Technical Reports

Public Summary

Port Hope Conversion Facility

Ecological Risk Assessment

Cameco Corporation's (Cameco) Port Hope Conversion Facility (PHCF or site) is located in Port Hope, Ontario on the northern shore of Lake Ontario. The site, shown in Figure 1, has a long history of industrial use by multiple users starting in the mid to late 1800s. The PHCF operates under a fuel facility operating licence from the Canadian Nuclear Safety Commission (CNSC) to process uranium that is used in the fuel for nuclear power generating stations. The PHCF is comprised of the following properties: the area of the plant operations (Main Site); storage facilities on the Centre Pier; and storage facilities located on Dorset Street East in the Municipality of Port Hope (MPH).

Figure 1 | Port Hope Conversion Facility Main Site and Centre Pier

In accordance with its licence requirements, Cameco has completed an environmental risk assessment (ERA) to align with the standardized requirements found in Canadian Standards Association (CSA) N288.6-12 Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills. An ERA is a systematic process used to identify and assess the risk posed by contaminants and physical stressors in the environment on biological receptors. There are two parts to an ERA – an assessment of the facility's operations on human receptors through a human health risk assessment (HHRA) and an assessment on non-human environmental receptors through an ecological risk assessment (EcoRA).

The PHCF ERA was completed to address the following question:

Is there potential for significant environmental (i.e. ecological and human health) effects from current emissions associated with Cameco's PHCF facility operations?

Environmental risk assessment follows a general tiered-approach methodology supported by CSA and various agencies such as Health Canada (HC), Canadian Council of Ministers of the Environment (CCME) and the CNSC. Potential impacts on humans or the environment are measured in terms of "screening indices". In simple terms, a screening index (SI) is the concentration or exposure level divided by a published criteria that has been deemed unlikely to have a significant effect on the receptor. These criteria can come from research or field studies, regulatory standards and objectives, scientific literature or other credible sources.

SI is the ratio of

$$\frac{\text{Exposure Level (or Concentration)}}{\text{Criterion}}$$

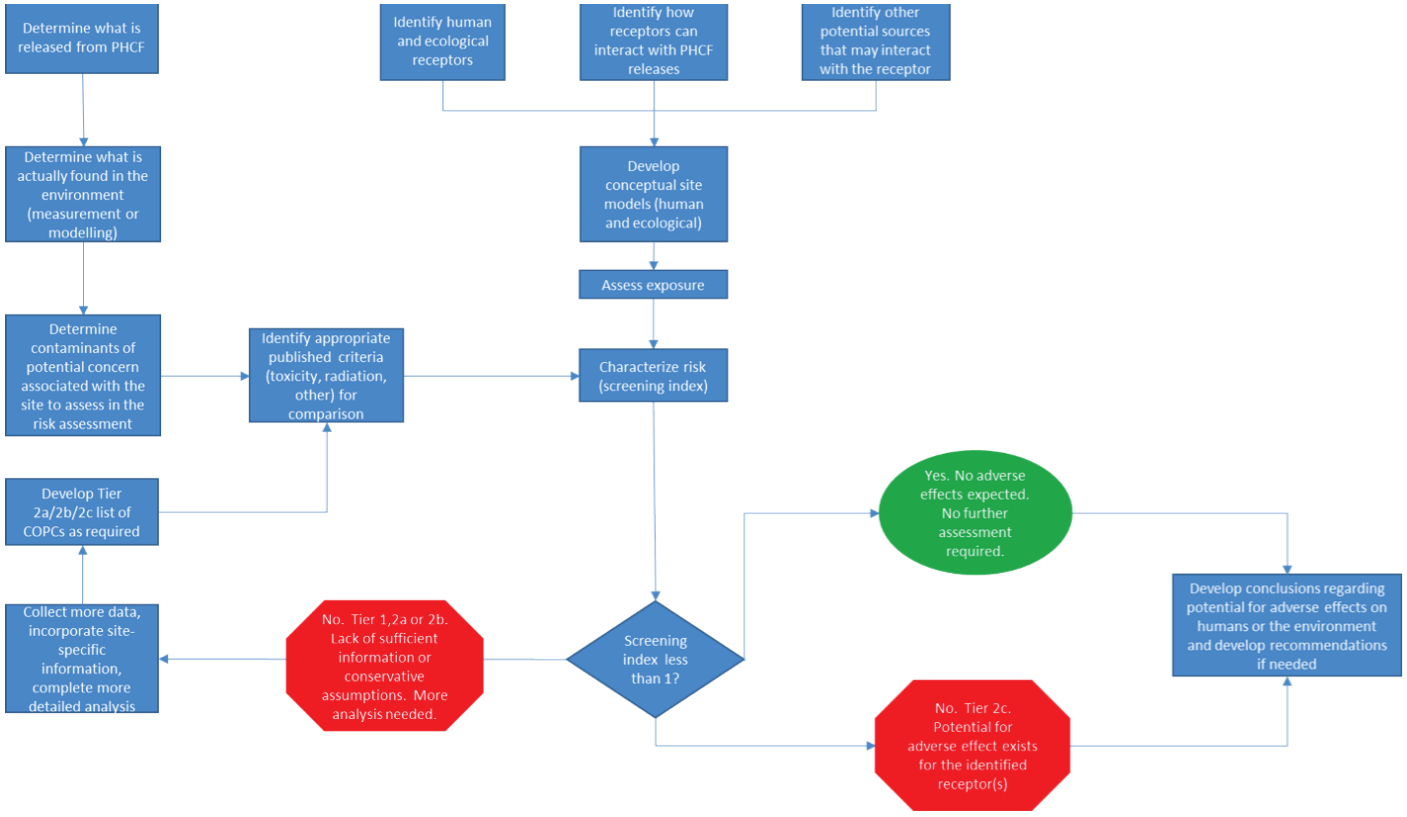
SI **below one** indicates that no harmful effects on living things are expected.

