided in Table 2-2 for the period 1981 to 2010, for the Peterborough Airport station (ECCC 2022a). Mean daily temperatures were below 0°C from December through March and ranged from 19.6°C in July to -8.5°C in January. The mean daily temperature is 6.2°C. The mean daily maximum temperature was in the range from a high of 26.4°C in July to a low of -3.2°C in January for the 1981 to 2010 period. The mean daily minimum temperature ranged from 12.8°C in July

to -13.7ºC in January between 1981 and 2010. For this 30-year period, the extreme temperature ranged from a maximum of 36.2ºC in August to a low of –37.9ºC in January.

Local temperature data for the most recent period of 2018 to 2022 were collected from the ECCC meteorological station at Peterborough (ECCC 2022b) and are summarized in Table 2-4. Mean daily temperatures were below 0ºC from December through March and ranged from 20.5ºC in July to -8.1ºC in January. The mean daily temperature was 6.8ºC. The mean daily maximum temperature was in the range from a high of 27.5ºC in July to a low of -2.7ºC in January for the 5-year period 2018 to 2022. The mean daily minimum temperature ranged from 13.5ºC in July to -13.4ºC in January between 2018 and 2022. For this 5-year period, the extreme temperature ranged from a maximum of 33.8ºC in July to a low of –34.1ºC in January. Figure 2-6 presents mean, mean maximum and mean minimum monthly temperatures for the period 2018 to 2022. For comparison, the average daily temperature climate normal is presented in the same figure. The temperature data from the recent 5-year period are generally consistent with the temperature climate normals.

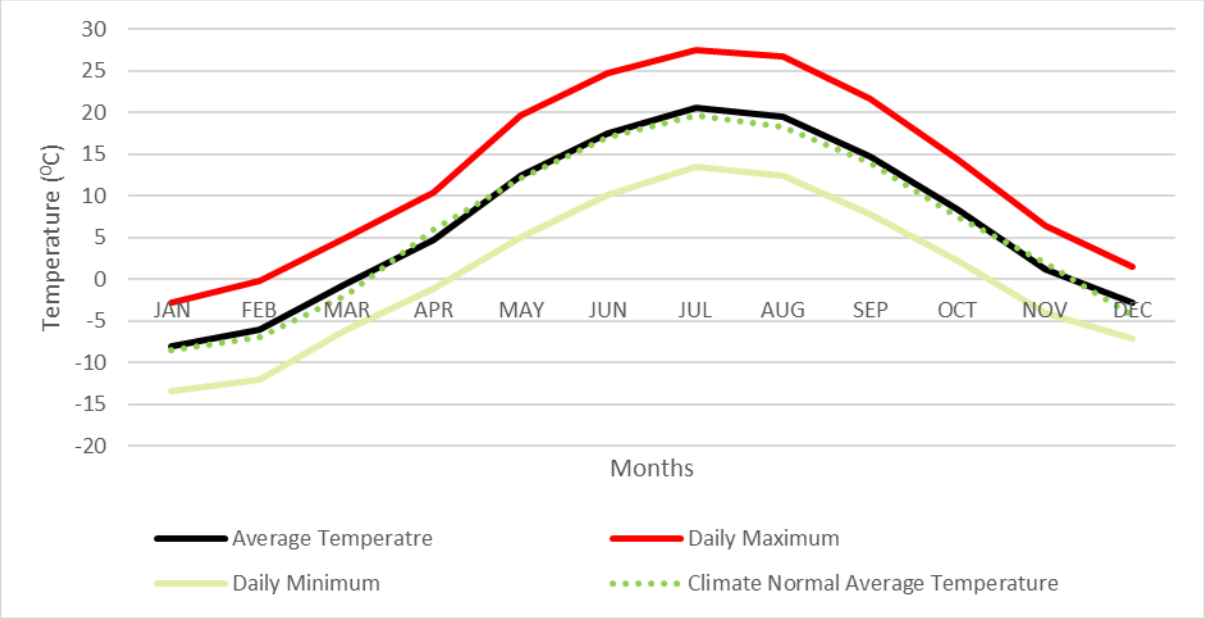


Figure 2-6 Average Monthly Temperatures at the Peterborough Meteorological Station (2018 - 2022)

The combination of low temperature and wind can produce a chilling effect experienced by the human body that is much greater than the actual measured temperature. Based on the Climate Normals (1981 to 2010) the lowest wind chill in Peterborough was calculated to be –44.5°C in February (see Table 2-3).

2.2.2.3 Precipitation

Table 2-5 summarizes the thirty-year precipitation normals for the Peterborough Airport station for the 1981 to 2010 period (ECCC 2022a). The average annual precipitation measured within 30-year period was 855.3 mm, with approximately 83% of the total annual precipitation falling as rain. The highest mean monthly rainfall was in September (84.5 mm), while the greatest rainfall in a 24-hour period occurred in July (83.8 mm). The highest mean

monthly snowfall was in January (40 cm), while the greatest snowfall in a 24-hour period occurred in February (33.2 cm). An extreme snow depth of 71 cm for the period from 1981 to 2010 was recorded in March.

Local precipitation data are available from daily data collected from the Peterborough meteorological station in the form of total precipitation (i.e., individual rain and snowfall data were not available). Total precipitation data for the 5-year period 2018 to 2022 are summarized in Table 2-6 and presented in Figure 2-7. The annual total precipitation over the 5-year period 2018 to 2022 was 685.3 mm, or 80% of the total precipitation climate normal. Monthly precipitation averages ranged from 34.1 mm in February to 75.4 mm in April.

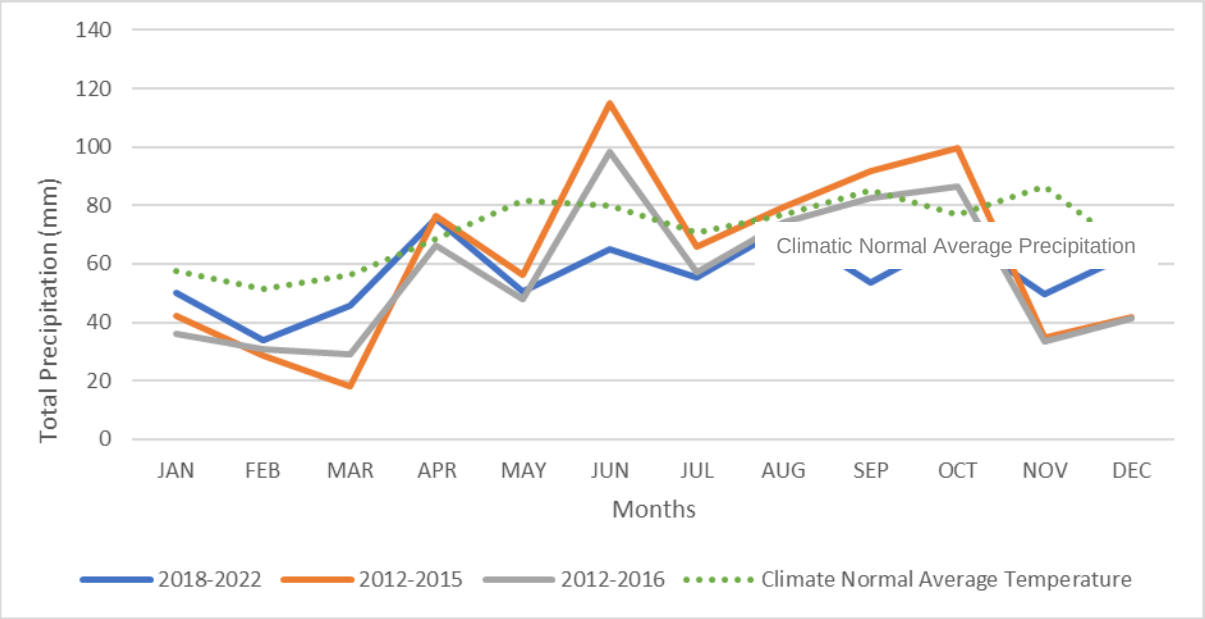


Figure 2-7 Total Monthly Precipitation at the Peterborough Meteorological Station (2018 - 2022)

Table 2-1 Wind Climate Normals, Peterborough A, Ontario, 1981 to 2010

Wind	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Speed (km/h)	12.3	11.7	12.2	12.6	11	9.7	8.8	7.7	8.4	9.8	11.6	11.7	10.6
Most Frequent Direction	W	W	W	W	W	W	W	W	W	W	W	W	W
Maximum Hourly Speed (km/h)	64	69	58	70	52	52	42	46	52	56	63	63	70
Direction of Maximum Hourly Speed	W	SW	SW	W	SW	SW	SE	S	W	SW	W	W	W
Maximum Gust Speed (km/h)	100	87	117	101	109	104	98	133	89	89	100	104	133
Direction of Maximum Gust	N	W	W	W	SW	W	NW	SW	W	W	SW	SW	SW

Source (ECCC, 2022a)

Table 2-2 Temperature Climate Normals, Peterborough A, Ontario, 1981 to 2010

Temperature	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Daily Average (°C)	-8.5	-7	-1.8	5.9	12.1	17	19.6	18.3	13.9	7.5	1.9	-4.4	6.2
Standard Deviation	3.6	2.6	2.1	1.5	1.7	1.4	**1.3**	1.3	1.3	1.2	1.5	3.2	1
Daily Maximum (°C)	-3.2	-1.4	3.7	11.7	18.6	23.6	26.4	25.2	20.6	13.4	6.4	0.2	12.1
Daily Minimum (°C)	-13.7	-12.5	-7.3	0.1	5.6	10.4	12.8	11.4	7.2	1.5	-2.6	-8.9	0.3
Extreme Maximum (°C)	12.2	12.5	24.3	29.7	32.5	34.4	36.1	**36.2**	33.9	28.9	22.8	19.2	36.2
Extreme Minimum (°C)	**-37.9**	-37.8	-31.4	-15	-7.7	-0.7	3.5	0	-6.3	-9.4	-19.2	-33.9	-37.9

Note: Bolded values represent the extreme temperature conditions

Source (ECCC, 2022a)

Table 2-3 Wind Chill Climate Normals, Peterborough A, Ontario, 1981 to 2010

Wind Chill	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Extreme Wind Chill	-44.2	-44.5	-35.4	-22.3	-7.2	0	0	0	-3.9	-13.3	-23.3	-37.8	-44.5

Source (ECCC, 2022a)

Table 2-4 Temperature Data, Peterborough, Ontario 2018 - 2022

Temperature	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Daily Average (°C)	-8.1	-6.0	-0.5	4.7	12.4	17.5	20.5	19.6	14.7	8.4	1.3	-2.7	6.8
Mean Daily Maximum (°C)	-2.7	-0.1	5.1	10.4	19.7	24.7	27.5	26.7	21.7	14.4	6.4	1.6	12.9
Mean Daily Minimum (°C)	-13.4	-11.9	-6.1	-1.1	5.1	10.2	13.5	12.4	7.8	2.3	-3.9	-7.1	0.6
Extreme Maximum (°C)	12.0	13.1	18.9	24.3	31.4	33.6	33.8	33.3	31.7	28.9	22.9	16.1	33.8
Extreme Minimum (°C)	-34.1	-28.3	-23.2	-10.8	-5.0	1.2	6.5	5.0	-3.1	-9.9	-22.9	-21.4	-34.1

Source (ECCC, 2022b)

Table 2-5 Precipitation Climate Normals, Peterborough A, Ontario, 1981 to 2010

Precipitation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Rainfall (mm)	24.5	24.7	30.8	60.5	81.4	79.9	70.6	77	**84.5**	75.2	71.7	31.8	712.5
Snowfall (cm)	**40.0**	29.2	24.6	6.7	0	0	0	0	0	1.4	15.2	34	151.2
Precipitation (mm)	57.4	51.5	56.1	68.6	81.5	79.9	70.6	77	85.3	76.9	**86.4**	64.2	855.3
Average Snow Depth (cm)	14	**16**	8	0	0	0	0	0	0	0	1	6	4
Median Snow Depth (cm)	13	**16**	8	0	0	0	0	0	0	0	0	5	4
Snow Depth at Month-end (cm)	**17**	13	1	0	0	0	0	0	0	0	1	9	3
Extreme Daily Rainfall (mm)	43.2	35.4	59.8	46.7	50.6	56.6	**83.8**	70	52.8	42.6	55.6	37.2	83.8
Extreme Daily Snowfall (cm)	20.7	**33.2**	22.4	16.8	1.5	0	0	0	0	10.4	17	33.2	33.2
Extreme Daily Precipitation (mm)	43.2	35.4	61.3	46.7	50.6	56.6	**83.8**	70	52.8	42.6	55.6	41	83.8
Extreme Snow Depth (cm)	61	70	**71**	38	0	0	0	0	0	7	25	64	71

Note: Bolded values represent the extreme precipitation conditions.
Source (ECCC, 2022a)

Table 2-6 Total Precipitation Means, Peterborough, Ontario, 2018 - 2022

Precipitation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2018 - 2022 Total Precipitation (mm)	50.2	34.1	45.6	75.4	50.4	65.2	55.5	72.4	53.5	69.8	49.7	63.5	685.3

Source (ECCC, 2022b)

2.2.3 Geology

Peterborough County is noted for its many drumlins, with the city of Peterborough occupying the geographic center of the drumlin field. The Peterborough drumlin field is composed of streamlined landforms of 1.5 kilometre in length, 400 meters or less in width and 25 meters in height. The dominant drumlin orientation is southwest to northeast. The drumlins are predominately spindle shaped in the Peterborough area and towards the east; whereas, south of Rice Lake they are more oval. The drumlins are composed of highly calcareous glacial till containing great quantities of angular limestone and Precambrian materials.

The bedrock in the area is originally composed of the Middle Ordovician-aged Verulam Formation. The Verulam Formation consists of relatively soft, fossiliferous to argillaceous limestone with layers of calcareous shale. The overburden in the area is part of an extensive till plain that has been drumlinized. The till consists of unsorted sand, silt and gravel, and typically contains high amount of fines.

Peterborough was originally built over seven drumlins, but has since continued to develop over several more. The rock underlying this region is limestone of the Lindsay and Verulam Formations. While drumlins are the most striking features of the plain, in respect to soils they are not as important as the deposits of clay, which lie between the drumlins. The site of the NFAO lies on such a deposit of clay. Due to the presence of multiple drumlins in the area, land use is influenced by stoniness, steep slopes, and wet swampy hollows, all characteristics of drumlins.

The overburden consists of glacial, glaciofluvial, and glaciolacustrine deposits of Pleistocene age and fluvial and organic deposits of Recent age. In general, the soils of the area belong to the Grey Brown Luvisolic group (Chapman and Putnam 1984). Soil profiles are often shallow and the content of the till is high in limestone since it is underlain by carbonate-rich, Palaeozoic bedrock (Chapman and Putnam 1984). Associated with the Otonabee River is the Otonabee loam, which lacks the distinct brownish grey, leached layer of the Luvisolic soils of the general area. It is a dark brown, clayey, nut-structured horizon under the surface (Chapman and Putnam 1984).

Based on Ontario groundwater well records (wells 7036280, 7048133, 7104323, 7188020, 7333140, 7336653, and 7365207) the site and surrounding area is characterized by fill or sand near surface. Sand was noted to extend from near surface to approximately 3 to 4.5 m below surface. Silt was noted in some wells 3 to 4.7 m below surface. Wells in the area are test holes or observation wells. with no wells developed below 6 m (MECP 2021a). Further characterization of the soil setting was not included in this assessment as there is not a groundwater pathway for contaminants release from the site (see Section 3.1.4).

2.2.4 Groundwater

The NFAO does not use any groundwater, with water needs met by the City of Peterborough municipal water system. There are no active groundwater extraction wells on or within 0.5 km of the site. There are no known or suspected groundwater contamination plumes or subsurface contamination attributable to the NFAO, either on- or off-site. As such, detailed information on subsurface utilities and infrastructure is not required for the purpose of risk assessment.

The entire drainage system in Peterborough County is part of the Trent River system, connected by a chain of lakes and rivers including, Pigeon, Buckhorn, Stony and Rice and Little lakes and the Otonabee River. These basins retain large quantities of water which aids in maintaining groundwater levels in the area.

Regionally, groundwater flow is to the southeast towards the Otonabee River. Groundwater elevation varies from 250 metres above sea level (masl) to around 210 masl at the Otonabee River. Based on the wells in proximity to the site, with groundwater information (e.g., wells 7036280, 7333140 and 7336653), the depth to groundwater was between 1.5 to 3.6 m, with some wells not encountering any groundwater (MECP 2021a).

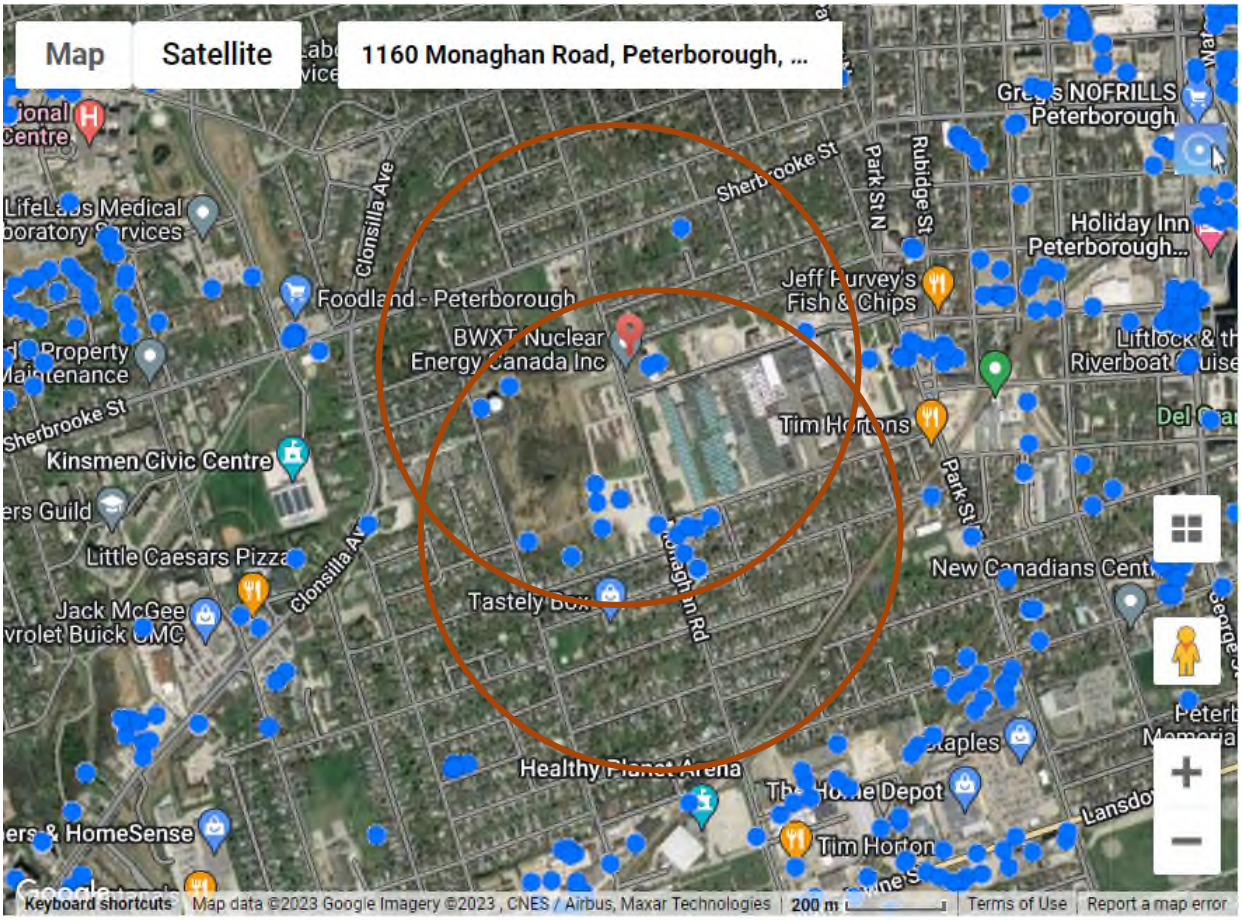
Figure 2-8 identifies groundwater wells located within a 0.5 km radius of BWXT NEC facility. Within this radius, all wells were identified as being observation wells. There are no active groundwater extraction wells on site or within 0.5 km of the site (MECP 2021a).

The NFAO does not use any groundwater. Water needs met by the City of Peterborough municipal water system.

The Provincial Groundwater Monitoring Network (PGMN) assesses current groundwater conditions and provides a warning system for changes in water levels and water quality. PGMN Well ID: W0000225-1, shown in Figure 2-9 and located in concession 4, lot 5 of South Monaghan Township is the closest representative PGMN monitoring location with on-going monitoring (MECP 2022a). Table 2-7 uranium and beryllium sample data from 2003-2020 show maximum levels of 0.155 ppb and 0.01 ppb respectively, with concentrations of both uranium and beryllium being detected at 0 ppb since 2009.