SI **above one** indicates that further analysis is required.

As depicted in Figure 2, the first level or tier of the assessment starts with very broad, very conservative assumptions designed to uncover any potentially significant environmental effects. If no potential effects are identified (SI is less than 1), the assessment stops. If a potential effect is identified (SI greater than 1), analysis continues to determine whether that potential effect is due to lack of sufficient information or assumptions that are too conservative. Another tier or step of analysis (in Tiers 2a, 2b

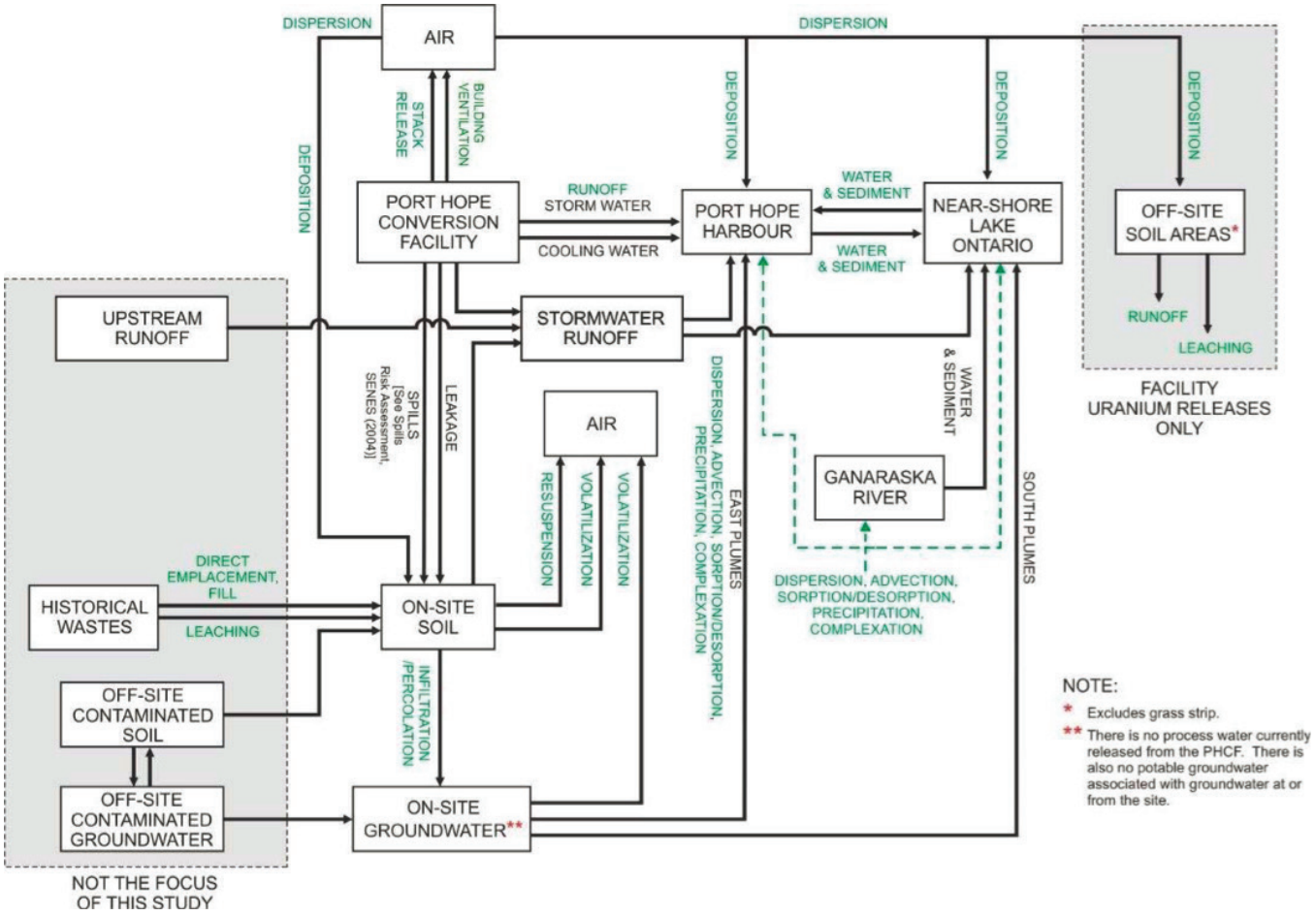
and 2c as required) would follow with more detailed analysis, additional field data, and more site specific information. As data gaps are closed and assumptions become more realistic, it becomes possible to determine if a stressor is actually having an effect. Each step results in increasing levels of certainty about environmental risk factors. Once the assessment is complete, a conclusion with associated recommendations to address potential harm to people or the environment is developed.