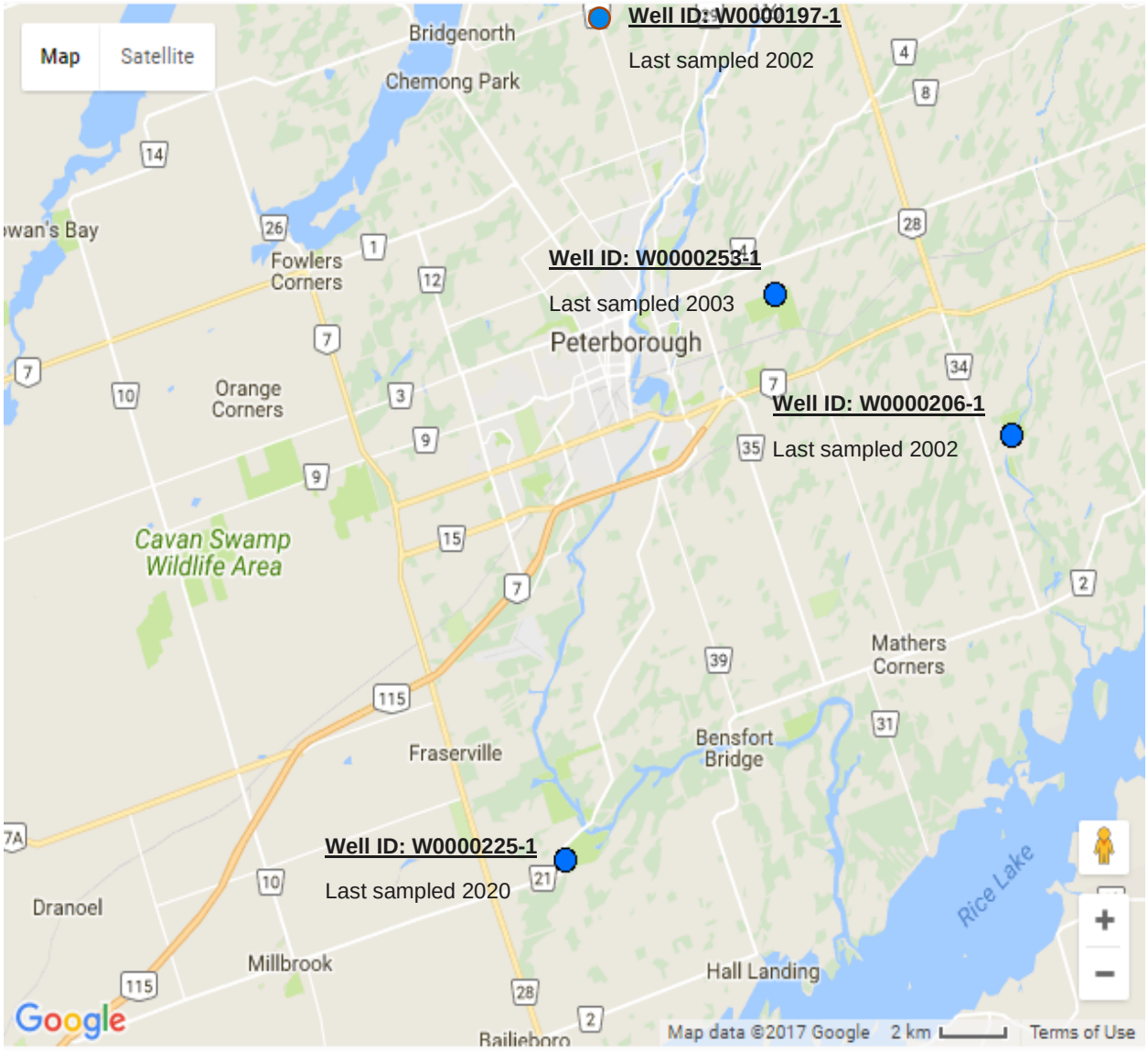
There are no known or suspected groundwater contamination plumes or subsurface contamination attributable to the operations, either on- or off-site. Groundwater water concentrations are low and associated with natural background.

As such, detailed information on subsurface utilities and infrastructure is not required for the purpose of risk assessment.



Source: (MECP 2021a)

Figure 2-8 Groundwater Wells Around the NFAO



Source: MECP 2022a

Figure 2-9 Provincial Groundwater Monitoring Network Wells (PGMN) in Peterborough

Table 2-7 Groundwater Quality Data - PGMN Well IDs W0000225-1

Parameter Name	Sample Date	Value	Units	Qualifiers
PGMN_WELL W0000225-1				
Beryllium	2003-08-13	0.01	µg/L	+/-0.05
	2006-10-11		µg/L	<
	2007-10-11		µg/L	<
	2008-09-12	0.01	µg/L	+/-0.05
	2009-10-16	0	µg/L	+/-0.25
	2010-10-15	0	µg/L	+/-0.25
	2011-10-18	0	µg/L	+/-0.25
	2012-10-16	0	µg/L	+/-0.20
	2013-10-22	0	µg/L	+/-0.20
	2014-10-28	0	µg/L	+/-0.20
	2015-10-26	0	µg/L	+/-0.20
	2016-10-25	0	µg/L	+/-0.20
	2017-09-27	0	µg/L	+/-0.20
	2018-10-30	0	µg/L	+/-0.20
	2019-11-13	0	µg/L	+/-0.17
	2020-03-11	0	µg/L	+/-0.17
Uranium	2003-08-13	0.01	µg/L	+/-0.05
	2006-10-11		µg/L	<0.02
	2007-10-11	0.155	µg/L	N/A
	2008-09-12	0.01	µg/L	+/-0.05
	2009-10-16	0	µg/L	+/-0.18
	2010-10-15	0	µg/L	+/-0.18
	2011-10-18	0	µg/L	+/-0.18
	2012-10-16	0	µg/L	+/-0.20
	2013-10-22	0	µg/L	+/-0.20
	2014-10-28	0	µg/L	+/-0.20
	2015-10-26	0	µg/L	+/-0.20
	2016-10-25	0	µg/L	+/-0.20
	2017-09-27	0	µg/L	+/-0.20
	2018-10-30	0	µg/L	+/-0.20
	2019-11-13	0	µg/L	+/-0.17
	2020-03-11	0	µg/L	+/-0.17

Source: MECP 2022a

2.2.5 Surface Water

Surface water concentrations are considered in the range of natural background and low compared to water quality guidelines. Uranium and beryllium concentrations are well below their drinking water guidelines.

The GE complex is entirely industrial with no surface water features. The immediately adjacent land to the GE complex is mostly a developed urban area with no surface water features. The NFAO does not directly use surface water, with water needs met by the City of Peterborough municipal water system which extracts and treats water from the Otonabee River. The nearest surface water body to the facility is the Otonabee River, located approximately 1 km to the east of the facility.

BWXT NEC is located within a drainage system that is part of the Trent River system, connected by a chain of lakes and rivers including, Pigeon, Buckhorn, Stony, Rice and Little lakes and the Otonabee River. BWXT NEC is located at the southern portion of a subcatchment lying south of Jackson Creek which flows into the Otonabee River. Stormwater runoff from the subcatchment is generally directed towards the south-east corner of the subcatchment.

Within approximately two kilometres from the BWXT NEC, the valley areas, all associated ravines, valleys and stream corridors of their primary tributaries include the following:

- Jackson Creek;
- Otonabee River;
- Trent Canal;
- Little Lake.

These surface water features are all part of the same watershed. This watershed is that of the Otonabee River, which covers an area of 1951 km^2 and extends over eight municipalities. The Otonabee Watershed contains several physiographic regions and features including the Oak Ridges Moraine, Peterborough Drumlin Field, Canadian Shield and Kawartha Lakes making it a very diverse watershed. This river is part of the Trent-Severn Waterway (Trent Canal).

In the vicinity of the NFAO, there are three surface water monitoring stations. These stations are part of the Provincial Water Quality Monitoring Network coordinated by the MECP. Water quality indicators used to screen overall water quality include temperature, pH, conductivity, turbidity, suspended solids, major ions, nutrients, metals and pesticides.

A drainage system analysis (UMA 2005) of the City of Peterborough's storm sewer system capacity notes that during heavy rainfall, all stormwater runoff in subcatchment area around the facility may not flow into the storm sewer system. Overland flow paths for the 100-year storm event were modeled to occur along Park Street North.

Due to the high impervious coverage of the NFAO site (i.e., parking lots, buildings and roads), stormwater runoff currently flows from north to south and from west to east via overland sheet flow and through an internal network of stormwater collection sewers. Stormwater is then conveyed from the corner of Albert Street and Park Street North to the City of Peterborough's trunk sewers, which flows approximately 500 m eastwards to Little Lake. Drainage from Little Lake flows southwards via the Otonabee River, eventually discharging to Rice Lake.

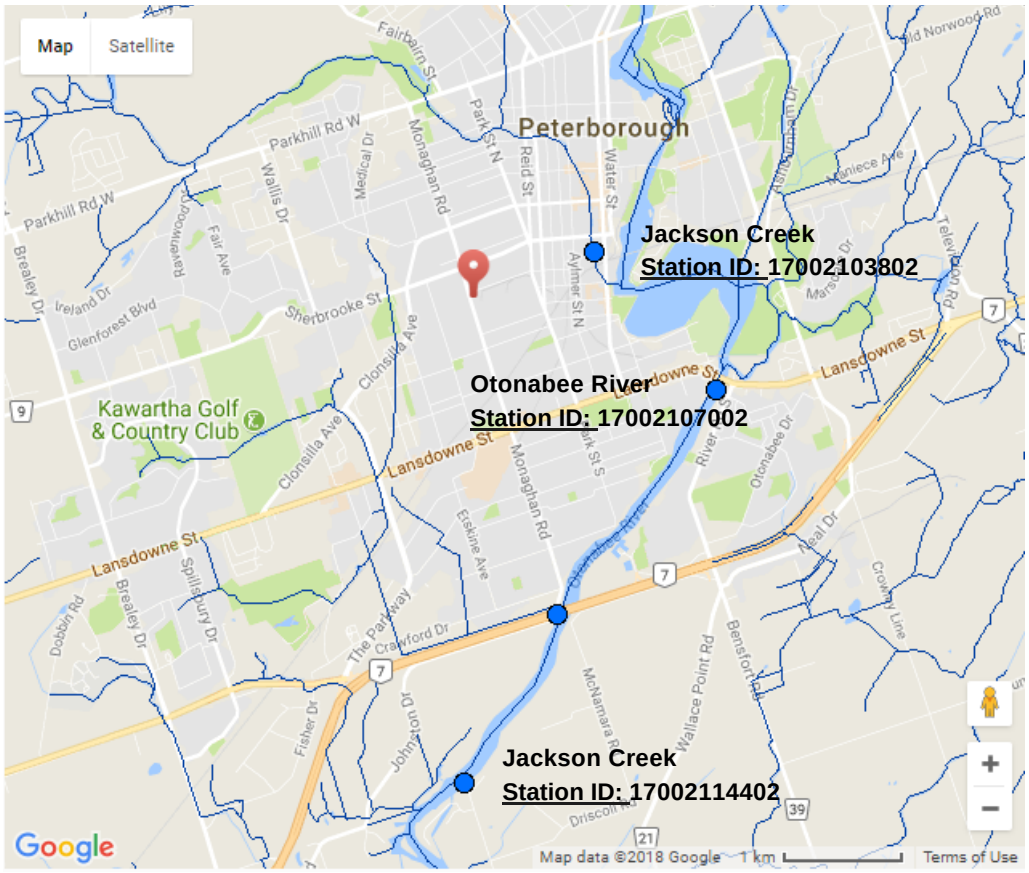
2.2.5.1 Surface Water Quality

Surface water monitoring (SWM) data are available from the Provincial (Stream) Water Quality Monitoring Network. Data for the most recent five years (2017-2021) at three stations (Station IDs: 17002103802 - Jackson Creek at Dalhousie St; 17002107002 - Otonabee River at Lock 19; and 17002114402 – Otonabee River at Marchett Ln) located in the Peterborough area (see Figure 2-10). Jackson Creek (ID 17002103802) is the only station in the vicinity with available data for uranium and beryllium (see Table 2-8).

The maximum concentrations measured for uranium and beryllium during this time period were 13.3 µg/L and 0.122 µg/L, respectively. Average annual uranium concentrations range from slightly above to approximately two times the Ontario Interim Provincial Water Quality Objective (PWQO) of 5 µg/L (MOEE 1994) but are below the Canadian Environmental Quality Guideline of 15 µg/L long term for the protection of aquatic life (CCME 2023), the Ontario O. Reg. 169/03: Ontario Drinking Water Quality Standard of 20 µg/L and the Health Canada drinking water guideline of 20 µg/L (Health Canada 2022). Beryllium concentrations are well below the Ontario Provincial Water Quality Objective (PWQO) of 1,100 µg/L for water with a hardness greater than 75 mg/L (as $CaCO_3$) (MOEE 1994)[2] and the World Health Organization drinking water guideline of 12 µg/L (WHO 2017). Groundwater and surface water concentrations are low and in any event associated with natural background and hence exposures associated with the NFAO are not expected.

For 2018 and 2019, the CNSC added two surface water monitoring stations to its Independent Environmental Monitoring Program (IEMP), as described in Appendix A. Uranium was detected in all four samples collected and was measured between 0.2 µg/L and 0.34 µg/L, which are at levels below those detected in the Provincial (Stream) Water Quality Monitoring Network program. All four beryllium samples were below the detection limit of 0.1 µg/L and were consistent with results of the Provincial (Stream) Water Quality Monitoring Network.

[2] The average hardness level measured in Jackson Creek is around 220 mg/L $CaCO_3$ (MECP, 2022b)



Source: (MECP 2022b)

Figure 2-10 Provincial Surface Water Monitoring Stations in Peterborough

Table 2-8 Surface Water Monitoring Station

Station ID	Parameter	2021	2020	2019	2018	2017
Jackson Creek Station No 17002103802	Uranium (µg/L)	<3	6.09	1.99	5.92	12.4
		5.71	-	2.6	2.61	13.3
		6.44	-	2.8	6.83	6.36
		<3	-	6.77	4.43	7.17
		<3	-	3.72	-3.88	6.19 UAL
		<3	-	1.64	8.4	5.63 UAL
		<3	-	-	7.61	5.7 UAL
		<3	-	-	6.41	5.13 UAL
						3.28 UAL
						5.64 UAL
	Max	**6.44**	**6.09**	**6.77**	**8.4**	**13.3**
	Min	**<3**	**6.09**	**1.64**	**2.61**	**3.28**
	Average	**2.6**	**6.09**	**3.25**	**6.03**	**7.08**

Station ID	Parameter	2021	2020	2019	2018	2017
Jackson Creek Station No 17002103802	Beryllium (µg/L)	<0.1	0.0357	-0.0114	-0.1	-0.0186
		<0.1	-	-0.0735	0.08	-0.0673
		<0.1	-	-0.0135	0	-0.0787
		<0.1	-	-0.0492	0.07	0.099
		<0.1	-	0.0653	0.03	0.0269 UAL
		<0.1	-	-0.0243	0.11	-0.0273 UAL
		<0.1	-	-	0.02	-0.0469 UAL
		<0.1	-	-	-0.02	0.122 UAL
						-0.00086 UAL
	Max	**<0.1**	**0.0357**	**0.0653**	**0.11**	**0.122**
	Min	**<0.1**	**0.0357**	**0.0653**	**0**	**0.0269**
	Average	**<0.1**	**0.0357**	**0.0653**	**0.06**	**0.0826**

Notes:

< T = A MEASURABLE TRACE AMOUNT: INTERPRET WITH CAUTION (½ of Trace Limit used for calculating averages)

< = BELOW DETECTION LIMIT (½ of Detection Limit used for calculating averages)

<=W = NO MEASURABLE RESPONSE (ZERO): <REPORTED VALUE (½ of Reported Value used for calculating averages)

UAL = UNRELIABLE: SAMPLE AGE EXCEEDED NORMAL LIMIT (Reported Value used for calculating averages)

A negative concentration value indicates that the sample was analyzed but that the concentration was below the determination limits of the analytical method.

Values less than 0 were set at 0 for calculating averages.

Source (MECP 2022b)

2.2.6 Air Quality

The measured airborne uranium and beryllium concentrations in air were well below the ambient air quality criteria.

As described in Appendix A, limited ambient air quality sampling was undertaken by the CNSC from 2014 through 2021 in the vicinity of the NFAO. CNSC sample results are summarized in Table 2-9.

The maximum measured airborne uranium concentration was 0.0013 µg/m^3, measured in 2014. Since 2014, all results have been below detection limits (0.0004 to 0.003 µg/m^3). All results are well below the MECP annual ambient air quality criteria of 0.03 µg (U in PM10)/m^3 and 0.06 µg (U in suspended particulate matter)/m^3 based on health effects (MECP 2020) and consistent with the measured annual average uranium in air concentration of 0.0001 ug/m^3 for urban environments (MOE 2011).

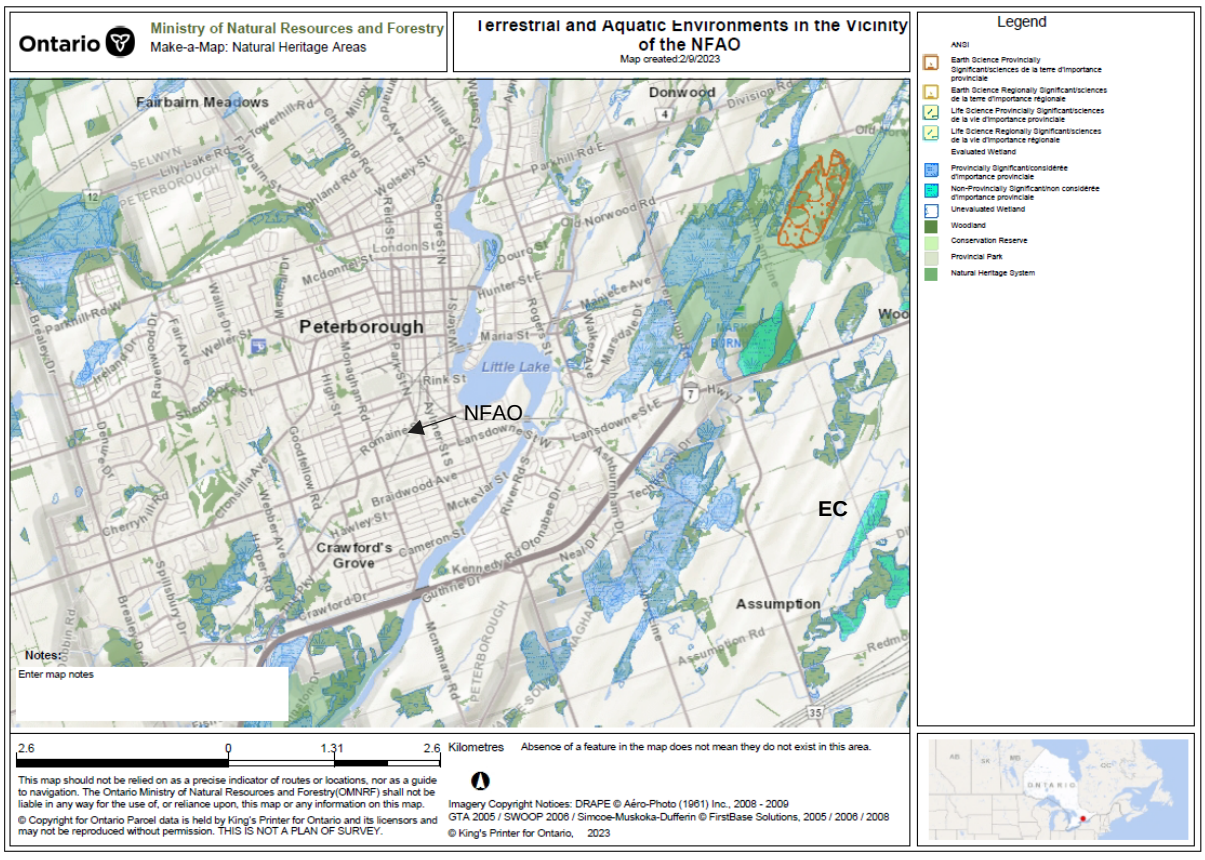
The measured airborne beryllium concentrations, with one exception at 0.000077 µg/m^3, were below the reported detection limits of < 0.0003 µg/m^3 and < 0.003 µg/m^3 depending on the sampling year (CNSC 2022) and were well below the MECP 24-hour ambient air quality criteria of 0.01 µg/m^3 based on health considerations (MECP 2020).

Table 2-9 IEMP Ambient Air Sampling Summary Results (2014 to 2020)

	Uranium	Beryllium
MECP Annual Ambient Air Quality Criteria	0.03 µg (U in PM10)/m^3	0.01 µg/m^3
Number of Samples Collected	14	14
Number of Samples below Detection Limits	13	13
Year of Last Sample Above Detection limits	2014	2014
Average Concentration	N/A	N/A
Maximum Concentration	0.0013 µg/m^3	0.000077 µg/m^3

2.2.7 Terrestrial and Aquatic Environments

The major components of terrestrial and aquatic environments within the greater area surrounding the NFAO are shown in Figure 2-11. All natural features within the City of Peterborough are identified in the Official Plan of the City of Peterborough as shown in Figure 2-13 (City of Peterborough 2021).



Source: (Ministry of Natural Resources and Forestry 2022)
Figure 2-11 Terrestrial and Aquatic Environment

There is one Provincially Significant Wetlands within approximately two kilometres of the NFAO, this being the Harper Creek Provincially Significant Wetland (Beacon 2021, MNRF 2022). The Harper Creek Wetland is approximately 16.4 ha in size, located 2.3 km southwest from the NFAO, and consists of 92% swamp and 8% marsh (MNRF 2022).

The City of Peterborough Official Plan Update Natural Heritage System Background Report states:

> *Areas of Natural and Scientific Interest (ANSIs) are representative examples of the many natural landscapes, geological features, communities, plants and animals in the province. To encourage the protection of these areas that are rich in biological, geological and ecological value, the MNRF leads the ANSI program; identifying ANSI's by surveying regions and evaluating sites to decide which areas have the highest value for conservation, scientific study and education in the province. Currently, there are neither Life Science ANSIs nor Earth Science ANSIs of any level (local, regional or provincial) within the City of Peterborough* (Beacon 2021).