Figure 2 Environmental Risk Assessment Overview



The first step in conducting an ERA is to understand how materials released from Cameco's operations may enter the natural environment. This is illustrated in Figure 3.

Figure 3 | On-Site and Off-Site Sources of Contamination and Interaction



Once this is understood, the Contaminants of Potential Concern (COPCs) need to be identified. This is a list of all radiological and non-radiological contaminants released to air and water from site operations. It is developed from operational knowledge of the facility, routine monitoring data, other available monitoring data and field investigations. Screening for COPCs at PHCF included the following broad categories: PHCF routine monitoring parameters; general chemistry parameters; metals; radionuclide; and, organics analysis. In developing the list of COPCs, some contaminants are removed from further consideration if they are released in very small quantities, are present at or below natural background levels, or are determined not to be a concern from a human or ecological health perspective. The concentration(s) in the environment are then determined for each source (i.e. soil, groundwater, surface water, air emissions) in the natural areas near the facility using field measurements, modelling or a combination of both. Where multiple samples are available, the maximum concentration or "worst-case" is used for the first or screening level assessment in the ERA.

The pathways assessment (also called risk characterization or risk assessment) is a series of calculations following the standardized requirements of N288.6-12 that are used to estimate the exposure of the human or ecological receptor to each of the COPCs. The calculations estimate the uptake of COPCs from the different environmental media and how the COPCs are passed up the food chain. The calculated exposure levels are compared to scientifically accepted benchmarks to determine whether there is a potential for an effect to human health or biota which results in a screening index.

It is important to understand the first tier of the assessment begins with conservative assumptions about both estimated exposure and the criteria used to assess the risks of that exposure, especially where information is not readily available. In keeping with this approach, the assumptions about the potential stressors associated with PHCF operations are also conservative. An example of a conservative assumption is when fish are assumed to be exposed to contaminants at the location of effluent discharge 100 percent of the time; whereas clearly most fish in the area would spend most of their time at some distance from the discharge point.

The assumptions used to derive the SI are conservative to ensure that if the index is estimated to be less than 1, there's a high level of confidence that, despite any uncertainty in the data, the index value won't exceed 1. If the screening index is estimated to be greater than 1, however, follow-up work is required in a higher tier assessment to determine whether this is due to conservatism in the assumptions, lack of sufficient data or a real impact. Tier 1 assessments are typically based on literature reviews. Higher tier assessments require field studies.

Human Health Risk Assessment

The HHRA component of the ERA included the following COPCs:

- Uranium
- Fluoride
- Nitrate
- Ammonia
- Arsenic
- Radium
- Metals
- Radionuclides
- Polychlorinated biphenyls (PCBs)
- Volatile organic compounds (VOCs)
- Petroleum hydrocarbons (PHCs)

These COPCs were assessed in one or more of the following pathways in the HHRA:

- Groundwater
- Soil
- Air
- Surface water
- Stormwater
- Sediment
- Gamma radiation

The human receptors and receptor characteristics are defined for the HHRA based on the members of the public who reside or use the natural areas near the facility who may be affected by the release of contaminants. Different scenarios are considered to assess nearby residents, such as their age, whether they work near the facility or participate in recreational activities such as fishing, walking around the PHCF fence-line, boating or spending time at the local park. The different routes of exposure, or pathways (i.e. how the contaminants travel through the natural environment and ultimately interact with the human or biological receptors) are determined and are collectively referred to as the conceptual site model (CSM). The following general pathways and receptors considered are illustrated in Figure 4 and Table 1 for the HHRA.

Figure 4 | Human Health Risk Assessment Conceptual Site Model

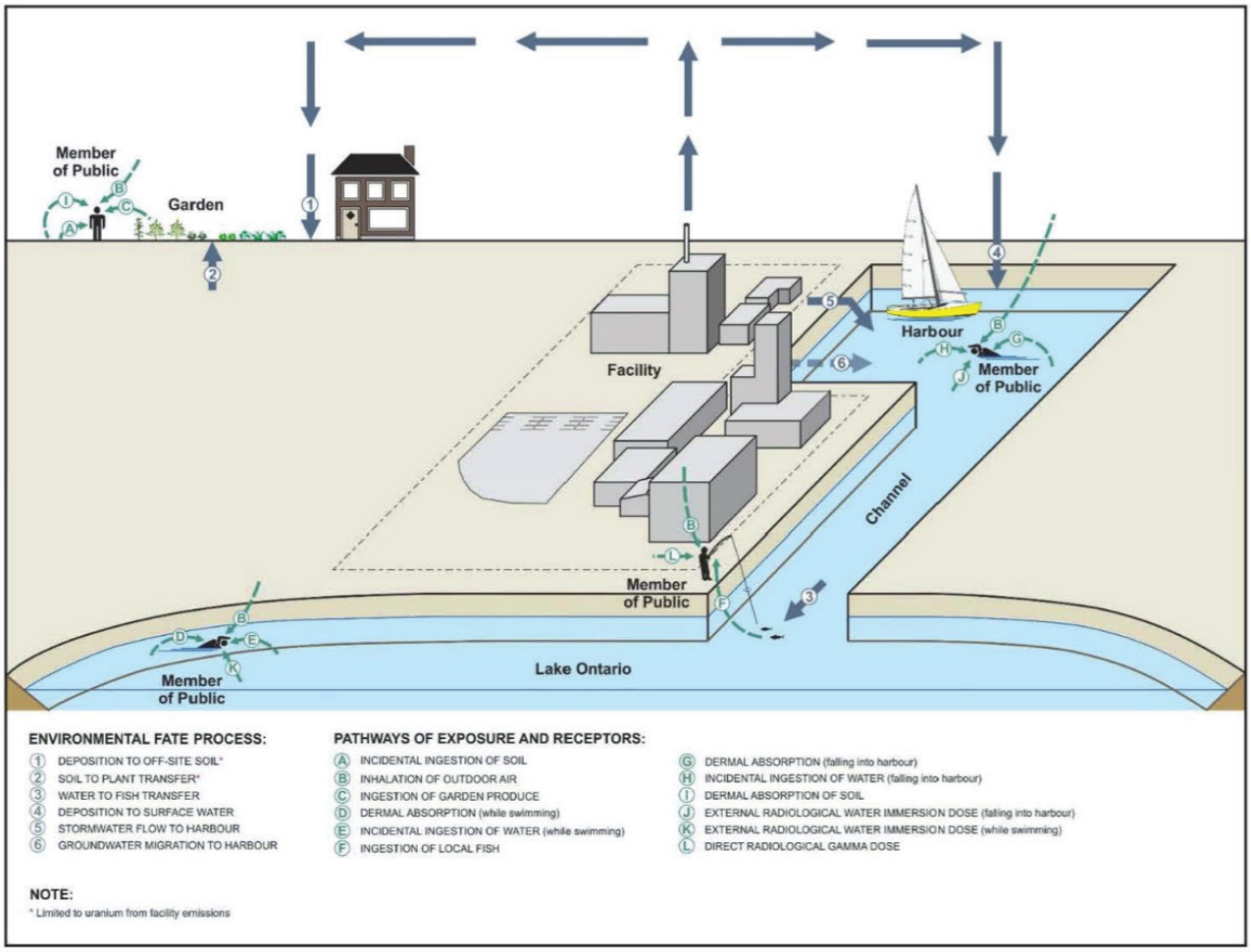


Table 1 | Human Receptor Exposure Locations and Environmental Media

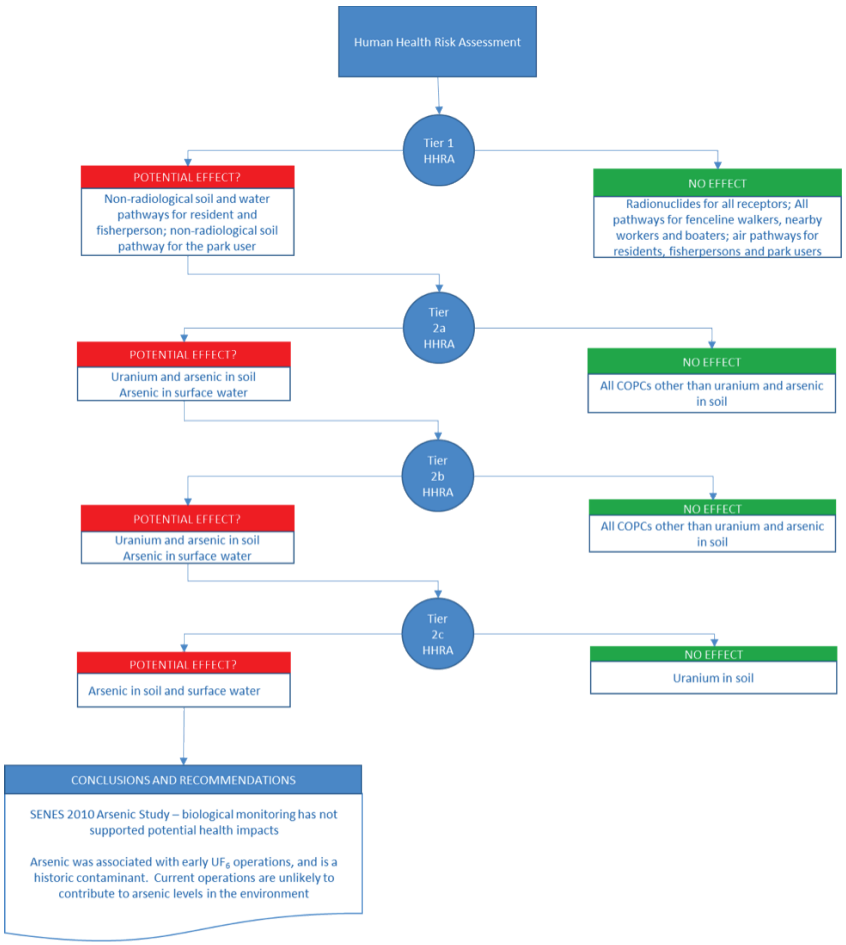
Potential Environmental Media	Exposure Location Description	Resulting Exposure
Soil	Based on their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to residential yard soil or park soil. *Note that access to the site is controlled. Members of the public cannot enter the site and consequently be exposed to on-site soil.*	**Residential Yard Soil** (resident) **Park Soil** (recreational park user)
Groundwater	Off-site member of the public receptors are not exposed to on-site groundwater, due to controlled access to the PHCF site. Exposure to off-site groundwater (i.e., not associated with the PHCF site) is not the focus of this study.	
Surface Water	Based on their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to: • Surface water from the Port Hope Harbour when falling into the harbour; and, • Surface water from the nearby beach when swimming. Note that human receptors do not swim in the Port Hope Harbour adjacent to the PHCF.	**Harbour Surface Water** (falling) **Beach Surface Water** (swimming)
Sediment	Off-site public receptors are not exposed to contaminated Harbour sediments as part of their activities.	
Garden Produce	As part of their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to contaminants via ingestion of garden produce grown in residential soil.	**Garden Produce** (estimated based on residential yard soil)
Local Fish	As part of their descriptions and behaviours, off-site member of the public receptors could potentially be exposed to contaminants via ingestion of fish caught from the Harbour.	**Local Fish** (estimated based on Harbour surface water)
Outdoor Air	As part of their behaviours, off-site member of the public receptors could potentially be exposed to contaminants via inhalation of outdoor air.	**Outdoor Air** (Based on off-site soil concentrations – measured and/or estimated)