The physiographic character of the Peterborough area is the Peterborough Drumlin Field Region (Chapman and Putnam 1984), which region is named after the City for occupying its geographical centre.

Peterborough is located within the Manitoulin-Lake Simcoe Ecoregion of the Mixedwood Plains Ecozone. The Mixedwood Plains Ecozone is bounded by the three Great Lakes in southern Ontario and extends along the St. Lawrence valley. The Manitoulin-Lake Simcoe Ecoregion extends from Manitoulin Island to Kingston in southern Ontario. The dominant land cover is cropped land with significant areas of mixed forest (Environment Canada and Agriculture and Agri-Food Canada 1995).

Native trees in the southcentral region of Ontario, including the Peterborough area, are characterized by Alternate-Leaf Dogwood, American Beech, American Chestnut, American Elm, American Mountain-Ash, Balsam Poplar, Basswood, Bitternut Hickory, Black Ash, Black Cherry, Black Oak, Black Walnut, Black Willow, Blue-Beech, Bur Oak, Butternut, Chokechery, Eastern Hemlock, Eastern White Cedar, Eastern White Pine, Green/ Red Ash, Hawthrones, Ironwood, Largetooth Aspen, Manitoba Maple, Northern Hackberry, Peachlife Willow, Pin Cherry, Pin Oak, Red Maple, Red Mulberry, Red Oak, Sassafras, Serviceberries, Shagbark Hickory, Silver Maple, Striped Maple, Sugar Maple, Swamp White Oak, Sycamore, Tamarack, Trembling aspen, White Ash, White Birch, White Oak, and Yellow Birch (MNRF n.d.).

Climax vegetation in the Manitoulin-Lake Simcoe Ecoregion is characterized by sugar maple, beech, eastern hemlock, red oak, and basswood. Pioneer species include white pine, paper birch, and trembling aspen. Moist sites are characterized by yellow birch, white elm, and red maple with slippery elm, black ash, and white cedar occurring in depressions and near streams. Drier sites contain red oak, and white and red pine (Environment Canada and Agriculture and Agri-Food Canada 1995).

The most extensive land use in this ecoregion is agriculture, which occupies 56% of the land area. Other significant land uses include urban development, recreation, and tourism. (Environment Canada and Agriculture and Agri-Food Canada 1995).

Wildlife is characterized by White-tailed Deer, Snowshoe Hare, Coyote, Red and Grey Squirrel, and Eastern Chipmunk. Bird species includes the Northern Cardinal, Wood Thrush, Screech Owl, Mourning Dove, Green Heron, Pileated and Red-bellied Woodpeckers, and Wood and American Black Ducks (Environment Canada and Agriculture and Agri-Food Canada 1995).

Urban wildlife that may be found in the area of the NFAO include birds such as Red-breasted Nuthatch, Downy Woodpecker, American Robin, Black-capped Chickadee, Blue Jay, and House Sparrow. Urban species of mammals may include House Mouse, Eastern Gray Squirrel, Eastern Cottontail, Striped Skunk, Raccoon and Red Fox.

A summary of endangered and threatened species and species of concern (a wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats (COSEWIC 2022)) that are known to have been recorded within the City of Peterborough that have likely bred in the area (i.e., excluding migrant birds) is shown in Table 2-10.

Table 2-10 Endangered or Threatened Species Records in City of Peterborough

Common Name	Scientific Name	SARO Status	SARA Schedule	SARA Status
Eastern Whip-poor-will	*Antrostomus vociferus*	THR	Schedule 1	THR
Chimney Swift	*Chaetura pelagica*	THR	Schedule 1	THR
Least Bittern	*Ixobrychus exilis*	THR	Schedule 1	THR
Loggerhead Shrike	*Lanius ludovicianus*	END	No Schedule	
Bank Swallow	*Riparia riparia*	THR	Schedule 1	THR
Barn Swallow	*Hirundo rustica*	THR	Schedule 1	THR
Bobolink	*Dolichonyx oryzivorus*	THR	Schedule 1	THR
Eastern Meadowlark	*Sturnella magna*	THR	Schedule 1	THR
Cerulean Warbler	*Setophaga cerulea*	THR	Schedule 1	END
Northern Myotis	*Myotis septentrionalis*	END	Schedule 1	END
Eastern Small-footed Myotis	*Myotis leibii*	END	Schedule 1	END
Little Brown Myotis	*Myotis lucifugus*	END	Schedule 1	END
Tri-colored Bat	*Perimyotis subflavus*	END	Schedule 1	END
Butternut	*Juglans cinerea*	END	Schedule 1	END
Eastern Hog-nosed Snake	*Heterodon platirhinos*	THR	Schedule 1	THR
Spotted Turtle	*Clemmys guttata*	END	Schedule 1	END
Blanding's Turtle	*Emydoidea blandingii*	THR	Schedule 1	THR

Notes: SARO = Committee on the Status of Species at Risk in Ontario SARA = federal *Species at Risk Act*

THR = Threatened END = Endangered

Source: (Beacon 2021)

Land immediately adjacent to the NFAO and the GE complex is mostly developed urban area with a mix of residential, commercial and industrial uses. Interspersed within the urban area are small recreational green spaces. There are no natural features within the NFAO site. Endangered species, threatened species and species of special concern identified within the Natural Heritage Information Centre (NHIC) grids including and immediately surrounding the NFAO (see Figure 2-12), as recorded in the Natural Heritage Information Centre (NHIC) database, are summarized in Table 2-11.

Table 2-11 Endangered or Threatened Species Records for the Area Surrounding the NFAO

OFG ID	Common Name	Scientific Name	SARO Status	SARA Status	ATLAS NAD83 IDENT
Birds					
1058853 1058863 1058873	Barn Swallow	*Hirundo rustica*	THR	THR	17QK1109 17QK1209 17QK1309
1058851 1058852 1058853 1058861 1058862 1058863 1058871 1058872 1058873	Bobolink	*Dolichonyx oryzivorus*	THR	THR	17QK1107 17QK1108 17QK1109 17QK1207 17QK1208 17QK1209 17QK1307 17QK1308 17QK1309
1058852 1058853 1058863	Canada Warbler	*Cardellina canadensis*	SC	THR	17QK1108 17QK1109 17QK1209
1058872 1058873	Chimney Swift	*Chaetura pelagica*	THR	THR	17QK1308 17QK1309
1058852 1058853 1058863 1058872 1058873	Eastern Meadowlark	*Sturnella magna*	THR	THR	17QK1108 17QK1109 17QK1209 17QK1308 17QK1309
1058852 1058853 1058862 1058863 1058872 1058873	Wood Thrush	*Hylocichla mustelina*	SC	THR	17QK1108 17QK1109 17QK1208 17QK1209 17QK1308 17QK1309
Mammals					
	None				
Reptiles					
1058863 1058873	Midland Painted Turtle	*Chrysemys picta marginata*		SC	17QK1209 17QK1308
1058871	Northern Map Turtle	*Graptemys geographica*	SC	SC	17QK1307

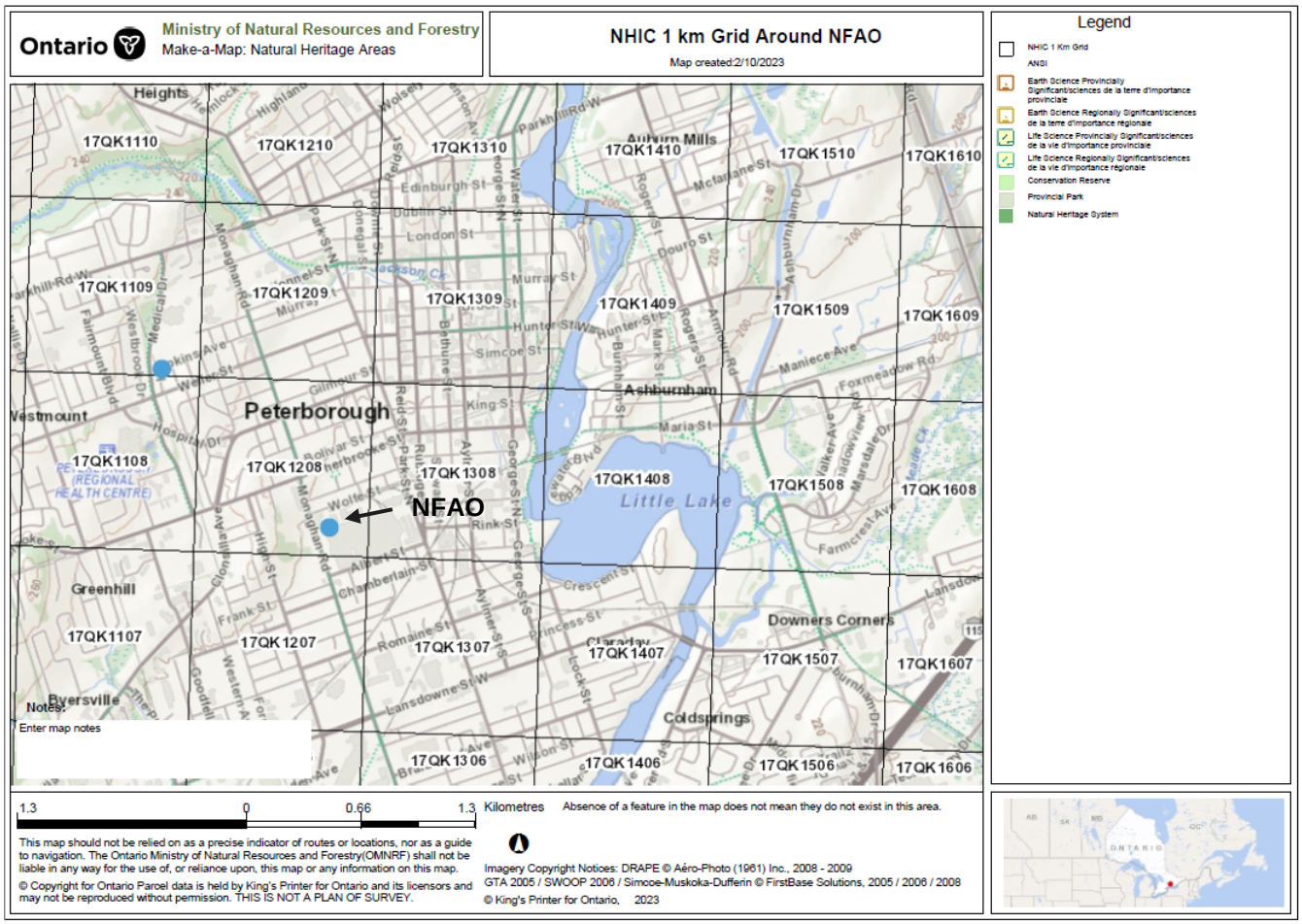
OFG ID	Common Name	Scientific Name	SARO Status	SARA Status	ATLAS NAD83 IDENT
1058851 1058853 1058863 1058872 1058873	Snapping Turtle	*Chelydra serpentina*	SC	SC	17QK1107 17QK1109 17QK1209 17QK1308 17QK1309
1058872 1058873	Common Five-lined Skink (Southern Shield population)	*Plestiodon fasciatus pop. 2*	SC	SC	17QK1308 17QK1309
1058863	Eastern Milksnake	*Lampropeltis triangulum*		SC	17QK1209
Insects					
1058863		*Ancistrocerus unifasciatus*			17QK1209
1058872	American Bumble Bee	*Bombus pensylvanicus*		SC	17QK1308
1058863	Northern Bush Katydid	*Scudderia septentrionalis*			17QK1209
1058863 1058872 1058873	Yellow-banded Bumble Bee	*Bombus terricola*	SC	SC	17QK1209 17QK1308 17QK1309
1058862	Nine-spotted Lady Beetle	*Coccinella novemnotata*	END	END	17QK1208
1058862	Transverse Lady Beetle	*Coccinella transversoguttata*		SC	17QK1208
1058873	Speckled Giant Lacewing	*Polystoechotes punctata*			17QK1309
Fish and Mussels					
1058872	Greater Redhorse	*Moxostoma valenciennesi*			17QK1308
Plants					
1058853	Butternut	*Juglans cinerea*	END	END	17QK1109

Note: SARO = Committee on the Status of Species at Risk in Ontario SARA = federal Species at Risk Act

THR = Threatened END = Endangered

SC = Special Concern (those Wildlife Species that are particularly sensitive to human activities or natural events but are not endangered or threatened Wildlife Species)

Source: (MNRF 2022)

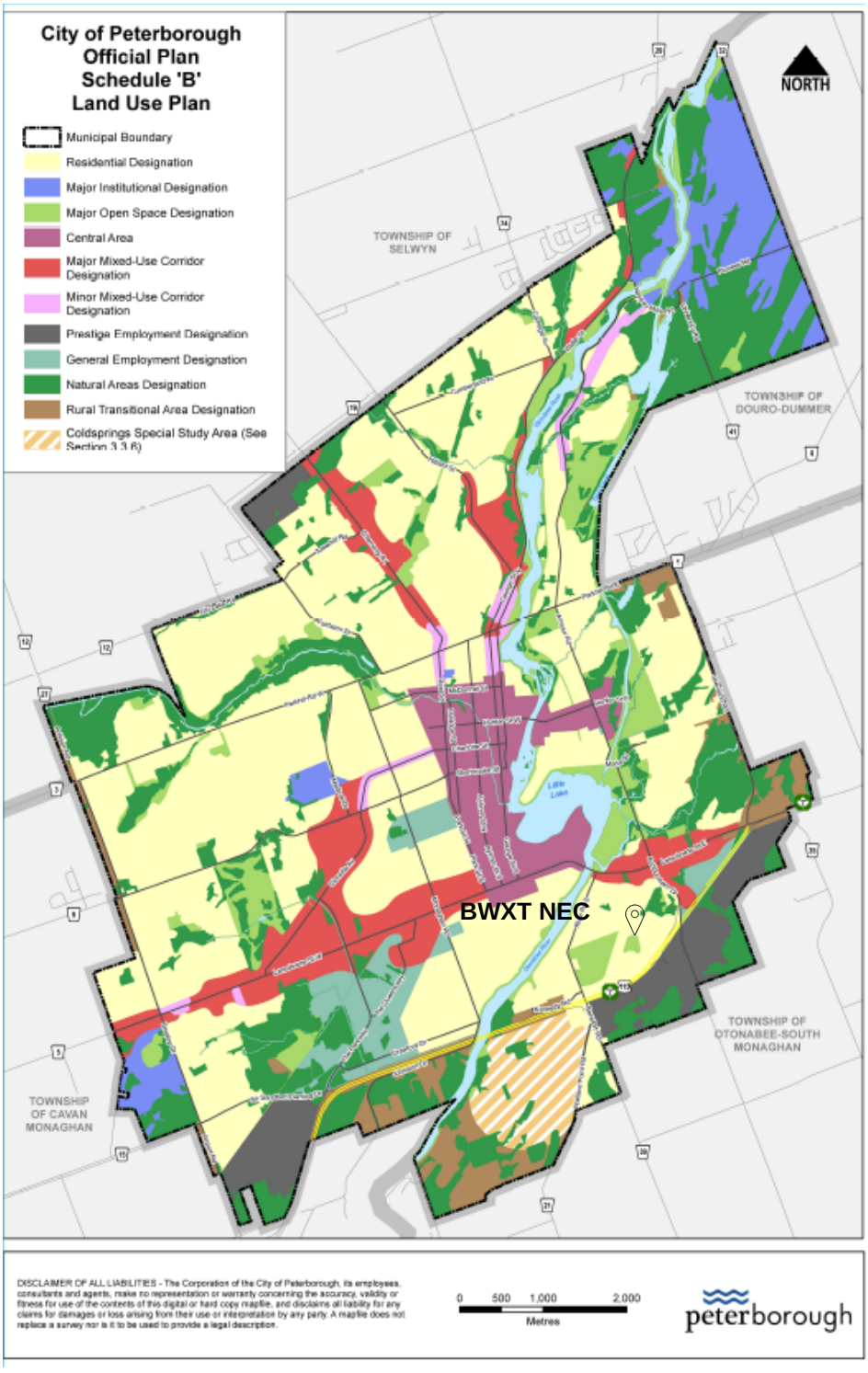


Source: (MNRF 2022)

Figure 2-12 NHIC Grid Around the NFAO

2.2.8 Land Use

The NFAO is located within the GE main plant complex within the City of Peterborough (Figure 2-1). The GE complex is located in a mixed industrial, commercial and residential area. General land use within the City of Peterborough is shown in Figure 2-13.



Source: (City of Peterborough 2021)

Figure 2-13 Land Use in City of Peterborough

2.2.9 Population

In 2021, 83,651 people resided within the City of Peterborough and 128,624 within the Peterborough census metropolitan area (CMA), representing a percentage change of 3.2% and 5.7%, respectively from 2016 (Statistics Canada, 2022). The City of Peterborough comprises a land area of 64.76 km^2 with a population density of 1,291.8 persons/km^2 (Statistics Canada 2022). The Peterborough CMA comprises a land area 1,508.4 km^2 with a population density of 85.3 persons/km^2 (Statistics Canada 2022). Demographic trends are summarized in Table 2-12.

Table 2-12 City of Peterborough Demographic Trends (1991 – 2021)

Age	1991	%	1996	%	2001	%	2006	%	2011	%	2016	%	2021	%
0 - 14	13605	19.9%	13520	19.4%	12710	17.8%	11485	15.3%	11355	14.4%	11940	14.4%	11995	14.3%
15 - 24	9360	13.7%	9210	13.2%	9985	14.0%	11615	15.5%	11600	14.7%	10765	13.1%	10185	12.2%
25 - 44	20735	30.3%	19905	28.6%	18530	25.9%	17855	23.8%	18465	23.4%	19485	23.7%	21155	25.3%
45 - 64	12700	18.6%	13915	20.0%	16380	22.9%	19390	25.9%	21545	27.4%	21565	26.3%	20100	24.0%
65+	11995	17.5%	12995	18.7%	13835	19.4%	14540	19.4%	15730	20.0%	18335	22.3%	20265	24.2%
Total	68395	100.0%	69545	100.0%	71440	100.0%	74885	100.0%	78695	100%	82095	100%	83700	10%

Source (Statistics Canada 2012, 2017, 2021)

2.2.10 Effluent and Environmental Monitoring Programs

Uranium and beryllium emissions to air and water are well below regulatory release limits and Action Levels.

Radiological and non-radiological substances are released to the environment as the result of the operation of the NFAO. Long-standing effluent monitoring programs and environmental monitoring programs have been established by BWXT NEC to monitor releases and potential environmental effects.

The "Environmental Protection" Safety and Control Area covers programs that monitor and control all releases of nuclear and hazardous substances into the environment, as well as their effects on the environment as a result of licenced activities. These long-standing effluent monitoring and environmental monitoring programs have been established by BWCT NEC to monitor releases and potential environmental effects.

As required by the CNSC, the effluent and environmental monitoring programs are designed, completed, reviewed and updated in accordance with the CSA N288 series of standards. CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* which addresses the monitoring of both radiological and hazardous substances and their potential impacts to human and non-human biota. Similarly, the effluent monitoring program is designed, completed, reviewed and updated in accordance with CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* which addresses the design, implementation, and management of an effluent monitoring program that meets legal and business requirements and incorporates current best practices and technologies used internationally. CSA N288.0:22 *Environmental*

management of nuclear facilities: Common requirements of the CSA N288 series of Standards came into effect after data considered in the current ERA was collected. CSA N288.0:22 captures the common elements of the CSA N288 series of Standards for the purposes of minimizing duplication of requirements within the series.

Given that NFAO's effluent and environmental monitoring programs conform with requirements of the CNSC and CSA standards and have been accepted by the CNSC, program data are considered to be of an acceptable quality for use in the HHRA and EcoRA. Programs and associated monitoring data are described in Sections 2.2.10.1 and 2.2.10.2.

In support of monitoring programs, BWXT NEC has established facility specific CNSC approved *Action Levels* for various radiological and non-radiological parameters. An *Action Level* is defined in the *Radiation Protection Regulations* "a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program, and triggers a requirement for specific action to be taken." *Action Levels* are set below regulatory limits; however, they are CNSC reportable events. Accordingly, BWXT NEC has established *Internal Control Levels* for various radiological and environmental parameters that are set even lower than *Action Levels* to act as an early warning system. An *Internal Control Level* exceedance results in internal investigation and corrective action.

To complement existing and ongoing compliance activities and site monitoring programs, the CNSC implemented an Independent Environmental Monitoring Program (IEMP) to verify that the public and environment around CNSC-regulated nuclear facilities are not adversely affected by releases to the environment. This verification is achieved through independent sampling and analysis by the CNSC. This program applies to the NFAO.

2.2.10.1 Effluent Monitoring at NFAO

Airborne and waterborne radiological and non-radiological emissions to the environment from the NFAO are monitored as part of the BWXT NEC effluent monitoring program.

Air

For airborne emissions, beryllium and uranium are monitored.

A single process uranium air emission point exists in the Peterborough facility. The R2 Area ventilation system exhausts through a High Efficiency Particulate Air. BWXT NEC performs weekly in-stack monitoring by removal of a filter capable of trapping uranium dust in the exhaust system. Filter papers are analyzed in-house and verified externally by an independent laboratory for testing by delayed neutron activation analysis. The minimum detection limit used by BWXT NEC is 0.01 µg uranium. Results are compared to the previous results, and to relevant Internal Control Level and Action Level.

BWXT NEC also uses alpha counting for uranium determination on process exhaust air samples. The *Action Level* for a process exhaust sample measurement is 1 µg uranium/m^3. This level is set based on past facility performance. A result above the *Action Level* would be considered outside the concentration range expected for routine operation. The license release limit for uranium is 410 µg uranium/m^3 (annual averge).