Results

Figure 5 summarizes the results of the HHRA for the PHCF. For radioactive parameters, there are no effects expected to humans as a result of PHCF operations. With respect to non-radioactive parameters, the Tier 1 assessment indicated the potential for effects and subsequent Tier 2a, 2b and 2c analysis were carried out following the guidance of N288.6-12.

At the end of the HHRA, only arsenic was identified as having the potential to cause effects. Arsenic was historically a contaminant in the hydrogen fluoride used in the UF_6 plant. More restrictive specifications for arsenic were implemented approximately 25 years ago, which has eliminated this source from current operations. Previous risk assessments for PHCF completed in 2010 incorporated a detailed arsenic exposure study. This study showed that based on current emissions from the PHCF there is expected to be essentially no change to the arsenic level in Port Hope. Furthermore, the study examined the exposure potentially experienced by Port Hope residents and determined that this level of exposure is within the "normal" or "background" exposure experienced by Canadians. From this, it was concluded that undue health risks are not expected. This is further supported by published biological monitoring of Canadian locations where people have been exposed to elevated arsenic which has not identified potential health impacts.

Figure 5 | Results of the Human Health Risk Assessment



Ecological Risk Assessment

The EcoRA component of the ERA included the following COPCs:

- Uranium
- Fluoride
- Nitrate
- Ammonia
- Arsenic
- Radium
- Metals
- Other ions
- Radionuclides
- Polychlorinated biphenyls (PCBs)
- Petroleum hydrocarbons (PHCs)

These COPCs were assessed in one or more of the following pathways in the EcoRA:

- Groundwater
- Soil
- Air
- Surface water
- Stormwater
- Sediment

The biological receptors and receptor characteristics are defined for the EcoRA based on the plants, invertebrates, mammals and birds who use the natural areas near the facility and may be affected by the release of contaminants.

Physical Stressors

Potential physical stressors were also considered in the ERA, including:

1. Potential impacts on fish and fish larvae of being caught in on a cooling water intake screen or being circulated through the cooling water system;
2. Potential impacts on fish and fish larvae from the thermal effects from water discharge from the facility;
3. Acoustic impacts from noise generated at the facility; and,
4. Potential impacts from acute stormwater effects during rain events.

The CSM for the EcoRA, illustrating the different routes of exposure, or pathways (i.e. how the contaminants travel through the natural environment and ultimately interact with the biological receptors) is shown in Figures 6-8 and Table 2.