Three beryllium exhaust vents are measured by inserting a probe into the duct centerline and withdrawing a sample of air. The air is passed through a filter capable of trapping beryllium. The filter is analyzed for beryllium using the

Atomic Absorption method or the Inductively Coupled Plasma - Atomic Emission Spectrometer method at an accredited external independent laboratory. The result is related to the air volume passed through the filter. The minimum detection level is 0.002 µg beryllium. Each of the three stacks is individually and continuously monitored on a weekly basis. The *Action Level* for a beryllium stack is 0.03 µg Be/m^3. The licensed release limit for beryllium is 2.6 µg Be/m^3 (weekly sample).

A summary of 2021 air effluent sampling results are provided in Table 2-13. A summary of 2017 to 2021 air effluent sampling results are provided in Table 2-14. As shown in the tables, effluent samples are well below the applicble licence release limit and Action Level. Concentrations of uranium and beryllium *at the point of discharge, prior to mixing with ambient air,* are actually well below the allowalbe enviornmental concentrations as permitted by Ontario Regulation 419/05 Air Pollution – Local Air Quality *at the point of impingement* (annual average concentration of 0.01 µg//m^3 for beryllium and 24-hr average concentration of 0.03 µg//m^3 for uranium) located at the plant/public boundary.

Figure 2-14 shows trending of annual uranium emissions over a four-year period. Note that the total grams of uranium released was not reported in these units in 2021, and therefore not graphed. Uranium air emission are well below the previous licenced release limit of 410 g/yr.

Table 2-13 Summary of Air Effluent Sampling Results (2021)

Stack Description	Emission Description	Total Number of Samples	Licence Release Limit (#Samples Exceeding Limit)	Highest Value Recorded (µg/m^3)	Average Value Recorded (µg/m^3)
R2 Decan	Uranium	48	*410* µg/m^3 annual average (0) *Action Level:* 1 µg/m^3 (0)	0.003	0.001
North	Beryllium	49	2.6 µg Be/m^3 (weekly sample) (0) *Action Level:* 0.03 µg Be/m^3 (0)	0.003	0.000
Acid	Beryllium	49		0.001	0.000
South	Beryllium	49		0.002	0.000

Source (BWXT NEC 2022)

Table 2-14 Summary of Air Effluent Sampling Trends (2017 to 2021)

Parameter	2017	2018	2019	2020	2021
Highest Uranium Concentration Value Recorded (µg/m^3)	0.003	0.006	0.014	0.003	0.003
Average Uranium Concentration (µg/m^3)	0.000	0.000	0.001	0.001	0.001
Number of Uranium Samples > Action Level (1 µg/m^3)	0	0	0	0	0
Highest Beryllium Concentration Value Recorded (µg/m^3)	0.001	0.001	0.001	0.001	0.003
Average Beryllium Concentration Recorded (µg/m^3)	0.000	0.000	0.000	0.000	0.000
Number of Beryllium > Action Level (0.03 Be µg/m^3)	0	0	0	0	0

Source (BWXT NEC 2018 - 2022)

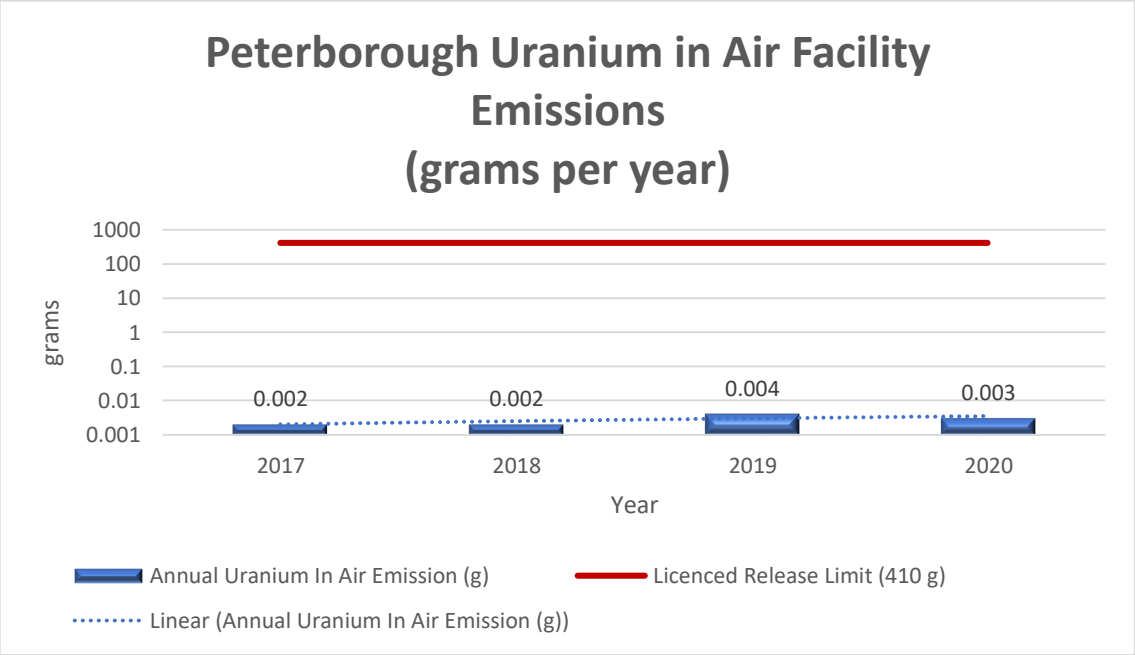


Figure 2-14 Four-year Trend Graph of Annual Uranium Air Releases

Water

All potentially uranium contaminated wastewater is held for determination of the quantity and concentration of uranium prior to disposal. Liquid waste generated from routine activities, such as washing floors, walls and equipment in the uranium pellet sort & stack, loading and end closure weld area, is held in a 205 litre (45-gallon) drum stored in the maintenance area. Most of the potentially contaminated wastewater originates from floor washing. The wastewater is filtered and agitated prior to sampling, and then sent for independent analysis at an accredited external laboratory. The minimum detectable concentration is 0.000002 mg U/L (parts per million (ppm)). After the wastewater sample result is verified to be below the Internal Control Level of 3 ppm (per batch) and the Action Level of 3 ppm (annual average), the wash water is discharged to the sanitary sewer. The licenced release limit (weekly composite) is 140 ppm.

Within the plant sewer system, the released water mixes with wastewater from other, non-nuclear operations in the GE Complex prior to discharge to the municipal sewer.

A second hazardous liquid effluent from the Peterborough facility is beryllium in water that is generated from cleaning activities as well as from the appendage de-burring operation. BWXT NEC has established an *Internal Control Level* of 4 µg/L, which is conservative and consistent with international drinking water guidelines for beryllium, noting that the discharge point is to the sanitary sewer (i.e., not to drinking water), and an Action Level of 40 µg/L. The licence release limit is 26 mg/L (individual sample). All potentially beryllium contaminated water passes through a weir settling system prior to release to the sanitary sewer. Regular sampling of the beryllium wastewater is conducted. The water sample consists of a 24-hour composite sample taken from the outflow lines. It is sent for analysis at an external independent laboratory. The minimum detectable level is 0.007 µg Be/L (0.000007 mg Be/L or parts per million (ppm)).

A summary of 2017 to 2021 water release results is provided in Table 2-15.

As shown in the table, uranium releases are well below the Action Level. Figure 2-15 shows trending of uranium effluent monitoring results over a four-year period (2021 loading was not reported in these units). The four-year trend graph of uranium water releases shows a relatively stable four-year performance consisting of very low water releases, despite a slight increase in 2020. The sample batch number size is limited, and trending is difficult due to small random fluctuations in low concentrations. Water releases are low and below the Action Levels of 6 ppm (per batch) and 3 ppm (annual average).

Table 2-15 shows beryllium average and maximum concentrations and *Internal Control Level* and *Action Level* exceedances. Beryllium concentrations are well below the Action Level, with only three weekly samples exceeding the Internal Control Level of 4 µg Be/L.

Table 2-15 Liquid Effluent Monitoring Results

Parameter	2017	2018	2019	2020	2021
Total Amount of Liquid Discharged (L) from Uranium Processing Areas	820	820	615	1025	410
Maximum Uranium Concentration at point of release (ppm)	0.09	0.03	0.07	0.37	0.41
Average Uranium Concentration at point of release (ppm)	0.04	0.02	0.04	0.20	0.22
Number of Samples Exceeding *Internal Control Limit* (3 ppm per batch)	0	0	0	0	0
Number of Samples Exceeding *Action Level* (6 ppm single batch)	0	0	0	0	0
Total Uranium Discharge to Sewer (g)	0.03	0.01	0.02	0.21	N/A
Maximum Beryllium Concentration in Water µg/L	5.4	2.5	1.8	9.1	3.1
Average Beryllium Concentration in Water µg/L	1	0.6	0.6	1.4	0.9
Number of Samples Exceeding Internal Control Level (4 µg/L)	2	0	0	1	0
Number of Samples Exceeding Action Level (40 µg/L)	N/A	0	0	0	0

Source (BWXT NEC 2022)

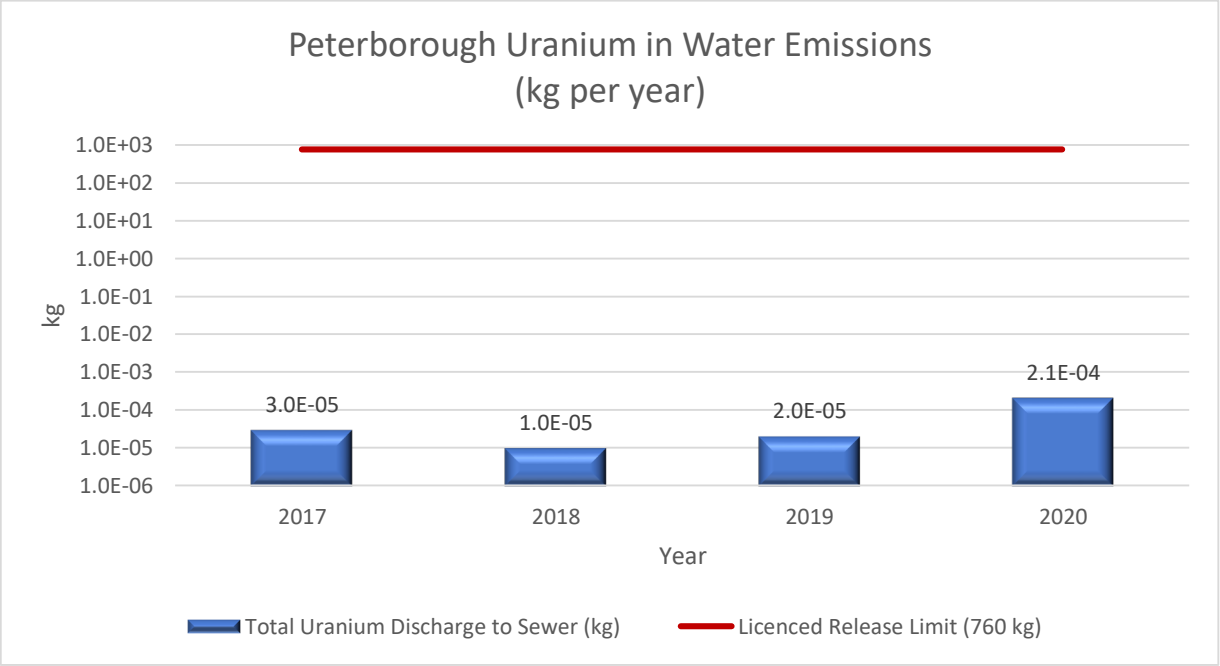


Figure 2-15 Four-year Trend Graph of Annual Uranium Water Releases

2.2.10.2 Environmental Monitoring at the NFAO

The measured uranium concentrations in ambient air and soil were well below established guidelines and standards and no environmental impacts are expected.

Radiological and Non-Radiological Emissions

Based on the low levels of air emisisons and water effluent from the NFAO, BWXT NEC is not required by the MECP, or by this analysis to N288.8, to complete environmental monitoring of radiological and non-radiological substances emitted from the NFAO. However, in its 2020 licence renewal Record of Decision, the CNSC required BWXT to conduct annual soil sampling for uranium and beryllium. Air and water emissions are routinely measured to demonstrate compliance with the CNSC's environmental protection requirements and the As Low As Reasonably Achieveable (ALARA) principle. All measurements were below BWXT NEC Action Levels and annual releases were a small fraction of regulatory limits. The effluent monitoring results from BWXT NEC show a consistent trend of very low air and water releases of uranium and beryllium for which routine environmental monitoring is not warranted. In response the the requirement in the 2020 Record of Decision, BWXT NEC initiated annual environmental soil sampling for uranium and beryllium in 2021.

To complement existing and ongoing compliance activities and site monitoring programs, the CNSC implemented an Independent Environmental Monitoring Program (IEMP) to verify that the public and environment around CNSC-regulated nuclear facilities are not adversely affected by releases to the environment. This verification is achieved

through independent sampling and analysis by the CNSC. This program applies to the NFAO. IEMP sampling was conducted in 2014, 2018, 2019 and 2021. The results of this program are presented in Appendix A and summarized in sections 2.2.5 and 2.2.6.

Soil

Facility air emissions are the primary pathway for potential release into the natural environment by impingement on the ground surface in the immediate vicinity of the facility depending on the wind direction. Uranium and beryllium may be washed into the soil by rainfall, snow, etc. Depositions of uranium or beryllium are detected by taking and analyzing small samples of surface soil. Soil sampling by BWXT NEC for beryllium and uranium started in 2021 and are conducted annually, by a third-party consultant.

In 2021, BWXT NEC retrieved samples of surface soil from 13 locations in accordance with a documented plan. The sampling methodology used is based on the MECP *Guidelines on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario* (MOEE 1996). Three quality control soil samples at a background location more than 19 km west of the facility are also taken, along with two replicate samples for field quality control purposes. The soil samples are stored in a cooler with ice and transported the next day for analysis at an independent accredited laboratory by Inductively Coupled Plasma Mass Spectrometry for uranium and beryllium content. The minimum detectable concentration of uranium is 1.0 part per million (1.0 µg U/g). The minimum detectable concentration of beryllium is 0.5 part per million (0.5 µg Be/g). Results are compared to previous years and the MECP guidelines.

The MECP released soil and groundwater standards under O. Reg. 153/04 (as amended) and which are included in *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*" (MECP 2021b). These generic standards are presented in the MECP document in Tables (1 through 9) that vary according to background, potable or non-potable groundwater, stratified or full depth standards, property use, shallow soil conditions, and proximity to a water body. The results of the soil sampling program were compared to the stringent standards in MECP Table 1 (Full Depth Background Site Condition Standards). For residential, parkland, institutional, industrial, commercial, and community property uses, the standard is 2.5 µg/g for both uranium and beryllium.

The guideline value for uranium and beryllium in soil established by the Canadian Council of Ministers of the Environment (CCME) is 23 µg U/g dry weight and 4 µg Be/g dry weight, respectively, for parkland and residential uses.

BWXT NEC 2021 soil sample results are summarized in Table 2-16.

Table 2-16 BWXT NEC Soil Sampling Summary Results

	Uranium	Beryllium
MECP Guideline (MEC 2021)	2.5 µg U/g	2.5 µg Be/g
CCME Canadian Soil Quality Guideline for Protection of Residential/Parkland CCME 2023)	23 µg U/g	4 µg Be/g
Minimum Detection Limit	1.0 µg U/g	0.5 µg Be/g
Number of Samples Taken	13	13
Average Concentration	1.0 µg U/g	0.5 µg Be/g
Maximum Concentration	1.0 µg U/g	0.52 µg Be/g

Source: (BWXT NEC 2022)

As described in Appendix A, limited soil sampling was undertaken by the CNSC from 2014 through 2021 in the vicinity of the NFAO. The CNSC laboratory began using a partial digestion method as opposed to the total digestion method used before 2020. This change was made so that results could be compared with the Canadian Council of Ministers of the Environment Environmental Quality Guidelines (CCME 2023) and the MECP Soil Quality Standards (MECP 2021b). As a result, soil concentrations in 2021 are lower than in previous years and are not directly comparable to samples from prior years. Samples prior to 2021 were therefore not further assessed.

CNSC sample results are summarized in Table 2-17.

Table 2-17 IEMP Soil Sampling Summary Results

	Uranium	Beryllium
MECP Guideline (MECP 2021b)	2.5 µg U/g	2.5 µg Be/g
CCME Canadian Soil Quality Guideline for Protection of Residential/Parkland (CCME 2023)	23 µg U/g	4 µg Be/g
Number of Samples Taken Analysed with Full Digestion (not comparable to MECP and CCME guidelines)	34	34
Number of Samples Taken Analysed with Partial Digestion	9	9
Average Concentration (partial digestion only)	1.27 µg U/g	0.67 µg Be/g
Maximum Concentration (partial digestion only)	0.67 µg U/g	0.48 µg Be/g

Source: (CNSC 2022)

Analytical results for uranium and beryllium concentrations for all soil samples analyzed are, without exception, well below the standards published by the MECP Table 1 Background Site Condition Standards and the applicable CCME soil quality guidelines. Uranium in soil samples results also were lower than the Ontario background level which is generally below 2.5 mg/kg (MOEE 2011). Beryllium samples also were below the Canadian background average level in soil of 0.75 mg/kg (arithmetic mean, SD=0.99, n=9876, range=0.25 to16 µg/g) (CCME 2015). At these low levels, it is expected to see natural variations in the concentrations measured in soil.

Radiation

Beginning in 2016, environmental Thermoluminescent Dosimeters (TLDs) were set up around the perimeter of the facility to monitor annual gamma dose rates with three along Monaghan Rd, one on Wolfe St. one at the critical receptor on Wolfe St. and one background location. In 2019 an additional location was added on Wolfe St. Monotiring locations are shown in Figure 2-16. Results for the 2016 to 2022 period are summarized in Table 2-18. While BWXT NEC also undertakes spot gamma dose rate measurements on a periodic basis, TLD readings provide a more reliable indication of gamma exposures than the spot gamma measurements.

Over the 2016 to 2022 period, the highest measured annual gamma dose rate was 0.19 µSv/h (inclusive of background), measured in 2021, at the Monaghan-7 location. Thus, even if someone were standing at this location for 100 h/year, he/she would have received an average dose of 19 µSv/year or 1.9 % of the dose limit. As both the highest measured value was used and background was included in this measurement, the dose attributable to sources inside the NFAO, is conservative and likely overestimated. Environmental TLDs are therefore used in estimating annual effective doses as a result of direct exposure to gamma radiation which ranged from a low of 0.0 µSv in all years but 2019 to a high of 11.5 µSv in 2019 to a member of the public (BWXT NEC 2018 to 2022).

Table 2-18 Environmental Monitoring TLDs (2016-2022)

		Annual µSv/hr						
Badge #	**Location ID**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
	Control	0.06	0.08	0.09	0.09	0.08	0.06	0.06
6	**Bkgd-Philip**	**0.08**	**0.10**	**0.08**	**0.09**	**0.08**	**0.06**	**0.06**
1	Monaghan-5	0.06	0.12	0.13	0.14	0.12	0.12	0.13
2	Monaghan-7	0.13	0.11	0.13	0.19	0.14	0.13	0.16
3	Monaghan-12	0.09	0.09	0.12	0.11	0.09	0.08	0.10
4	Wolfe-10	0.08	0.08	0.09	0.10	0.08	0.06	0.07
5	Wolfe-CR	0.07	0.07	0.07	0.09	0.07	0.05	0.06
256	Wolfe-4	No sample	No sample	No sample	0.08	0.07	0.06	0.07

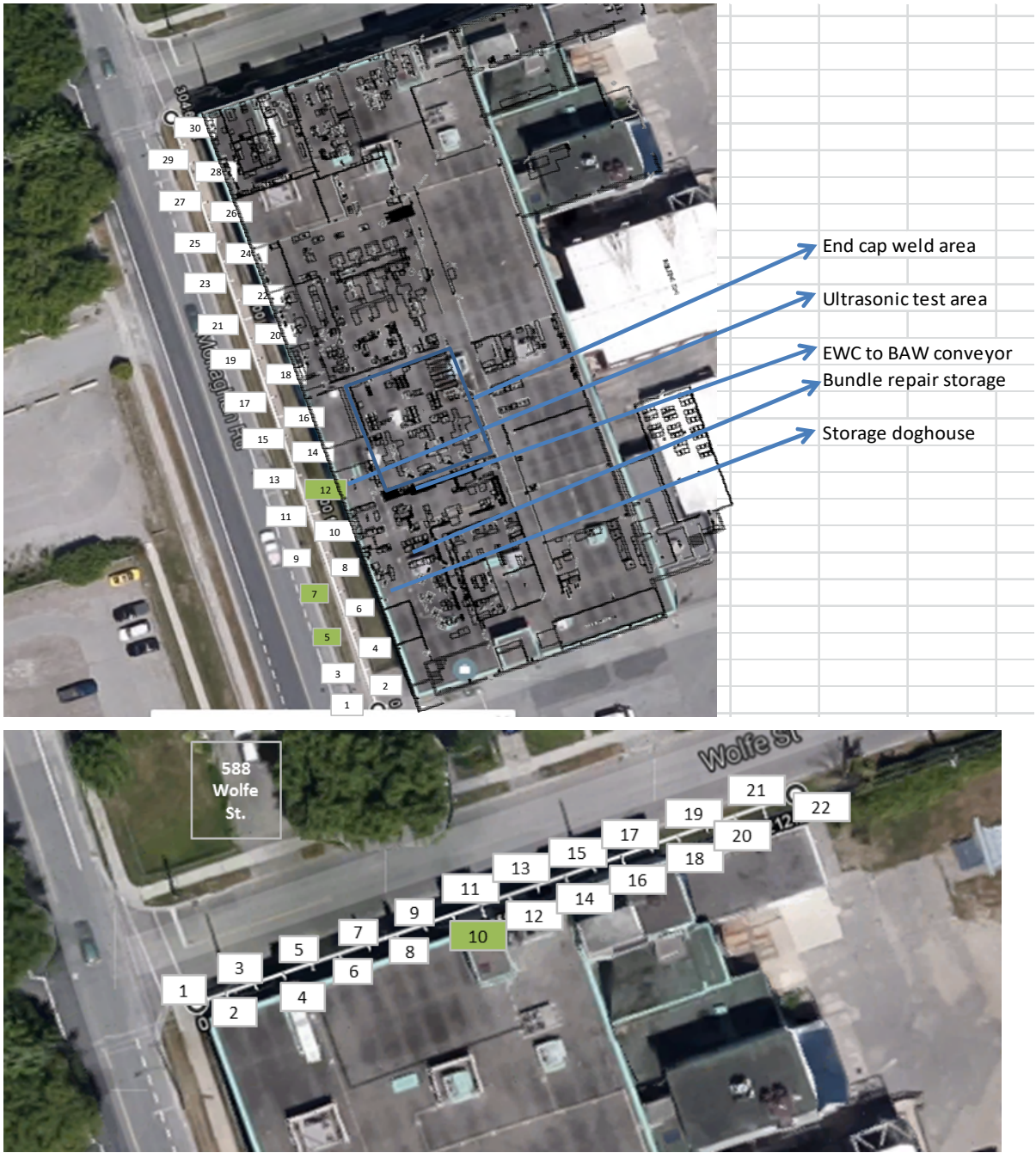


Figure 2-16 Boundary Gamma Radiation Monitoring Locations

2.2.11 Uncertainties in the Natural and Physical Environment

Well established and long running effluent and environmental monitoring programs are in place to measure the key Contaminants of Potential Concern (COPCs) (uranium, beryllium and gamma radiation) increasing the likelihood of identifying maximum emission cases and reducing the uncertainty in the risk assessment. In the risk assessment,

maximum concentrations, emissions and/or measurements were used in the screening, providing a further degree of conservatism into the assessment.

The CNSC IEMP is operated independently of BWXT NEC in accordance with quality programs establised in accordance with CNSC internal requirements. This independent data assists in validating that the low level of emisisons from the NFAO have minimal impact on the environment.

There are some uncertainties in the characterization of the natural and physical environment. In particular, there is limited data on surface and groundwater quality, site-specific groundwater flow and depth and site soil characteristics. There are no human or ecological exposure pathways to COPCs from on-site groundwater and there are no indications to suggest contamination or potential impacts on local groundwater resources. Indirect emissions of COPCs to surface water are very low, with concentrations further reduced during dispersion in the air and mixing in surface waters. As such, human and ecological exposure pathways to COPCs from groundwater and local surface water are trivial and these uncertainties do not affect the risk assessment.

3 Human Health Risk Assessment

An HHRA is the evaluation of the probability of health consequences to humans caused by the presence of chemical contaminants at a facility. The requirement for, approach to, and scope of, a HHRA is based on a fundamental understanding of: site conditions, including the nature, extent and distribution of the radiological and chemical hazards; the potential exposure pathways; and opportunities for human receptors that will frequent, use or populate the area on or surrounding the facility.

As allowed under CSA N288.6:22, HHRAs apply to off-site receptors (i.e., members of the public) and on-site non-nuclear energy workers (non-NEWs) that are not covered under the facility's radiation protection program or health and safety program. In this report, the receptors considered for the HHRA consist of off-site members of the public. Health and safety of on-site workers is protected by BWXT NEC's Radiation Protection Program and Conventional Safety Program, which are discussed in section 3.1.1.

3.1 Problem Formulation

The prime hazards to the environment from the NFAO operations are uranium, beryllium and gamma radiation through emissions to air and water.

Pathways for human exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*

Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, consequently detailed receptor characterization was not required.

Potential physical stressors to humans identified include noise exposure.

Problem formulation is a step undertaken early in the ERA process to constrain and focus the ERA on the key questions. For the NFAO ERA, the problem formulation focuses the assessment to the key contaminants and identifies the receptors and exposure pathways that are relevant to the proposed undertaking. The following discussion describes the approach taken to focus the HHRA.

3.1.1 Health and Safety of On-site Workers

Exposure to workers is considered and controlled through the application of BWXT NEC's well-established Occupational Safety and Health Procedures. On-site employees, contractors, and visitors are protected with the implementation of BWXT NECs Radiation Protection Safety and Control Area and conventional safety program.

On-site workers, such as BWXT NEC employees, contractors, and visitors are protected through the "Radiation Protection" Safety and Control Area which covers the implementation of the radiation protection program, in accordance with the *Radiation Protection Regulations*. This program ensures that contamination and radiation doses received are monitored and controlled.

BWXT NEC has an established radiation protection program to address the hazards from uranium dioxide (UO_2) and keep employee doses ALARA. The major potential hazard is inhalation of airborne uranium dioxide particles. A respiratory protection program is in place. Measurements are performed of airborne and surface traces of uranium as an indicator of process containment efficiency. Urine samples provided by employees are used to indicate if inhalation may have occurred and to monitor clearance of uranium from the body. A lesser potential hazard exists in the form of low-level external gamma and beta doses to employees. The BWXT NEC program ensures that surface and airborne contamination and radiation doses to employees are monitored and controlled.

Whole body, skin and extremity dose measurements are performed using TLDs to ensure compliance with the CNSC's radiation dose limits and the ALARA principle.

On-site workers could also potentially be exposed to non-radiological substances. These exposures are considered and controlled through the application of BWXT NEC's well-established Occupational Safety and Health procedures.

As it is expected that the health and safety of on-site employees, contractors, and visitors is protected with the implementation of BWXT NEC's "Radiation Protection" Safety and Control Area and conventional safety program, no further risk assessment will be performed for these individuals.

3.1.2 Receptor selection and characterization

A toddler (0.5 – 4 years) was identified as the critical receptor for assessment purposes. However, because the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed receptor characterization was not required.

3.1.2.1 Receptor Selection

The critical receptor for the general public is defined as the "*most affected neighbour*" in order to be inclusive of all types of receptors.

The MECP, for land use categories where people of all ages are expected to have access (i.e. residential, parkland, institutional), consider the toddler (0.5 – 4 years) to be the more highly exposed receptor. Toddlers are considered to be the more highly exposed receptors because they eat, drink, and breathe more in proportion to body size, and exhibit behaviours (e.g., hand-to-mouth activity) that increased exposure to media such as soil (MOE, 2011). Based on this rationale, and the fact that toddlers could spend most of their time in a residence near the facility, toddlers were identified as the critical receptor.

The critical receptor included in the HHRA is consistent with that identified in the 2009 Environmental Impact Statement for the Low Enriched Uranium Fuel Bundle Production Project (GEH-C 2009).

3.1.2.2 Receptor Characterization

As discussed in Sections 3.2 and 3.3, since the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed receptor characterization was not required.

3.1.3 Selection of Chemical, Radiological, and Other Stressors

BWXT NEC has a long history of operations in Peterborough which has allowed for the identification, assessment and monitoring of emissions over an extended period of time. Generally, there are minimal emissions associated with the production of natural uranium fuel bundles which is largely an assembly operation.

The prime hazards to the environment from BWXT NEC are uranium, beryllium and gamma radiation.

Uranium is both a radioactive substance (it decays at a slow rate by primarily emitting alpha radiation and, at lower levels, beta and gamma radiation) and a hazardous substance (since exposure to uranium can lead to chemical toxicity). Uranium is classified as a low specific activity radionuclide and emits very low amounts of radiation as compared to certain other isotopes. The main chemical effect associated with exposure to uranium and its compounds is kidney toxicity.

Beryllium is a hazardous substance which can impact health if inhaled. The two major effects are respiratory illness resulting from inhalation of excessive quantities of beryllium dust, and skin reaction, which will take place as a result of direct contact of some beryllium compounds with an open wound, or implantation under the skin.

Release of both uranium and beryllium is controlled at the source by judicious design of machines, material handling equipment and dust collection systems. Dust collection system design and controls are described in the Radiation Protection Manual and the Beryllium Safety Manual.

In addition to these contaminants, a number of contaminants are also emitted to air which are associated with spray booth operations, bundle manufacturing and QA/QC and maintenance activities. These contaminants have been identified in the Peterborough Emission Summary and Dispersion Modelling Report (GHD 2022b).

Consistent with CSA N288.6:22, noise was also selected as a physical stressor for human receptors.

The tiered approach to HHRA, requires these contaminants to undergo a Tier 1 preliminary screening where conservative estimates of emissions and environmental concentrations are compared to screening criteria. The objective of this preliminary screening process is to identify COPCs which are those contaminants that have undergone preliminary screening and have been selected for evaluation in higher tiers of assessment.

3.1.4 Selection of Exposure Pathways

Pathways for human exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*

Exposure through soils and the terrestrial food chain are not expected to be relevant due to the negligible amounts of beryllium and uranium released to air and the low concentration of these substances in soil. Exposures through surface water consumption and exposure and the aquatic food chain are also not relevant due to the negligible amounts of beryllium and uranium released indirectly to surface waters and stormwater. Given the low concentrations of beryllium and uranium in stormwater runoff and soil and the absence of any soil or groundwater contamination on site, pathways associated with groundwater are also not considered pathways of concern.

Radiological and non-radiological materials are released to the environment as a result of the NFAO. Consequently, this could result in the emissions to various media, potentially including air, surface water, soil, sediment, groundwater, and other media such as vegetation. Receptors could be exposed to contamination through various pathways, as shown generically in Figure 3-1.

BWXT NEC has implemented track out control measures to minimize the potential for on-site contamination and associated contamination of stormwater. Therefore, any on-site or off-site contamination of runoff is associated with the emission of uranium through plant stacks and its subsequent deposition to the ground. Uranium emissions from Peterborough are negligible at 0.002 to 0.004 g U/y over the 2017 to 2020 period. Conservatively assuming a

depositional radius around the facility of 1 km, the estimated stormwater runoff concentrations assuming equal deposition within this area is:

- average precipitation = 786 mm = 0.786 m
- assuming no infiltration
- Impacted area = 3.14 km^2 (very conservative as uranium emissions would be in the form of a very fine particulate and dispersed over a larger area – if for example we assume all stack emissions are deposited in a 2-km radius the average deposited uranium would be 4 times smaller)
- Maximum annual U emission 2017 to 2020 = 0.004 g
- Assuming all deposited uranium is picked up in precipitation (very conservative as much of the dust fall will work its way into the surface soil horizon)

$$Avg\ Concentration\ of\ U\ in\ Stormwater = \frac{0.004\ g}{0.786\ m * 3140000\ m^2} = 1.6\ x\ 10^{-9}\ \frac{g}{m3} = 0.000002\ ppb$$

Similar calculations for beryllium, assuming a release rate of 9.57E-8 g/s (from ESDM) or 3.0 g/year (conservatively assuming around the clock operations) yield a concentration of 0.0012 ppb of beryllium in stormwater runoff.

Completing similar calculations for soil deposition, conservatively assuming a soil density of 1.6 g/cm^3 a mixing zone of 5 cm (CSA, 2014) the average annual increase in soil concentrations are:

$$Avg\ annual\ increase\ in\ U\ in\ Soil = \frac{0.004\ g}{0.05\ m * 3140000\ m^2} * \frac{1\ cm^3}{1.6\ g} * \frac{1\ m^3}{(100\ cm)^3} = \ 1.6x10^{-8}\ \frac{\mu g}{g}\ dry\ weight$$

$$Avg\ annual\ increase\ in\ Be\ in\ Soil = \frac{3.0g}{0.05m * 3140000m^2} * \frac{1\ cm^3}{1.6\ g} * \frac{1\ m^3}{(100\ cm)^3} = \ 1.2\ x10^{-5}\ \frac{\mu g}{g}\ dry\ weight$$

Therefore, exposure through soils and the terrestrial food chain are not relevant due to the negligible amounts of beryllium and uranium released to air and the low concentration of these substances in soil (as confirmed by BWXT's soil sampling and the CNSC IEMP program). Exposures through surface water consumption and exposure and the aquatic food chain are also not relevant due to the negligible amounts of beryllium and uranium released indirectly to surface waters through plant sewer effluent, the low concentrations of uranium and beryllium in stormwater runoff and the absence of any surface waters in the immediate area of the facility. Given the low concentrations of beryllium and uranium in stormwater runoff and soil and the absence of any soil or groundwater contamination on site, pathways associated with groundwater are also not considered pathways of concern.

Of the generic pathways shown in Figure 3-1, the primary pathways for COPCs associated with the NFAO are therefore:

- Air inhalation/skin absorption; and
- Air immersion (external exposure).

Given the ongoing monitoring programs of both uranium and beryllium releases in both air and water effluents, there is high level of confidence in effluent estimates and the conclusion that all pathways but these two air pathways

are negligible contributors to environmental concentrations in surface and ground water, soil and the terrestrial food chain and associated exposure pathways.

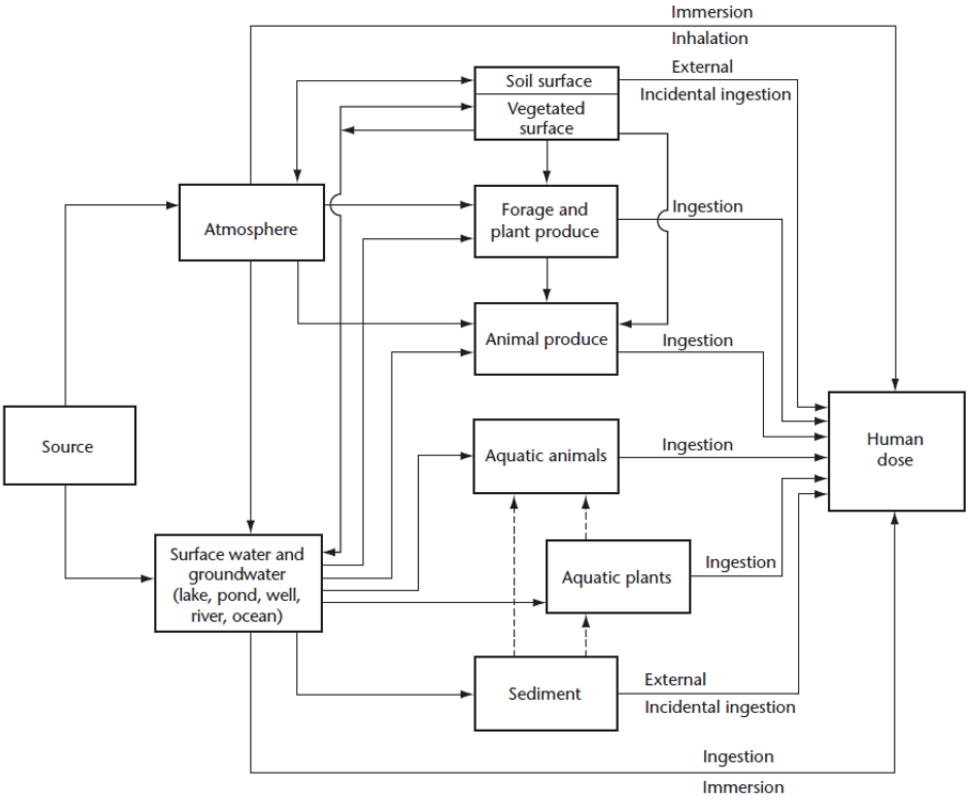


Figure 3-1 Sample Human Pathway Model (CSA 2022)

3.2 Assessment of Radiological Impact

Radiological materials expected to be released include uranium to air and water. Direct gamma radiation from the facility and internal exposure through pathways such as consumption of locally-sourced food and water is also a consideration.

The estimated annual effective dose as a result of air releases and direct gamma exposure radiation from the combined operation is estimated to be negligible (~ 0.00 Sv). Therefore, there are no radiological effects to the public due to the NFAO, and there is no radiological risk posed to off-site human receptors, thus, no further assessment is required.

Radiological materials are released to the environment as a result of the NFAO. In this section, the impacts of radiological releases on human health are assessed at the screening level (Tier 1) first. PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) is not required based on the screening level review.

Radiological materials released include uranium to air through stack emissions and water through discharges to sewer. Direct gamma radiation from the facility and internal exposure through pathways such as consumption of locally-sourced food and water is also a consideration.

Uranium has both radiological and non-radiological (primarily on kidney toxicity) effects. Uranium releases are discussed in more detail in Section 3.3.

3.2.1 Screening Criteria

Radiological releases to air and water were screened to identify COPCs. The CNSC's regulatory dose limit for members of the public, as defined in the *Radiation Protection Regulations,* is 1 mSv (1,000 µSv) per year. The Canadian average effective dose from background radiation is 1.8 mSy per year (CNSC 2013). The ICRP (Publication 103 at para 268) suggests a risk based constraint for members of the public of $1x10^{-5}$ per year (ICRP 2007). Assuming the combined radiological detriment of about 5% per Sievert (ICRP 102 at para e), this converts to an annual dose of about 200 µSv per year which coincidentally, is about 10% of the unavoidable annual dose from natural background (ICRP 2007). For present purposes, we have assumed an annual reference dose of 200 µSv for the purpose of screening.

3.2.2 Dose to Members of the Public

Member of the public could receive radiation doses from direct external exposure to gamma radiation from the NFAO and internal exposure through pathways such as air exposure and water consumption.

The external dose rates at the boundary of the NFAO are routinely measured (see Section 2.2.10.2). As shown in Table 2-18, the maximum dose rate resulting from gamma radiation at the plant boundary is 0.19 µSv/h (inclusive of background). If someone were to stand at this location for 100 h/y she/he would receive only 1.9 µSv/y or 9.5%

of the annual screening criterion (0.2 mSv) for the dose limit to the general public. As the external exposure to radioactivity falls off with distance from the facility, the external dose from the NFAO is not a significant contributor to the radiological dose received by the general public. Therefore, the assessment is focused on the exposure of the public due to emissions to air. Also, exposure from liquid effluent discharges is not expected as only 0.01 to 0.2 g of uranium were discharged annually over the 2017 to 2020 period.

The facility has developed Derived Release Limits to account for the realistic pathways occurring as a result of air emissions as described in the facilities Radiation Protection Manual to restrict dose to a member of the public to 1,000 µSv per year. The Derived Release Limits assume that a member of the public occupies the NFAO boundary continuously (24 hours per day, 365 days per year).

Table 3-1 Radiological Exposure Pathways

Pathway	Description
Air immersion	Airborne uranium dioxide particles (UO_2) can expose members of the public via direct radiation.
Soil deposition gamma ground shine	Gamma ground shine dose from direct radiation. This is not applicable to the Peterborough site due to the extremely low levels of uranium emissions.
Soil deposition beta ground shine	Beta ground shine dose from direct radiation. This is not applicable to the Peterborough site due to the extremely low levels of uranium emissions.
Soil re-suspension and inhalation	Soil re-suspension and inhalation dose. This is not applicable to the Peterborough site due to the extremely low levels of uranium emissions.
Backyard gardens	Ingestion of background grown produce. This is not applicable to the Peterborough site due to the extremely low levels of uranium emissions.
Air inhalation	Airborne uranium dioxide particles (UO_2) can expose members of the public via inhalation.

As discussed in annual reports and shown in Table 3-2, through direct correlation with the facility Derived Release Limits, over the 2017 to 2021 period, the estimated annual effective dose as a result of air releases and direct gamma exposure radiation ranged from a low of 0.0 µSv/yr in all years but 2019 where the estimated dose was 11.5 µSv/yr (BWXT NEC 2022). These doses represent from <0% to 1.2% of the 1 mSv (1,000 µSv) per year effective dose limit to a member of the public and 0% to 5.8% of the 0.2 mSv (200 µSv) per year screening criterion for radiological releases to air and water.

Table 3-2 Estimated Annual Public Dose

Year	Estimated Annual Public Dose (µSv)	% of Public Dose Limit (1,000 µSv = 1 mSv)	% of Screening Limit (200 µSv = 0.2 mSv)
2021	0.0	0%	0.0%
2020	0.0	0%	0.0%
2019	11.5	1.2%	5.8%
2018	0.0	0%	0.0%
2017	0.0	0%	0.0%

Uranium emissions to air are very low at a maximum of 0.0004 g/y. Based on Derived Release Limit calculations, BWXT NEC has estimated a maximium effective dose as a result of air releases of 0.0 µSv/y, representing 0% of the screening dose criteria of 200 µSv/y (BWXT NEC 2018 to 2022). Air emissions and associated atmospheric pathways are therefore not relevant due to the low concentrations in the natural environment.

Therefore, it can be concluded that there are no radiological effects to the public due to the NFAO, and there is no radiological risk posed to off-site human receptors and no further assessment is required.

3.3 Assessment of Non-Radiological Impact

No non-radiological airborne or waterborne substances have been identified as COPCs for further assessment in the HHRA.

Non-radiological releases to the environment occur as a result of the NFAO. In this section, the impacts of non-radiological contaminants on human health are assessed at the screening level (Tier 1) first. Based on the results of the screening level assessment, PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) are not required.

3.3.1 Screening Criteria

The non-radiological substances in air and water were screened to identify COPCs. Screening criteria are identified in each section below.