Figure 6 | Ecological Risk Assessment Conceptual Site Model

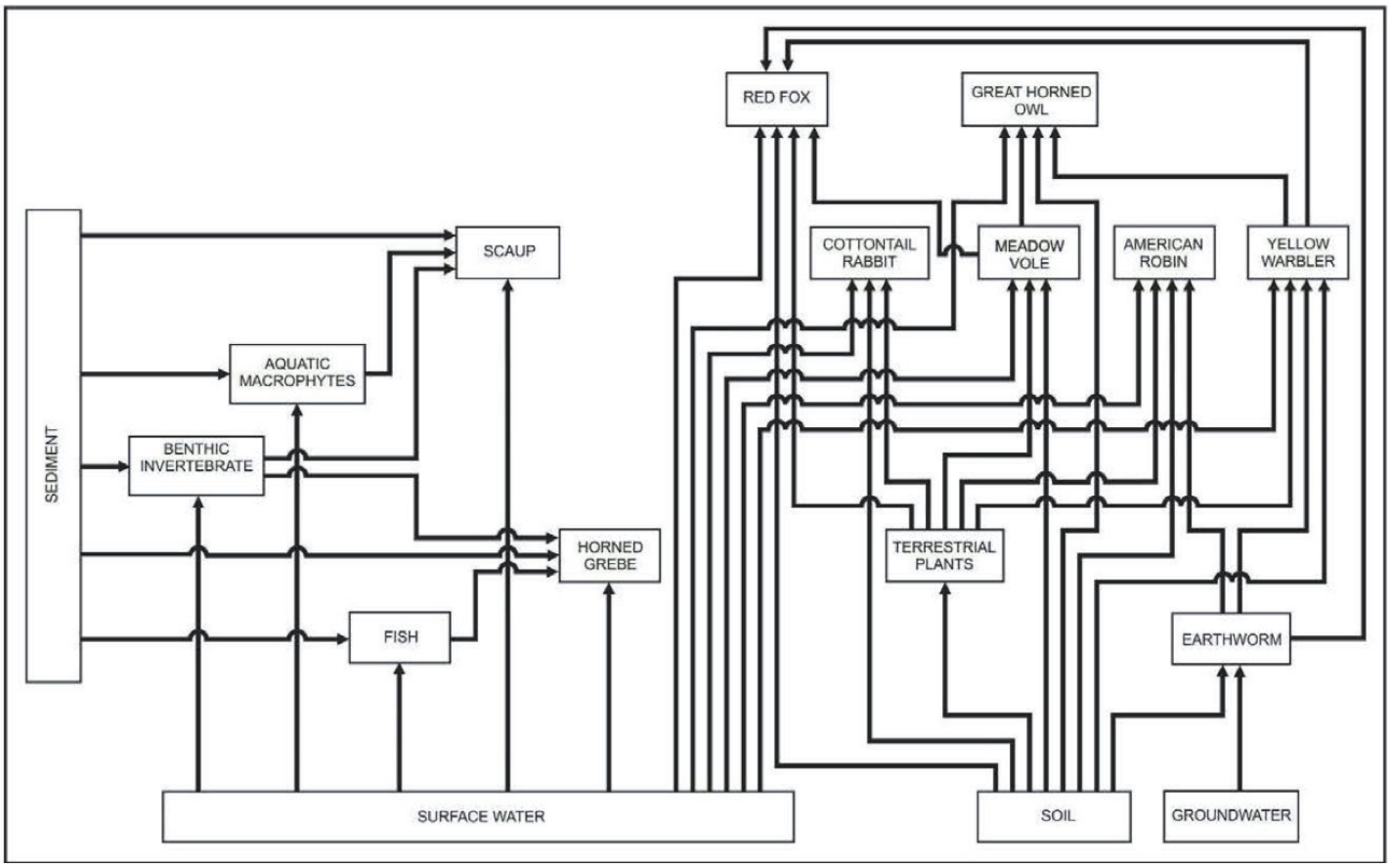


Figure 7 | PHCF Ecological Receptor Locations

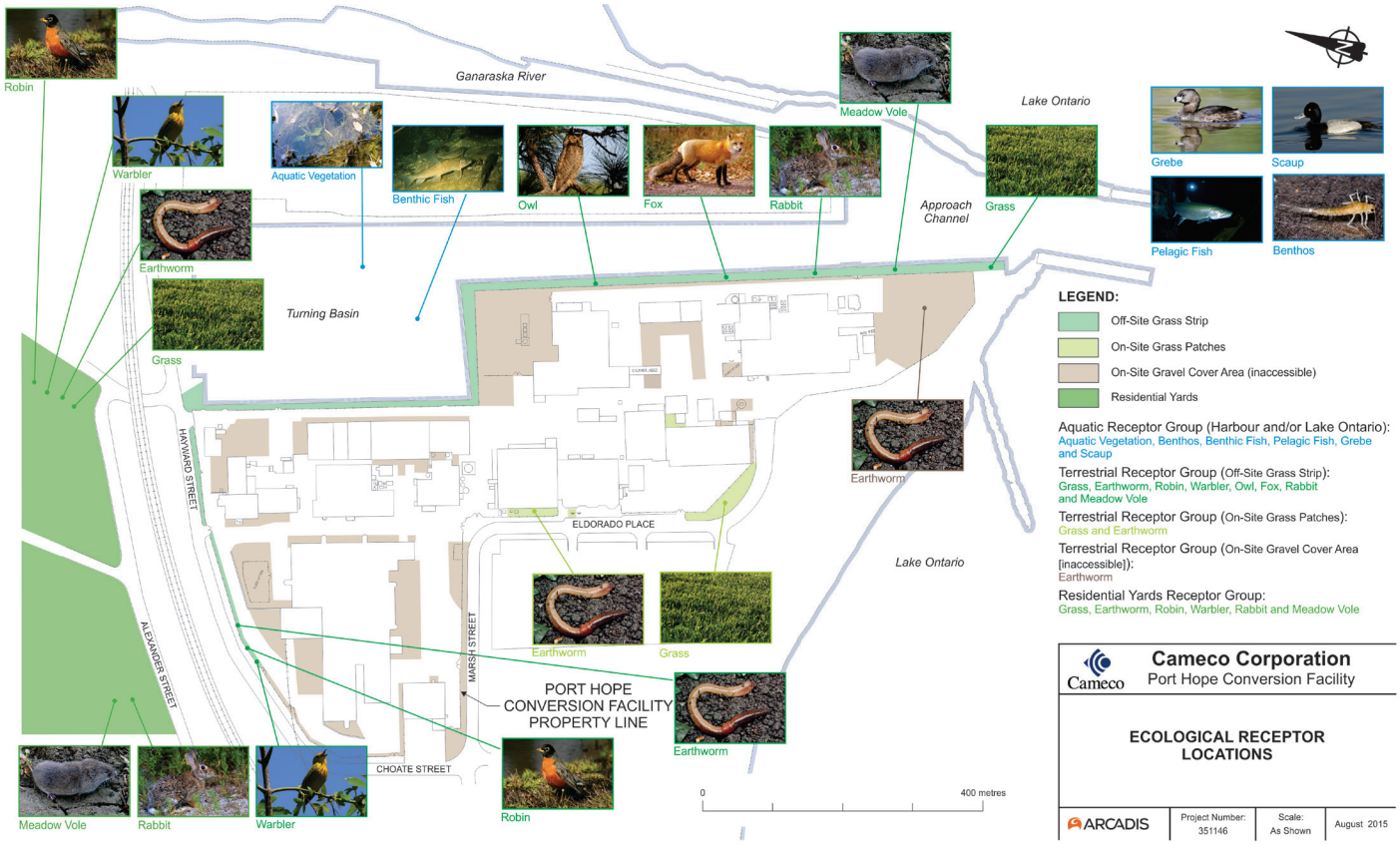


Figure 8 | Dorset Street East Ecological Receptor Locations

Table 2 | EcoRA Exposure Pathways Summary

Receptor	Environmental Media Exposed	Modes of Exposure	Risk Calculation Method	
			Non-Radioactive	Radioactive
Fish	• surface water • sediment	• uptake from water; • immersion in water; • exposure to sediment (benthic fish, radiological only).	Comparison of surface water concentrations with corresponding benchmark values.	**Pelagic fish:** • Internal dose from water; • External dose from water. **Benthic fish:** • Internal dose from water; • External dose from water; • External dose from sediment.
Benthic Invertebrates	• surface water • sediment	• uptake from water; • immersion in water (radiological only); • immersion in sediment (radiological only).	Comparison of water concentrations with benchmark values.	• Internal dose from water; • External dose from water; • External dose from sediment.
Aquatic Plants	• surface water	• uptake from water; • immersion in water (radiological only).	Comparison of water concentrations with benchmark values.	• Internal dose from water; • External dose from water.
Terrestrial Invertebrates	• soil • groundwater	• uptake from soil; • immersion in soil (radiological only); • uptake from groundwater; • immersion in groundwater (radiological only).	Comparison of soil or groundwater concentrations with benchmark values.	• Internal dose from soil or groundwater; • External dose from soil or groundwater.