3.3.2 Air

Non-radiological airborne emissions considered included uranium, beryllium, particulate matter, volatile organic compounds, trace metals, and nitrogen oxides. 70% of non-negligible airborne non-radiological contaminants emitted from the NFAO had modelled air concentrations 10% or less of the applicable screening criteria and only 2 had modelled concentrations of 50% or more of the applicable screening criteria at 50% and 65%. Other than uranium, beryllium and combustion sources, all other airborne sources were from low use, intermittent operations which were very conservatively modelled as operating continuously and are therefore highly overestimated. Furthermore, non-radiological substances with CNSC licence limits, BWXT NEC Action Levels, BWXT NEC Internal Control Levels were well below these limits and are therefore expected to be negligible.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the HHRA.

Non-radiological substances, such as Uranium, Beryllium, Particulate Matter (PM), Volatile Organic Compounds (VOCs), Trace Metals, and other miscellaneous contaminants could be released to air from the NFAO. The primary continous airborne emission sources at the NFAO include:

- Uranium from the Uranium Oxide Element Decan Exhaust in Building 21;
- Beryllium from three stacks in the Beryllium Area; and
- Combustion sources.

Other miscellaneous minor sources located at the NFAO include, but are not limited to, a spray booth, metals bundle wash area, graphite area, and maintenance areas.

The NFAO has licenced release limits for uranium and beryllium and has established facility specific CNSC approved *Action Levels* for uranium and beryllium. BWXT NEC has also established *Internal Control Levels* for uranium and beryllium that are set even lower than Action Levels to act as an early warning system. *Internal Control Level* exceedances trigger an internal investigation and corrective actions; however, they are not CNSC reportable events.

The *Environmental Protection Act* of Ontario (R.S.O. 1990, c. E. 19) and Ontario Regulation 419/05 *Air Pollution – Local Air Quality Regulation* also determine permitted concentrations of contaminant releases, as published in in the MECP publication *Air Contaminants Benchmarks List (ACB List): standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants* (MOECC 2018a).

To assess the airborne emissions of non-radiological COPCs from the NFAO, emission estimates, based on measurements, engineering calculations and emission factors, and modelling of airborne emissions conducted in support of the facility's Emissions Summary and Dispersion Modelling Report ESDM) (GHD 2022b) were used. For each contaminant, the ESDM includes a calculation of the maximum Point of Impingement (POI) concentrations for

the averaging periods (10-minute, ½-hour, 24-hour or one year) for which critria exist. The calculations are based on the operating conditions, including start-up and shut-down, where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with section 11 of O.Reg. 419/05.

Prior to modelling, contaminants with MECP Limits were screened by GHD. for significance using the "Emissions Threshold" analysis method as documented in section 7.1.2 of the MECP publication *Guideline A-10: Procedure for Preparing an Emission Summary and Dispersion Modeling (ESDM) Report* (MOECC 2018b). Any emission below the following threshold was screened out as negligible:

Emission Threshold (g/s) = [0.5 x MECP POI Limit] / [Dispersion Factor]

The estimated maximum POI concentrations are presented in Table 3-3, along with applicable criteria. Table 3-3 shows that no COPCs approach the screening criteria, with the maximum concentration at 65% for talc.

70% of non-negligible substances are below 10% of the applicable criteria. Other than beryllium, uranium and combustion sources, all contaminants, while being emitted from intermitent sources, were modelled as if the discharge occurred continously. As such, 24-hour and annual concentrations are higly conservative and overestimated and are not assessed further. CNSC IEMP environmental air sampling (see Appendix A) confirms that uranium and beryllium levels are very low (<5% of applicable standards). Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the HHRA.

3.3.3 Surface Water

There are no surface waters present in the vicinity of the NFAO and limited liquid effluent from the facility, therefore no measurable effects on surface water and sediment components are expected. Uranium and beryllium are the key contaminants in NFAO effluent which discharges to sewer. For discharges to sewer, after passing through the municipal wastewater treatment plant, concentrations of uranium and beryllium are well below drinking water quality guidelines.

Therefore, no non-radiological waterborne substances have been identified as COPCs for further assessment.

Uranium and beryllium are the key COPCs in the NFAO effluent. The NFAO releases are discharged to the plant sewer system where it combines with the wastewater from other, non-nuclear operations in the GE Peterborough Complex prior to discharge to the municipal sewer.

There are no surface waters present in the vicinity of the NFAO and there is a very limited liquid effluent from the facility. Moreover, surface water monitoring data for the most recent five years (2010-2014) from three Provincial Monitoring Network stations (Station IDs: 17002103802, 17002107002 and 17002114402) show a maximum uranium concentration of 13.3 ppb, which is below the drinking water guideline of 20 ppb. However, as effluent is discharged to the municipal sewer system and ultimately to the natural environment, screening of non-radiological

contaminants in this effluent was conducted based on the comparison of effluent concentrations against appropriate screening criteria.

Neither the Peterborough Sewer Use By-Law (By-Law Number 15-075) nor the CCME Model Sewer Use Bylaw (Marbek Resources Canada Ltd. 2009) specify limits for either beryllium or uranium compounds. For purposes of screening, effluent discharges were therefore screened against licence and internal limits as well as drinking water and environmental quality standards.

It is noted that the general public has no direct access to sewer discharges and that significant additional dilution is expected in transit to and within the sewage treatment plant with further significant dilution expected when effluent from the municipal sewage treatment plant is discharged to surface waters. Therefore, comparison of effluent to drinking water quality criteria is extremely conservative.

As shown in Table 3-4, average annual uranium concentrations discharged range from 20 to 220 ppb, at the point of discharge to the plant sewer system, with a maximum concentration of 410 ppb at this location. Average annual uranium concentrations are at or approximately 10 times the Health Canada and Ontario drinking water criteria of 20 ppb. These discharges go through substantial dilution both within the City of Peterborough sewage treatment plant and again once effluent from the plant is discharge to the environment. For example, a batch dicharge consists of 205 L compared to a sewage treatment plant approved average daily flow capacity of of 68,200,000 L/day (i.e., 0.0003% of total plant flow) (City of Peterborough n.d.). As such, uranium concentrations on discharge to the enviroment will be trivial compared to to the drinking water criteria.

At the point of release to the sewer, the highest single measured value of beryllium at 9.1 µg/L exceeds the *Internal Control Level* but is below the WHO drinking water quality guideline. The maximum annual average concentration of 1.4 µg/L is below the *Internal Control Level*. As noted above, significant dilution occurs both in the City of Peterborough sewage treatment plant and in the receiving waters reducing the dischages to well below the WHO driking water guidelinw.

Therefore, no non-radiological waterborne substances have been identified as COPCs for further assessment.

Table 3-3 Air Quality Screening – Human Health Risk

Contaminant	NFAO Emission Rate (g/s)	Averaging Period	Air Dispersion Model Used	Maximum Ground Level Concentration (µ/m^3)	ACB Limit Screening Criteria (µ/m^3)	Limiting Effect	Percentage of MECP POI Criteria	Carried Forward to Tier 2 Assessment
Uranium	4.13E-10	Annual	AERMOD	1.59E-07	0.03	Health	<1%	No
Beryllium	7.96E-08	24 Hour	N/A	(1)	0.01	Health	<1%	No
Ethylbenzene	3.53E-01	24 h	AERMOD	48.4	1000	Health	5%	No
Ethylbenzene	3.53E-01	10-min	AERMOD	160	1900	Health	8%	No
Benzyl Alcohol	2.76E-01	24 h	AERMOD	37.8	880	Health	4%	No
Nitrogen Oxides(3)	8.54E-1	1 h	AERMOD	125	400	Health	31%	No
Methyl Isobutyl ketone	6.21E-01	24	AERMOD	85.1	1200	Odour	7%	No
Meta-Xylene	1.20E-01	24 h	AERMOD	16.5	730	Health(2)	2%	No
Meta-Xylene	1.20E-01	10-min	AERMOD	54.4	3000	Odour(2)	2%	No
Cyclohexanone	1.20	24-h	AERMOD	165	400	Health	41%	No
Xylenes	1.22	24-h	AERMOD	168	730	Health	23%	No
Xylenes	1.22	10-min	AERMOD	553	3000	Odour	18%	No
Barite	3.17E-03	24-h	AERMOD	0.43	2.5	Health	17%	No
Talc	9.5E-03	24-h	AERMOD	1.3	2	Health	65%	No
Quartz, Silica	1.17E-03	24-h	AERMOD	0.16	5	Health	3%	No
Chromium VI	1.55E-08	annual	AERMOD	1.-2E-06	0.00014	Health	<1%	No
Epoxy Resin	6.58E=02	24-h	AERMOD	9.01	120	Health & Particulate	8%	No
Isophoronedeiamine	6.67E-04	24-h	AERMOD	0.0914	19	Health	<1%	No

Contaminant	NFAO Emission Rate (g/s)	Averaging Period	Air Dispersion Model Used	Maximum Ground Level Concentration (µ/m^3)	ACB Limit Screening Criteria (µ/m^3)	Limiting Effect	Percentage of MECP POI Criteria	Carried Forward to Tier 2 Assessment
Propylene Glycol T-butyl Ether	1.04E-01	24-h	AERMOD	14.2	365	Health	4%	No
Aromatic 100	1.12E-01	24-h	AERMOD-	15.3	500	Health	3%	No
Nickel	2.42E-05	Annual	AERMOD	0.00159	0.04	Health	4%	No
Chromium	2.17E-04	24-h	AERMOD	.115	0.5	Health	23%	No
Isobutyl Alcohol	1.04E-01	24-h	AERMOD	14.2	4600	Health	<1%	No
Isobutyl Alcohol	1.04E-01	10-min	AERMOD	46.8	2340	Odour	2%	No
Methyl Ethyl Ketone (MEK)	3.68	24-h	AERMOD	504	1000	Health	50%	No
Naphthalene	4.96E-03	24-h	AERMOD	0.68	22.5	Health	3%	No
Naphthalene	4.96E-03	10-min	AERMOD	2.24	50	Odour	4%	No
Particulate Matter	2.26E-02	24	AERMOD	12	120	Visibility	10%	No

Notes
1. Beryllium was not modelled as it was determined to be a *de minimum* compound. The MECP Point of Impingement (POI) for Beryllium is 0.01 µg/m^3. The POI is the plant/public boundary. BWXT NEC has established an *Internal Control Level* of 0.01 µg/m^3 air at the stack exit. Dilution between the stack and the plant boundary also reduces the concentrations at the POI. As no emissions in excess of the *Internal Control Level* were measured over the 2017 to 2021 period, the maximum ground level concentration is well below the POI standard (i.e., concentrations are below the POI at the point of discharge).
2. Limit for xylene used as per note 22 of the ACB list (MOECC 2018a).
3. Include emissions for GE.

Table 3-4 Water Screening – Human Health Risk

Contaminant[1]	BWXT NEC Undiluted Maximum Effluent (2017 to 2021)	BWXT NEC Undiluted Average Annual Effluent (2017 to 2021)	Screening Criteria	Source	Carried Forward to Tier 2 Assessment
Uranium	0.41 mg/L	0.02 to 0.22 mg/L	6 mg/L (per batch)	Action Level [2]	No
			0.02 mg/L MAC [3]	Health Canada (2022);	
			0.02 mg/L[4]	O.Reg. 160/03	
Beryllium	9.1 µg/L	0.6 to 1.4 µg/L	4.0 µg/L	Internal Control Level [5]	No
			12.0 µg/L	WHO 2017	

Notes

1. See Table 2-15 for effluent data.
2. An A*ction Level* is defined in the *Radiation Protection Regulations* "as specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program, and triggers a requirement for specific action to be taken." *Action Levels* are also applied to environmental protection and are approved by the CNSC.
3. MAC - maximum acceptable concentrations for drinking water.
4. Prescribed as drinking water quality standards for the purposes of the *Safe Drinking Water Act*, 2002.
5. The *Internal Control Level* corresponds to the US Environmental Protection Agency Maximum Contaminant Level for beryllium (US EPA 2016).

3.4 Assessment of Physical Stressors

Noise was identified as a potential physical stressor for human health. The NFAO complies with MECP NPC-300 noise criteria. Therefore, it is expected that noise levels from the proposed facility will pose no adverse effects to human health.

Noise is the only physical stressor to be considered for the HHRA, consistent with CSA N288.6:22

3.4.1 Screening Criteria

The criteria specified in the Ontario Ministry of the Environment, "Environmental Noise Guideline Stationary and Transportation Source – Approval and Planning" Publication NPC-300 (MOE 2013) are used for the noise assessment:

3.4.2 Noise

An Acoustic Assessment Report (AAR) prepared by GHD (GHD 2022a) estimates that the steady state sound levels at the identified sensitive receptors (Points of Reception - POR) near the Facility comply with the NPC-300 criteria of 50 dBA for the 7 a.m. to 11 p.m. period and 45 dBA at the plane of window of noise sensitive spaces for the 11 p.m. to 7 a.m. period as applicable to an urban (Class 2) setting. PORs considered include indoor and outdoor exposure to ten residences located near the property line, six on the north side, three on the south side and one to the east of the NFAO. Noise modelling completed in support of the AAR shows that the noise level from the NFAO meet the MECP noise criteria. As such, it can be concluded that the current noise levels from the NFAO pose no adverse effects to human health.

3.5 Risk Characterization

For the radiological emissions, gamma dose rates at the fenceline are at or marginally above background. The estimated doses as a result of air releases and gamma radiation are estimated to be 5.8 % of the screening dose limit. Therefore, no adverse radiological effects to human health are expected, and additional assessment is required.

Non-radiological emissions are generally well below applicable screening criteria and pose no threat of adverse effects to human health. No additional assessment is required.

Noise levels from the NFAO are compliant with the NPC-300 for all locations and time periods. Therefore, the NFAO poses no adverse effects to human health.

The screening level risk assessment takes into account emissions to and concentration in different applicable media including air and surface water and uses conservative estimates of emissions and effects criteria.

For the radiological emissions, gamma dose rates at the fenceline are at or marginally above background. Doses from water exposure are trivial due to the extremely small quantity of uranium released. The estimated annual effective dose to the general public as a result of air releases from the NFAO is estimated to be 0.0 µSv/y, representing 0.0% of the public dose limit, with a maxium estimated dose for one of five years (2019) of 11.5 µSv/y or 5.8% of the screening dose criteria of 200 µSv/y). Therefore, no adverse radiological effects to human health are expected due to the NFAO and no additional assessment is required.

Non-radiological contaminants emitted to air and water as a result of the NFAO are generally well below applicable screening criteria and pose no threat of adverse effects to human health. No additional assessment is required.

For noise, the analysis of the modelling results shows that noise levels from the NFAO are compliant with the NPC-300 for all locations and time periods. Therefore, the NFAO poses no adverse effects to human health.

3.6 Uncertainty Associated with the Human Health Risk Assessment

Uncertainty could be introduced into the risk assessment during the screening level assessment or risk characterization. This uncertainty can be minimized through the use of longer term data sets, along with the use of conservative assumptions to ensure that human health is protected. A qualitative analysis of the uncertainty associated with the HHRA is presented below.

The HHRA followed the process defined in N288.6:22 providing a level of assurance that the screening HHRA was completed in an acceptable manner.

There is uncertainty in the selection of the critical receptor and associated behaviours. Given that only a screening level risk assessment was necessary, detailed receptor characteristics were not required.

For the radiological risk assessment, site monitoring data were used along the CNSC accepted approach to calculating the derived release limit. Calculated doses to the general public using this CNSC approved approach have been consistent over a number of years, and are well below the regulatory dose limit.

The two key non-radiological contaminants, uranium and beryllium, are frequently monitored in air emissions and liquid effluent increasing the likelihood that the monitored results are representative of actual emissions and able to detect any adverse trends. The detection limits used are very low allowing for the detection of these contaminants in facility emissions. During the screening process, to be conservative, the maximum concentrations of uranium and beryllium detected over a number of years were compared against a range of screening criteria accepted by the CNSC or published by reputable agencies. Further, monitoring results were well below screening criteria, providing additional confidence that the screening criteria are not exceeded. These conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

For other non-radiological air emissions, the calculations are based on the operating conditions, including start-up and shut-down, where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with s. 11 of O. Reg. 419/05. The majority of emissions other than beryllium and uranium are attributed to the operation of the spray paint booth and the metallurgical lab which are intermittent operations.

In particular, emissions from the spray paint booth represent all potential emissions from all products potentially used and therefore significantly overestimate the total emissions at any given time. Therefore, these emission rates are not likely to underestimate the actual emission rates. Further, screening criteria established by the MECP for its environmental compliance approval process on the basis of scientific review and analysis were used.

There is uncertainty in the AERMOD model used to predict atmospheric dispersion of air releases. These include uncertainty in modelling building-induced turbulence on the effective release height and plume spread and the use of a given meteorological dataset. In general air dispersion models can vary by a factor of two. The air assessment was completed using a methodology established and a model approved by the MECP, based on criteria established by the MECP, and reviewed by the MECP through the environmental compliance approvals process. The conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

There is uncertainty in both the noise measurements and the modelling. Sound level monitoring units generally have a measurement error of within +/- 1 dBA. For noise modelling, uncertainty arises in the assessment of source sound levels in the noise modelling of sound propagation. The noise assessment was completed using a methodology established and a model approved by the MECP, based on criteria established by the MECP, and reviewed by the MECP through the environmental compliance approvals process. Therefore, it is expected that the uncertainty associated with the noise levels has no impact on the conclusions.

In summary, the assessment method and the conservative assumptions used for the HHRA ensure that the actual risks are not underestimated. Therefore, the uncertainty associated with the assessment has no impact on the conclusions of the HHRA.

4 Ecological Risk Assessment

The prime hazards to the environment from the NFAO are uranium, beryllium and gamma radiation through emissions to air and water.

Pathways for ecological exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*
- *Soil deposition gamma and beta ground shine; and*
- *Soil ingestion and resuspension inhalation*

Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, consequently detailed receptor characterization was not required.

Potential physical stressors to biota include road kill, bird strikes, heat, noise and artificial lighting.

4.1 Problem Formulation

As noted in Section 3.1, Problem formulation is a step undertaken early in the ERA process to constrain and focus the ERA on the key questions. The following discussion describes the approach taken to focus the EcoRA.

4.1.1 Receptor (Valued Component) Selection and Characterization

Valued Components identified include:

- *Doses to non-humans;*
- *Soil invertebrates.*
- *Terrestrial vegetation; and*
- *Mammals and birds.*

However, because the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed receptor characterization was not required.

4.1.1.1 Receptor Selection

It is not practical to assess the radiological or non-radiological dose to each species residing in the vicinity of the NFAO. For the purpose of the EcoRA, Valued Components (VCs) were chosen for assessment.

VCs, as defined by the Impact Assessment Agency of Canada, refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples or the public. The value of a component may be determined on the basis of cultural ideals or scientific concern (CEAA 2018). Examples of VCs are provincially significant wetlands, fish habitat, species (flora and fauna), and significant landscapes.

Selection of ecological VCs is based on knowledge of the site ecology and habitats as summarized in the Environmental Impact Statement for the Low Enriched Uranium Fuel Bundle Production Project (GEH-C, 2009). During the environmental assessment (EA) for the Low Enriched Uranium Fuel Bundle Production Project, a "*Plugged into Peterborough*" newsletter was published in the fall of 2008 and distributed to approximately 3600 households, after the project Guidelines had been approved by the CNSC. This newsletter provided a preliminary list of VCs and included a mail back response card for residents to complete and provide feedback on the list of VCs. No changes or additions were required as a result of input received.

Selection of VCs and indicators was made from members of the terrestrial and aquatic biota found within the "Local Study Area" defined in the EA as the area bounded by High Street to the west, Park Street to the east, Albert Street in the south, and Sherbrooke Street to the north (see Figure 2-1). Criteria used for the selection of VCs and indicators included presence and abundance, sensitivity to changes and ecological niche of the various species of the terrestrial and aquatic environments.

Three potential sub-components were identified as part of the terrestrial environment: terrestrial vegetation (species and communities); and wildlife (species and community) and wildlife habitat. In order to capture changes in these sub-components, a total of seven measurable indicators were chosen:

- Soil invertebrates, as represented by earthworms;
- Vegetation as represented by grass (contamination levels);
- Insectivorous birds as represented by the American Robin;
- Herbivorous birds as represented by the American Robin;
- Small mammalian herbivores as represented by the Eastern Cottontail;
- Small mammalian omnivores (mostly insects) as represented by the Deer Mouse; and;
- Small mammalian omnivores as represented by the Red Fox.

The American Robin relies on seeds and vegetation for a portion of the year and on insects for a different portion of the year, and therefore can be a surrogate for both insectivorous and herbivorous avian species. Potential sub-components associated with the aquatic environment were not considered as there is no aquatic environment present on or near the site.

Table 4-1 identifies the VCs applicable to the NFAO and provides a rationale for the selection of these VCs.

Table 4-1 Valued Components

Environmental Components	Sub-components	VCs	Indicator/Receptors	Rationale
Radiation and Radioactivity	Radiation	Doses to non-humans	• Non-human biota as identified by Terrestrial Environment	• Non-human biota are potentially exposed to stressors produced by the NFAO • Protection of ecological health
Terrestrial Environment	Soil Quality	Soil invertebrates	• Earthworm	• Protection of ecological health
	Vegetation Communities and Species	Terrestrial Vegetation	• Grass	• Protection of ecological health
	Wildlife Communities and Species	Mammals & birds	• Red Fox (omnivore) • Deer Mouse (omnivore mostly insects) • Eastern Cottontail (herbivore) • American Robin (insectivore and herbivore)	• Terrestrial species are potentially exposed to stressors produced by the NFAO • Protection of ecological health

4.1.1.2 Receptor Characterization

As discussed in Sections 4.2 and 4.3, as the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed ecological receptor characterization was not required.

4.1.2 Assessment and Measurement Endpoints

Assessment endpoints are directly related to management goals but are usually stated in terms of an attribute of populations or communities. When it is not practical to quantify those attributes, measurements endpoints representing more readily measured or predicted surrogates are used (CSA 2022). The assessment endpoint for each VC in this EcoRA is either population success or contaminant level, as shown in Table 4-2.

Table 4-2 Assessment Endpoints for Indicator Species

VC/Indicator Species	Assessment Endpoint			
	Individual Success	Population Success	Community Success	Contaminant Level
Grass	-	-	-	✓
Earthworm	-	✓	-	-
American Robin	-	✓	-	-
Eastern Cottontail	-	✓	-	-
Deer Mouse	-	✓	-	-
Red Fox	-	✓	-	-

4.1.3 Selection of Chemical, Radiological, and Other Stressors

The key stressors to the environment from the NFAO are uranium, beryllium and gamma radiation. Artificial night lighting and noise were identified as potential physical stressors.

Radiological and non-radiological stressors used in the EcoRA are identical to those used for the HHRA. Key stressors are uranium, beryllium, and gamma radiation.

CSA N288.6:22 also identifies heat, wildlife-vehicle/bird-structure mortalities, and intake cooling water withdrawal as the physical stressors applicable to ecological receptors. None of these stressors are relevant to the NFAO. Artificial night lighting and noise also have the potential to interact with receptors.

The tiered approach to EcoRA, requires these contaminants to undergo a Tier 1 preliminary screening where conservative estimates of emissions and environmental concentrations are compared to screening criteria. The objective of this preliminary screening process is to identify COPCs which are those contaminants that have undergone preliminary screening and have been selected for evaluation in higher tiers of assessment.

4.1.4 Selection of Exposure Pathways

Pathways for ecological exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*

Exposure through soils and terrestrial plant chain are not relevant due to the negligible amounts of beryllium and uranium released to air and consequent negligible contribution to soil levels. Exposures through surface waters and the aquatic food chain are also not relevant due to the negligible amounts of beryllium and uranium released to water and the absence of any surface waters in the immediate area of the facility. Exposures through groundwater and surface runoff are not expected.

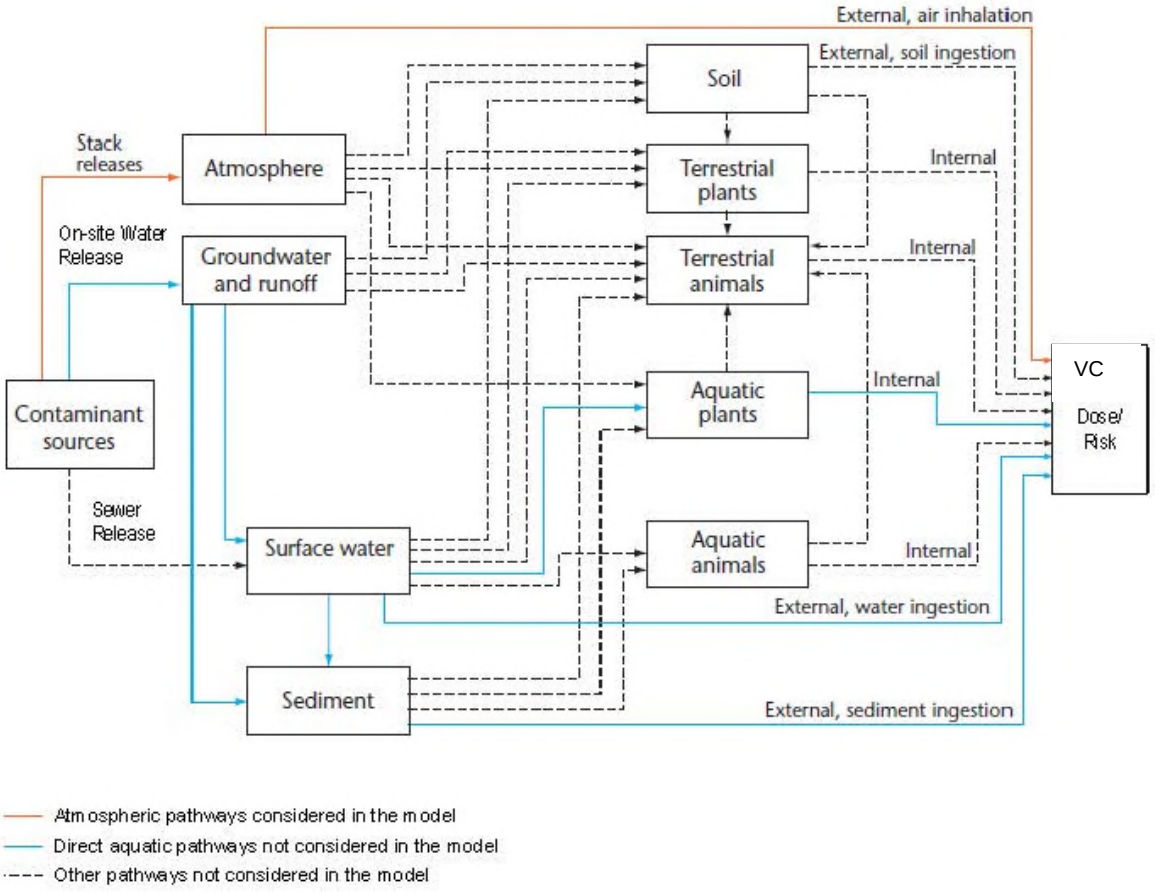
Radiological and non-radiological materials are released by the NFAO to the environment. Consequently, this could result in the emissions to various media, potentially including air, surface water, soil, sediment, groundwater, and other media such as vegetation. VCs could be exposed to contamination through various pathways, an example of which is shown in Figure 4-1.

Of the pathways shown in Figure 4-1, the primary pathways for COPCs associated with the NFAO are:

- Air inhalation/skin absorption; and
- Air immersion (external exposure).

Exposure through soils and terrestrial plant chain are not relevant due to the negligible amounts of beryllium and uranium released to air and consequent negligible contribution to soil levels. This is confirmed through CNSC IEMP sampling (see Appendix A) which measured uranium and beryllium concentrations around background in soil and no uranium in detectable quantities in grass.

Exposures through surface waters and the aquatic food chain are also not relevant due to the negligible amounts of beryllium and uranium released to water (see Section 2.2.10.1) and the absence of any surface waters in the immediate area of the facility. Exposures through groundwater and surface runoff are not expected.



Source (Adopted from CSA, 2022)

Figure 4-1 Sample Ecological Exposure Pathway Model

4.2 Assessment of Radiological Impact

Radiological materials expected to be released which may affect non-human biota include uranium to air and water (which is negligible) and direct gamma radiation from the facility.

Radiation (external and internal) exposure due to uranium emissions to air is negligible as the uranium in air concentrations and soil concentrations associated with the NFAO are negligible, consequently inhalation and soil ingestion are not expected to be of concern. Direct external exposure to gamma radiation is estimated to be well below levels that are known to cause adverse effects. Therefore, it can be concluded that no radiological effects to VCs are expected due to the NFAO and no further assessment is required.

Radiological materials are released to the environment by the NFAO. In this section, the impacts of radiological releases on non-human biota are assessed at the screening level (Tier 1) first. PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) is not required, based on the screening level review.

Radiological materials released include uranium to air and water (which is negligible). Direct gamma radiation from the facility is also a consideration. Internal exposure through pathways such as consumption of soil, vegetation and water is negligible.

Uranium has both radiological and non-radiological effects. Uranium releases are discussed in more detail in Section 4.3.

4.2.1 Radiation Benchmark

Currently, dose limits to non-human biota have not been set by the CNSC or other regulatory agencies in Canada (CSA, 2022). Radiological releases to air were screened to identify COPCs. The following dose benchmark values, as recommended in CSA N288.6:22, are used in this assessment:

- 100 µGy/h for terrestrial biota, and;
- 400 µGy/h for aquatic biota.

In accordance with N288.6;22, risk to radiation is quantified for each category based on the calculation of a hazard quotient (HQ) defined as:

$$HQ = \frac{Calculated\ radiation\ dose}{Radiological\ criteria\ (Benchmark)}$$

For radiological risk, the HQ is calculated based on the total dose received by each receptor from all radionuclides through all pathways. If the HQ for radiological exposure is less than one, then no adverse effects are likely as levels are below those that are known to cause adverse effects. If the HQ exceeds one, it may be inferred that

adverse effects to individuals are possible. In general terms, an increase in exposure is associated with an increase in risk. As the magnitude of the HQ increases so does the potential for environmental effects. An HQ greater than1 indicates that there is the potential for adverse effects and further assessment is required.

4.2.2 Radiation Exposure to VCs

VCs could potentially receive radiation doses from direct external exposure to gamma radiation from the NFAO and external and internal exposure through pathways such as air exposure.

The external dose rates from environmnental TLDs at the boundary of the NFAO are routinely measured (see Section 2.2.10.2). As shown in Table 2-18 the maximum annual dose rate was 0.19 µSv/h (inclusive of background) over the 2016 to 2022 period. Measured dose rates at the property boundary are similar to and of the same order of magnitude as background doses and are well below the benchmark of 100 µGy/h for terrestrial biota.

Radiation (external and internal) exposure due to uranium emissions are trivial as only between 0.002 to 0.004 g of uranium per year have been emitted from the NFAO over the 2017 to 2021 period. Measured airborne concentrations of uranium in the environment were also very low, with a maximum value of 0.0013 µg U/m^3 (CNSC, 2022). Further, as per CSA N288.6:22, Clause 7.3.4.2.5, “inhalation exposures to biota are usually minor compared to soil and food ingestion pathways and can be ignored in most EcoRAs. For particulate substances released to air and accumulating over time in the soil, the steady state concentration is usually high enough that soil and food components of dose are dominant”. As discussed in Section 2.2.10.2, uranium in soil concentrations are at or below the Ontario background level of 2.5 µg U/g dry weight. Therefore, exposure of VCs to facility emissions through direct inhalation of soil ingestion is not of concern.

As a result, direct external exposure to gamma radiation is the only pathway for radiation exposure to VCs. The resulting HQ of approximately 0.0003 (assuming continuous exposure at the maximum gamma radiation level measured) is well below one, the value at which no adverse effects are likely as levels are below those that are known to cause adverse effects.

Therefore, it can be concluded that there are no radiological effects to VCs due to the NFAO and no further assessment is required.

4.3 Assessment of Non-Radiological Impact

No non-radiological airborne or waterborne substances have been identified as COPCs for further assessment in the EcoRA.

Non-radiological releases to the environment occur from the NFAO. In this section, the impacts of non-radiological contaminants on VCs are assessed at the screening level (Tier 1) first. Based on the results of the screening level assessment, PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) are not required.

4.3.1 Screening Criteria

The non-radiological substances in air were screened to identify COPCs. CSA N288.6:22, Clause 7.2.5.3.1, indicates that "For non-radiological COPCs, the most restrictive applicable federal or provincial guidelines for environmental quality should be used as screening criteria, if such guidelines are available, because their values are intended to be protective of all or most organisms in the media to which they apply."

4.3.2 Air

Non-radiological airborne emissions considered included uranium, beryllium, particulate matter, volatile organic compounds, trace metals, and nitrogen oxides. 70% of non-negligible airborne non-radiological contaminants emitted from the NFAO have modelled air concentrations 10% or less of the applicable screening criteria and only 2 had modelled concentrations of 50% or more of the applicable screening criteria at 50% and 65%. Other than uranium, beryllium and combustion sources, all other airborne sources were from low use, intermittent operations which were very conservatively modelled as operating continuously and are therefore highly overestimated. Furthermore, non-radiological substances with CNSC licence limits, BWXT NEC Action Levels, BWXT NEC Internal Control Levels were well below these limits and are therefore expected to be negligible.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the EcoRA.

As per CSA N288.6:22, Clause 7.3.4.2.5, "inhalation exposures are usually minor relative to soil and food ingestion pathways and can be ignored in most EcoRAs. For particulate sustances released to air and accumulating over time in the soil, the steady state concentration is usually high enough that soil and food components of dose are dominant." Some gaseous substances [e.g. nitrogen oxides (NO_x)] that do not partition well to soil might need to be addressed. These substances are usually addressed relative to air concentration benchmarks, without calculating dose. Under current conditions nitrogen oxides (NO_x) are emitted only from the combustion equipment at the site (natural gas fired boilers and hot water heater).

Other than beryllium in soil sampling commenced in 2021, environmental sampling of non-radiological substances is not completed by BWXT NEC. As such, airborne concentrations predicted in the site's ESDM (see Section 3.3) were used to screen non-radiological substances, such as Uranium, Beryllium, Particulate Matter (PM), Volatile Organic Compounds (VOCs), Trace Metals, and other miscellaneous contaminants that could be released to air from the NFAO. The primary airborne emission sources at the NFAO, include:

- Uranium from the Uranium Oxide Element Decan Exhaust;
- Beryllium from three stacks in the Beryllium Area; and
- Combustion sources.

As discussed in Section 3.3, the maximum POI concentrations modelled for contaminants emitted by the NFAO are below limits published in the MECP publication *Air Contaminants Benchmarks List: standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants* (MOE 2018a), and are not likely to have potential effects on ecological receptors located on site. CNSC IEMP environmental air sampling (see Appendix A) confirms that uranium and beryllium levels are very low (<5% of applicable standards).

Further, per CSA N288.6:12, soil and food components are dominant pathways sources for uranium. As discussed in Section 2.2.10.2, uranium in soil concentrations are at or below the Ontario background level of 2.5 µg U/g dry weight. Therefore, exposure of VCs to uranium through soil ingestion is insignificant.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment.

4.4 Assessment of Physical Stressors

The NFAO is located in a highly urbanized area which limits the site-specific potential for physical stressors such as wildlife-vehicle/bird-structure mortalities, heat, noise or artificial lighting. As such, none of these stressors are particularly relevant to the NFAO and no further assessment is required.

CSA N288.6:22 identifies heat, wildlife-vehicle/bird-structure mortalities, and intake cooling water withdrawal as the physical stressors applicable to ecological receptors. Artificial night lighting and noise also have the potential to interact with receptors.

For noise, the analysis of the modelling results shows that noise levels from the operation of the NFAO are compliant with the NPC-300 for all locations and time periods. The noise generated by the NFAO is common to other noise sources in the urban setting which must meet MECP noise limits and would have similar impacts on exposure to ecological receptors in the vicinity of the facility. Therefore, the NFAO poses no adverse noise effects.

Aritifical light from the facility is not substantively different than that of the surrounding urbanized environment.

The NFAO is located in a highly urbanized area which limits the site-specific potential for physical stressors (artificial night lighting or noise) to impact on VCs. As such, neither of these stressors are particularly relevant to the NFAO and no further assessment is required.

4.5 Risk Characterization

The estimated radiological doses to non-human biota are estimated to be at or marginally above background. Potential non-radiological contaminants are estimated to be well below applicable screening criteria and pose no adverse effects to the environment.

No physical stressors to non-human biota were identified.

The screening level risk assessment takes into account emissions to and concentration in different applicable media including air and surface water and uses conservative estimates of emissions and effects criteria.

For the radiological emissions, gamma dose rates at the fenceline are at or marginally above background. Doses from water exposure are trivial due to the extremely small quantity of uranium released. Radiation (external and internal) exposure due to uranium emissions are trivial as only between 0.002 to 0.004 g of uranium per year have been emitted from the NFAO over the 2017 to 2020 period. As a result, direct external exposure to gamma radiation is the only pathway for radiation exposure to VCs. The resulting HQ of approximately 0.0019 (assuming continuous exposure at the maximum gamma radiation level measured, inclusive of background) is well below one, the value at which no adverse effects are likely as levels are below those that are known to cause adverse effects. Therefore, it can be concluded that there are no radiological effects to VCs due to the NFAO and no further assessment is required.

Non-radiological contaminants emitted to air and water from the NFAO are generally well below applicable screening criteria and pose no adverse effects the environment. No additional assessment is required.

For noise, the analysis of the modelling results shows that noise levels from the operation of the NFAO are compliant with the NPC-300 for all locations and time periods. The noise generated by the NFAO is common to other noise sources in the urban setting which must meet MECP noise limits and would have similar impacts on exposure to ecological receptors in the vicinity of the facility. Therefore, the NFAO poses no adverse noise effects.

The NFAO is located in a highly urbanized area which limits the site-specific potential for physical stressors (artificial night lighting or noise) to impact on VCs. As such, neither of these stressors are particularly relevant to the NFAO and no further assessment is required.

4.6 Uncertainty Associated with Ecological Risk Assessment

Uncertainty could be introduced into the risk assessment during the screening level assessment or risk characterization. This uncertainty can be minimized through the use of longer term data sets, along with the use of conservative assumptions to ensure that human health is protected. A qualitative analysis of the uncertainty associated with the EcoRA is presented below.

The EcoRA followed the process defined in N288.6:22 providing a level of assurance that the screening EcoRA was completed in an acceptable manner.

The two key non-radiological contaminants, uranium and beryllium, are frequently monitored in air emissions and liquid effluent increasing the likelihood that monitoring results are representative of actual emissions and able to detect any adverse trends. Detection limits used are very low allowing for the detection of these contaminants in facility emissions. For both the radiological and non-radiological EcoRA, long term site monitoring data were used.

For other non-radiological air emissions, the calculations are based on the operating conditions, including start-up and shut-down, where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with s. 11 of O. Reg. 419/05. Therefore, these emission rates are not likely to underestimate the actual emission rates. Further, screening criteria established by the MECP for its environmental compliance approval process on the basis of scientific review and analysis were used. Conservatively, all emissions from the Peterborough complex, including non-radiological operations not related to BWXT NEC were used in the screening process. The air assessment was completed using a methodology established and a model approved by the MECP, based on criteria established by the MECP, and reviewed by the MECP through the environmental compliance approvals process. The conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

Other than boundary gamma radiation monitoring data, limited site generated environmental monitoring data are available. The very low levels of uranium and beryllium emissions do not warrant comprehensive environmental monitoring. As such, alternate methods of screening were required. Given the very low levels of emissions and monitored boundary gamma radiation levels near background, this is not viewed as a limitation; environmental concentrations are expected to be correspondingly low allowing for a wide margin of safety in the screening process. MECP groundwater and surface water monitoring data confirm that environmental uranium and beryllium concentrations are low. Additional information on environmental uranium in air concentrations is provided through the CNSC IEMP program which confirms the assessment that uranium in ambient air and soil concentrations are very low.

During the screening process, to be conservative, the maximum concentrations of uranium and beryllium and maximum monitored boundary gamma radiation levels detected over a number of years were compared against a range of screening criteria published by reputable agencies, and, in the case of the radiation risk assessment, N288.6:22 recommended benchmark criteria. Further, monitoring results were well below screening criteria, providing additional confidence that the screening criteria are not exceeded. These conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

There is some uncertainty in the selection of critical human receptors, VCs and exposure pathways assumed. Given the very low levels of emissions, screening was undertaken based on abiotic concentrations, negating any uncertainty in the selection of VC and exposure pathways assumed.

In summary, the assessment method and the conservative assumptions used for the EcoRA ensure that the actual risks are not underestimated. Therefore, the uncertainty associated with the assessment has no impact on the conclusions of the EcoRA.

5 Conclusions And Recommendations

5.1 Conclusions

Overall, emissions associated from the NFAO and associated risks are low.

5.1.1 Human Health Risk Assessment

5.1.1.1 Radiological Exposure

The screening level HHRA concluded that emissions of radioactive materials from the facility were very low and that the maximum estimated annual effective dose as a result of air releases and direct gamma radiation from the facility is negligible at 11.5 µSv/y or 6% of the screening dose criteria of 200 µSv/y. Exposure to water releases are also estimated to be trivial. Based on the screening level risk assessment, it is concluded that emissions of radiological materials from the NFAO pose no adverse effects to human health. Further assessment of the impact of radiological materials on human health is not required.

5.1.1.2 Non-Radiological Exposure

The screening level HHRA concluded that emissions of non-radioactive contaminants from the facility were below, and often substantially below, MECP Point of Impingement standards based on human health and odour considerations. Exposure to water releases is also estimated to be trivial based on the concentrations and quantities released. Based on the screening level risk assessment, it is concluded that emissions of non-radiological substances resulting from the NFAO pose no adverse effects to human health. Further assessment of the impact of non-radiological contaminants on human health is not required.

5.1.1.3 Physical Stressors

Noise was the only physical stressor requiring consideration. The screening level HHRA concluded that noise levels were below MECP established criteria. Based on the screening level risk assessment, it is concluded that noise emissions resulting from the NFAO pose no adverse effects to human health. Further assessment of the impact of non-radiological contaminants on human health is not required.

5.1.2 Ecological Risk Assessment

5.1.2.1 Radiological Exposure

The screening level EcoRA concluded that emissions of radioactive materials from the facility resulted in exposure to non-human biota well below the benchmark criteria of 100 µG/h for terrestrial biota. Based on the screening level risk assessment, it is concluded that emissions of radiological materials from the NFAO pose no adverse effects to non-human biota. Further assessment of the impact of radiological materials on non-human biota is not required.

5.1.2.2 Non-Radiological Exposure

The screening level EcoRA concluded that emissions of non-radioactive contaminants from the facility were below, and often substantially below, MECP Point of Impingement standards. Exposure to water releases is also estimated to be trivial based on the concentrations and quantities released. Based on the screening level risk assessment, it is concluded that emissions of non-radiological substances from the NFAO pose no adverse effects to non-human biota. Further assessment of the impact of non-radiological contaminants on non-human biota is not required.