Terrestrial Birds	• soil
	• surface Water
		• ingestion:
		  • terrestrial vegetation;
		  • terrestrial invertebrates;
		  • soil;
		  • surface water;
		  • mammals (owl only).
		• direct exposure to soil (radiological only)
			Comparison of dose from intake with benchmark values	• Internal dose from ingestion

Receptor	Environmental Media Exposed	Modes of Exposure	Risk Calculation Method	
			Non-Radioactive	Radioactive

Terrestrial Mammals	• soil
	• surface water
		• ingestion:
		  • terrestrial invertebrates;
		  • terrestrial vegetation;
		  • soil;
		  • surface water;
		  • other mammals (fox only).
		• direct exposure to soil (radiological only).
			Comparison of dose from intake with benchmark values.	• Internal dose from ingestion;
				• External dose from soil.

Terrestrial Plants	• soil	• uptake from soil; • exposure to soil (radiological only).	Comparison of soil concentrations with benchmark values.	• Internal dose from soil; • External dose from soil.

Aquatic Birds	• surface water
	• sediment
		• ingestion (as appropriate):
		  • surface water;
		  • fish (grebe only);
		  • benthic invertebrates;
		  • aquatic vegetation;
		  • sediment.
		• immersion in surface water (radiological only).
			Comparison of dose from intake with benchmark values.	• Internal dose from ingestion;
				• External dose from water.