5.1.2.3 Physical Stressors

The NFAO is located in a highly urbanized area which limits the site-specific potential for physical stressors (artificial night lighting or noise) to impact on VCs. The screening level EcoRA concluded that the NFAO poses no physical stressors on VCs. Further assessment of the impact of physical stressors on VCs is not required.

5.2 Recommendations for the Monitoring Program

Based on the results of the HHRA and EcoRA, there are no specific recommendations for changes in the effluent or environmental monitoring programs.

5.3 Risk Management Recommendations

Based on the results of the HHRA and EcoRA, there are no specific recommendations for changes in risk management practices.

6 Quality Assurance / Quality Control

A foundational document for this risk assessment is the 2009 Low Enriched Uranium Fuel Bundle Production Project. Based on a project description submitted to the CNSC, the CNSC determined that a screening level environmental assessment (EA) of the proposed project was required, and issued environmental assessment Guidelines on August 1, 2008. These guidelines identified the scope of the assessment, the basis for carrying out the EA and the focus of the assessment on relevant issues and concerns. This process provide transparency by communicating the EA process to stakeholders.

The ERA was conducted by Arcadis Canada Inc. (Arcadis) in accordance with the requirements of Arcadis' Quality Management System. The Arcadis Quality Management System is ISO 9001 registered and the scope of the ISO 9001:2008 registration covers "environmental consulting services to the nuclear fuel cycle".

BWXT NEC collects emissions and environmental monitoring data in accordance with Peterborough EHS documents in the EHS series, including:

- EHS-P-EMS-1.0P – Environmental Management System Manual
- EHS-P-E-1.0P – Air
- EHS-P-E-2.0P – Water
- EHS-P-BMS-001P, Beryllium Safety Manual
- EHS-WI-RPM-ENV-001P – In-Stack Air Sampling
- EHS-WI-RPM-ENV-002P – Liquid Effluent Sampling
- EHS-WI-RPM-ENV-003P – Boundary Radiation Monitoring
- EHS-WI-BSM-005P, Beryllium Stack Air Sampling
- EHS-WI-BMS-008P, Beryllium Water Sampling

BWXT NEC operates these monitoring programs in accordance with the *Licensed Activity Quality Assurance Program* documentation (BMS-### series), including BMS-BP-004; BMS-P-001 to 016; BMS-P-41 BMS-P-42; and BMS-P-057.

All data used in the risk assessment has been submitted to and reviewed by regulatory agencies, including:

- BWXT NEC Annual Compliance Reports prepared in accordance with Canadian Nuclear Safety Commission's *Annual Compliance Monitoring and Operational Performance Reporting Requirements for Class 1 A & B Nuclear Facilities* and reviewed by the CNSC;
- Emission Summary and Dispersion Modelling Report (ESDM) reviewed by the MECP Approvals Branch; and
- Acoustic Audit Report (AAR) reviewed by the MECP Approvals Branch.

Under BWXT NEC's Environmental Compliance Approval (Air) Number 2755-9GUJWY, both the ESDM and AAR must be kept up to date, with annual reports submitted to the MOECC.

Internal monitoring programs undergo QA/QC and comparative analysis including:

- in-house filter papers used for monitoring uranium stack emissions analyzed in-house are verified by an external independent laboratory by delayed neutron activation analysis;
- in-house filter papers used for monitoring beryllium stack emissions analyzed in by an external independent laboratory; and
- uranium and beryllium water samples analyzed in by an external independent laboratory.

Independent monitoring by regulatory agencies provides additional information for confirming site monitoring programs. The Independent Environmental Monitoring Program (IEMP) completed by the CNSC provides an additional level of QA/QC through additional sampling of parameters monitored by the NFPO. The IEMP involves taking samples from public areas around the facilities and measuring and analyzing the amount of nuclear and hazardous substances in those samples. CNSC staff collect the samples and send them to the CNSC's laboratory for testing and analysis. Results of the CNSC IEMP are consistent with facility monitoring program results.

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Appendix A

BWXT NEC NFAO CNSC IEMP

APPENDIX A – NFAO CNSC IEMP

To complement existing and ongoing compliance activities and site monitoring programs, the Canadian Nuclear Safety Commission (CNSC) implemented an Independent Environmental Monitoring Program (IEMP) to independently verify that the public and environment around CNSC-regulated nuclear facilities are safe. The IEMP is carried out by CNSC staff in publicly accessible areas and consists of sampling environmental media and analyzing radioactive and hazardous substances (as applicable) released from a facility. This program applies to the BWXT NEC Peterborough Nuclear Fuel Assembly Operations (Peterborough NFAO).

The IEMP sampling plan for BWXT NEC NFAO focused on uranium and beryllium. “Uranium is both a radioactive substance (it decays at a slow rate by primarily emitting alpha radiation and, at lower levels, beta and gamma radiation) and a hazardous substance (since exposure to uranium can lead to chemical toxicity). Beryllium is a hazardous substance (can impact health if inhaled) used in the fuel bundle manufacturing process” (CNSC, 2022).

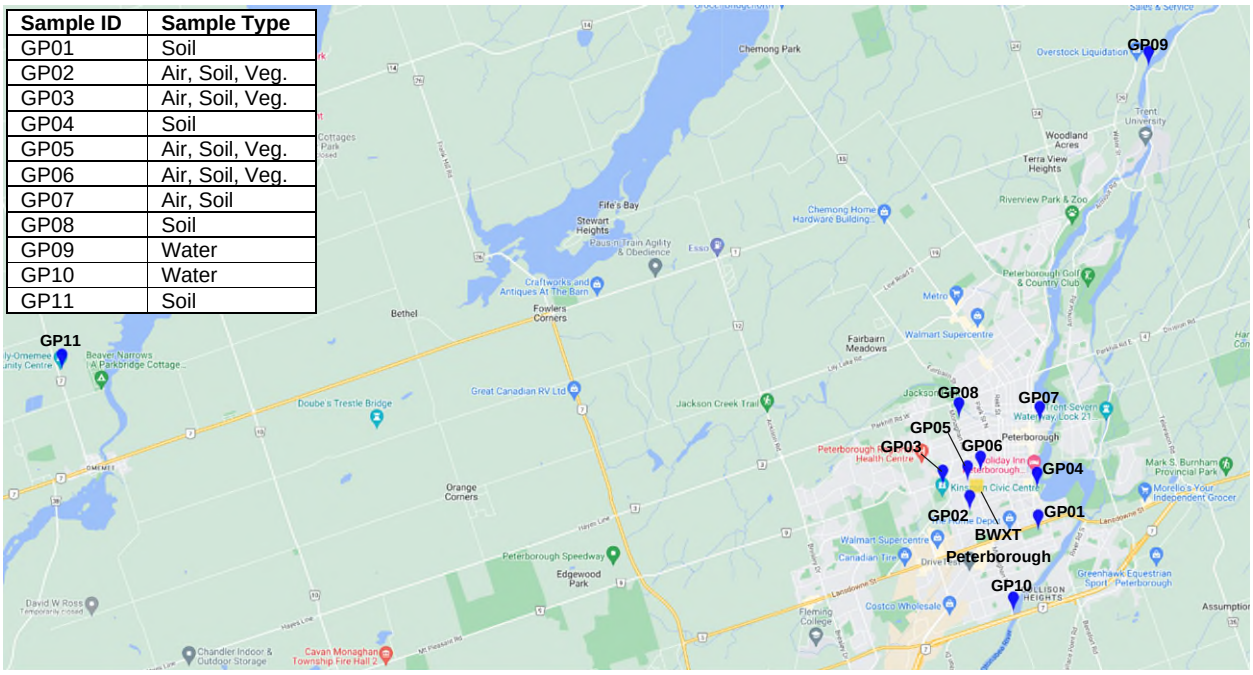
The most recent IEMP sampling was in 2021 for BWXT NEC NFPO and focused on uranium and beryllium in air, soil, and water in publicly accessible areas outside the facility perimeter. IEMP sampling at BWXT NEC NFAO for July 2014, July 2018 and May 2019 also focused on uranium and beryllium in air, soil, and water. In 2020, further to the BWXT NEC licence renewal hearing in March 2020, the CNSC conducted soil resampling for beryllium, as directed by the Commission, at sites adjacent to BWXT’s Peterborough facility (CNSC, 2022). Site-specific sampling plans were developed based on the licensee’s approved environmental monitoring program and CNSC regulatory experience with the site (CNSC 2022). IEMP sampling locations are shown in Figure A-1.

The CNSC concluded that:

> *The levels of uranium and beryllium measured in the samples have been below available guidelines. Measurements conducted by the IEMP to date have consistently found levels of radioactivity in the environment to be low, and well within the range of natural background radiation levels. The concentrations of beryllium in soil collected around the BWXT Peterborough facility remain well below guidelines. As a result, no health or environmental impacts are expected at these concentrations (CNSC 2022).*
>
> *The IEMP results from 2014, 2018, 2019 and 2021 show that the ambient environment surrounding BWXT Nuclear Energy Canada Inc. Peterborough (BWXT Peterborough) is within provincial guidelines, confirming that the licensee’s environmental protection program is effective. The results add to the body of evidence that people and the environment in the vicinity of the BWXT Peterborough facility are protected and that there are no anticipated health impacts.* (CNSC 2022)

Figure A-1 CNSC IEMP Environmental Sampling Locations

Sample ID	Sample Type
GP01	Soil
GP02	Air, Soil, Veg.
GP03	Air, Soil, Veg.
GP04	Soil
GP05	Air, Soil, Veg.
GP06	Air, Soil, Veg.
GP07	Air, Soil
GP08	Soil
GP09	Water
GP10	Water
GP11	Soil



(Source produced based on CNSC 2022)

CNSC IEMP Radioactive Substances Monitoring

The CNSC IEMP completed limited sampling of environmental air, vegetation and soil quality for uranium around the facility starting in 2014. Sample results are summarized in Table A-1 for radioactive substances.

Table A-1 CNSC IEMP Radioactive Substances Monitoring Data

Sample Type	Sample Description	Parameter	2014	2018	2019	2021	Guideline/ Reference Level	Expected Health Impact (Yes/No)	Sample Code
Air	Ambient (Particulate)	Uranium	NA	NA	<0.00009 µg/m³	<0.00004 µg/m³	0.03 µg/m³	No	GP02-A02
Air	Ambient (Particulate)	Uranium	NA	<0.003 µg/m³	N/A	<0.000004 µg/m³	0.03 µg/m³	No	GP03-A03
Air	Ambient (Particulate)	Uranium	0.0013 µg/m³	<0.003 µg/m³	<0.00009 µg/m³	<0.00004 µg/m³	0.03 µg/m³	No	GP05-A01
Air	Ambient (Particulate)	Uranium	N/A	<0.003 µg/m³	<0.00009 µg/m³	<0.00004 µg/m³	0.03 µg/m³	No	GP06-A06
Air	Ambient (Particulate)	Uranium	N/A	<0.003 µg/m³	<0.00009 µg/m³	<0.00004 µg/m³	0.03 µg/m³	No	GP07-A07
Soil	0-5 cm	Uranium(1)	1.2 mg/kg dry weight	1.38 mg/kg dry weight	1.42 mg/kg dry weight	0.57 mg/kg dry weight	23 mg/kg dry weight	No	GP01-S01
Soil	0-5 cm	Uranium	1.8 mg/kg dry weight	1.75 mg/kg dry weight	1.60 mg/kg dry weight	0.71 mg/kg dry weight	23 mg/kg dry weight	No	GP02-S02
Soil	0-5 cm	Uranium	1.6 mg/kg dry weight	1.63 mg/kg dry weight	1.21 mg/kg dry weight	0.5 mg/kg dry weight	23 mg/kg dry weight	No	GP03-S03
Soil	0-5 cm	Uranium	1.5 mg/kg dry weight	1.44 mg/kg dry weight	1.60 mg/kg dry weight	0.74 mg/kg dry weight	23 mg/kg dry weight	No	GP04-S04
Soil	0-5 cm	Uranium	1.6 mg/kg dry weight	1.70 mg/kg dry weight	1.88 mg/kg dry weight	0.65 mg/kg dry weight	23 mg/kg dry weight	No	GP05-S05
Soil	0-5 cm	Uranium	1.5 mg/kg dry weight	1.65 mg/kg dry weight	1.97 mg/kg dry weight	0.64 mg/kg dry weight	23 mg/kg dry weight	No	GP06-S06
Soil	0-5 cm	Uranium	1.mg/kg dry weight	1.67 mg/kg dry weight	1.37 mg/kg dry weight	0.57 mg/kg dry weight	23 mg/kg dry weight	No	GP07-07
Soil	0-5 cm	Uranium	1.7 mg/kg dry weight	1.92 mg/kg dry weight	2.05 mg/kg dry weight	1.27 mg/kg dry weight	23 mg/kg dry weight	No	GP08-S08
Soil	0-5 cm	Uranium	N/A	NA	1.28 mg/kg dry weight	0.44 mg/kg dry weight	23 mg/kg dry weight	No	GP11-S11
Water	Surface Water	Uranium	NA	0.2 µg/L	0.34 µg/L	0.26 µg/L	15 µg/L	No	GP09-W01
Water	Surface Water	Uranium	NA	0.2 µg/L	0.29 µg/L	0.26 µg/L	15 µg/L	No	GP10-W02

Note: (1) For soil samples, the CNSC laboratory began using the partial digestion method as opposed to the total digestion method used before 2020. This change was made so that the 2020 results could be compared with the Canadian Council of Ministers of the Environment Canadian Environmental Quality Guidelines and MECP Soil Quality Standards. As a result, soil concentrations are lower than in previous years.

Source: (CNSC 2022)

Air

Under the IEMP, uranium in air samples have been collected since 2014 at the location shown in Figure A-1 as detailed in Table A-1. The maximum measured airborne uranium concentration was 0.0013 µg/m^3, measured in 2014. Since 2014, all results were below detection limits. All results are well below the MECP ambient air quality objective of 0.03 µg (U in PM10)/m^3 over a 24-hour averaging period (MECP, 2020) corresponding to the sample collection period.

Soil

For uranium soil samples, the CNSC laboratory began using the partial digestion method as opposed to the total digestion method used before 2020. This change was made in 2021 so that the 2021 results could be compared with the Canadian Council of Ministers of the Environment guidelines. As a result, soil concentrations in 2021 are lower than in previous years and are not directly comparable to samples from prior years. Samples prior to 2021 were therefore not further assessed.

Under the CNSC's IEMP, uranium in soil samples have been collected since 2014 at the location shown in Figure A-1 as detailed in Table A-1.

In 2021, uranium in soil concentrations measured ranged from 0.44 to 1.27 mg/kg dry weight. IEMP uranium in soil samples results were lower than the Ontario background levels which is generally below 2.5 mg/kg and were well below the Canadian Council of Ministers of the Environment (CCME) guideline of 23 mg/kg dry weight for parkland and residential uses. At these low levels, it is expected to see natural variations in the concentrations measured in soil.

Water

Under the IEMP, uranium in surface water samples were collected in 2018 and 2019 at the location shown in Figure A-1 as detailed in Table A-1. Uranium in surface water concentrations ranged from 0.2 to 0.34 µg/L. These results are well below the Canadian Environmental Quality Guideline of 15 µg/L long term for the protection of aquatic life (CCME 2023).

Vegetation

The concentrations of uranium in vegetation samples (grass) were analyzed in 2014 and 2018. Concentrations were below the laboratory method detection limit of 0.1 mg/kg dry weight.

CNSC IEMP Hazardous Substances Monitoring

The CNSC IEMP completed limited sampling of environmental air, vegetation, soil and water quality for beryllium around the facility starting in 2014 (2020 for water). Sample results are summarized in Table A-2 for hazardous substances.

Table A-2 CNSC IEMP Hazardous Substances Monitoring Data

Sample Type	Sample Description	Parameter	2014	2018	2019	2021	Guideline/ Reference Level	Expected Health Impact (Yes/No)	Sample Code
Air	Ambient (Particulate)	Beryllium	N/A(1)	N/A	<0.0003 µg/m³	<0.0003 µg/m³	0.01 µg/m³	No	GP02-A02
Air	Ambient (Particulate)	Beryllium	N/A	<0.003 µg/m³	N//A	<0.0003 µg/m³	0.01 µg/m³	No	GP03-A03
Air	Ambient (Particulate)	Beryllium	0.000077 µg/m³	<0.003 µg/m³	<0.0003 µg/m³	<0.0003 µg/m³	0.01 µg/m³	No	GP05-A01
Air	Ambient (Particulate)	Beryllium	N/A	<0.003 µg/m³	<0.00003 µg/m³	<0.0003 µg/m³	0.01 µg/m³	No	GP06-A06
Air	Ambient (Particulate)	Beryllium	N/A	<0.003 µg/m³	<0.00003 µg/m³	<0.0003 µg/m³	0.01 µg/m³	No	GP07-A07
Soil	0-5 cm	Beryllium(2)	0.8 mg/kg dry weight	1.27 mg/kg dry weight	1.33 mg/kg dry weight	0.37 mg/kg dry weight	4.0 mg/kg dry weight	No	GP01-S01
Soil	0-5 cm	Beryllium	1.1 mg/kg dry weight	1.14 mg/kg dry weight	1.34 mg/kg dry weight	0.44 mg/kg dry weight	4.0 mg/kg dry weight	No	GP02-S02
Soil	0-5 cm	Beryllium	1.1 mg/kg dry weight	1.28 mg/kg dry weight	1.10 mg/kg dry weight	0.43 mg/kg dry weight	4.0 mg/kg dry weight	No	GP03-S03
Soil	0-5 cm	Beryllium	0.9 mg/kg dry weight	1.08 mg/kg dry weight	1.17 mg/kg dry weight	0.38 mg/kg dry weight	4.0 mg/kg dry weight	No	GP04-S04
Soil	0-5 cm	Beryllium	1.0 mg/kg dry weight	1.27 mg/kg dry weight	2.34 mg/kg dry weight	0.56 mg/kg dry weight	4.0 mg/kg dry weight	No	GP05-S05
Soil	0-5 cm	Beryllium	1.0 mg/kg dry weight	1.24 mg/kg dry weight	1.44 mg/kg dry weight	0.61 mg/kg dry weight	4.0 mg/kg dry weight	No	GP06-S06
Soil	0-5 cm	Beryllium	0.7.mg/kg dry weight	1.34 mg/kg dry weight	1.28 mg/kg dry weight	0.48 mg/kg dry weight	4.0 mg/kg dry weight	No	GP07-07
Soil	0-5 cm	Beryllium	1.0 mg/kg dry weight	1.19 mg/kg dry weight	1.33 mg/kg dry weight	0.67 mg/kg dry weight	4.0 mg/kg dry weight	No	GP08-S08
Soil	0-5 cm	Beryllium	N/A	NA	1.25 mg/kg dry weight	0.4 mg/kg dry weight	4.0 mg/kg dry weight	No	GP11-S11
Water	Surface Water	Beryllium	N/A	< 0.1 µg/L	< 0.1 µg/L	N/A	N/A	No	GP09-W01
Water	Surface Water	Beryllium	N/A	< 0.1 µg/L	< 0.1 µg/L	N/A	N/A	No	GP10-W02

Notes:

1) N/A = No sample collected
2) For soil samples, the CNSC laboratory began using the partial digestion method as opposed to the total digestion method used before 2020. This change was made so that the 2020 results could be compared with the Canadian Council of Ministers of the Environment Canadian Environmental Quality Guidelines and MECP Soil Quality Standards. As a result, soil concentrations are lower than in previous years.

Source: (CNSC 2022)

Air

Under the IEMP, beryllium in air samples have been collected since 2014 at the location shown in Figure A-1 as detailed in Table A-2. The measured airborne beryllium concentrations were below detection limits (with one

exception) and ranged from a low of 0.000077 µg/m^3 to a high of < 0.003 µg/m^3 (CNSC, 2022) and were well below the MECP 24-hour ambient air quality objective of 0.15 µg/m^3 based on health considerations (MECP, 2020).

Soil

For beryllium soil samples, the CNSC laboratory began using the partial digestion method as opposed to the total digestion method used before 2020. This change was made in 2021 so that the 2021 results could be compared with the Canadian Council of Ministers of the Environment guidelines. As a result, soil concentrations in 2021 are lower than in previous years and are not directly comparable to samples from prior years. Samples prior to 2021 were therefore not further assessed.

Under the IEMP, beryllium in soil samples have been collected since 2014 at the location shown in Figure A-1 as detailed in Table A-2. Beryllium in soil concentrations measured in 2021 ranged from 0.37 to 0.67 mg/kg dry weight. These results are below the Canadian background average level in soil of 0.75 mg/kg (arithmetic mean, SD=0.99, n=9876, range=0.25 to 16 µg/g) (CCME 2015) and were well below the Canadian Council of Ministers of the Environment (CCME) guidelines of 4 mg/kg dry weight for parkland and residential uses. At these low levels, it is expected to see natural variations in the concentrations measured in soil.

Water

Under the IEMP, beryllium in surface water samples were collected in 2018 and 2019 at the location shown in Figure A.1 as detailed in Table A-2. Beryllium in surface water concentrations were less than detection limits in all samples. Beryllium concentrations are well below the Ontario Provincial Water Quality Objective (PWQO) of 1,100 µg/L for water with a hardness greater than 75 mg/L (as $CaCO_3$) (MOEE 1994)[3] and the World Health drinking water guideline of 12 µg/L (WHO 2017).

Vegetation

The concentrations of beryllium in vegetation samples (grass) were analyzed in 2014 and 2018. Concentrations were below the laboratory method detection limit of 0.1 mg/kg dry weight.

[3] The average hardness level measured in Jackson Creek is around 220 mg/L $CaCO_3$ (MECP, 2022b)

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