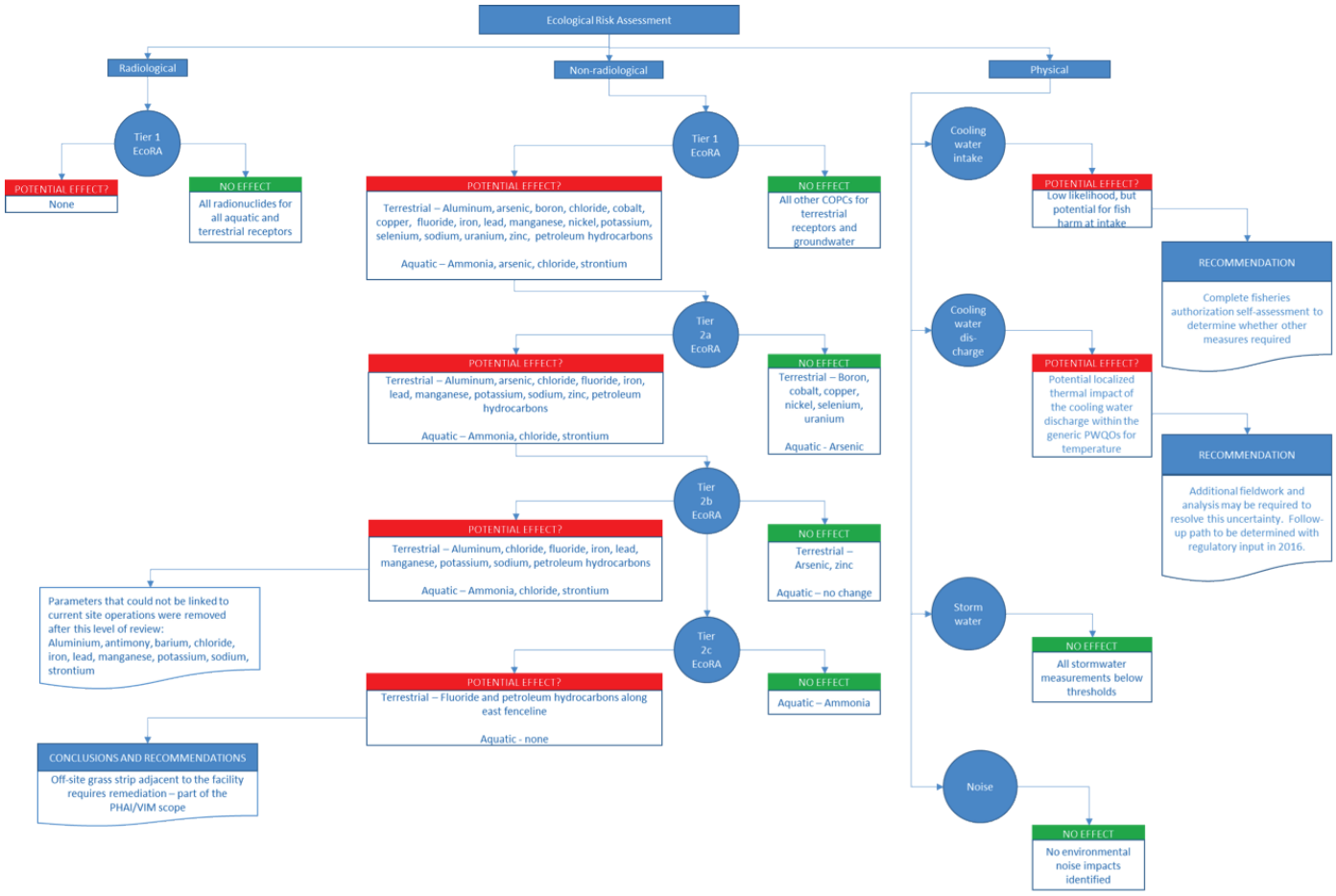
Results

Figure 9 summarizes the results of the EcoRA for the PHCF. For radioactive parameters, there are no effects expected on ecological (terrestrial and aquatic) receptors as a result of PHCF operations. With respect to non-radioactive parameters, the Tier 1 assessment indicated the potential for effects and subsequent Tier 2a, 2b and 2c analysis were carried out following the guidance of N288.6-12.

At the end of the EcoRA, fluoride and PHCs linked to PHCF operations were identified as having the potential to cause effects for terrestrial receptors (earthworm and vegetation) in localized areas alongside the fence adjacent to the harbour. This area is not suitable habitat and surface soils will be remediated during the Vision in Motion (VIM) and Port Hope Area Initiative (PHAI) projects. There were no expected effects on aquatic receptors as a result of PHCF operations.

With respect to physical stressors, previous studies were included in this ERA. This work indicated that there were no adverse effects associated with terrestrial receptors from noise. While there does not appear to be an issue for fish impingement and entrainment associated with the cooling water intake, further assessment will be completed. A potential localized impact, which is not expected to have population level effects, was identified from the temperature of the cooling water discharge through the thermal risk assessment studies. Given the significant works to be undertaken within the harbour over the next few years that will change the profile of the harbour, Cameco does not have any additional studies planned in this area, and is in discussions with the regulatory agencies regarding what, if any, follow-up or interim measures are required for this aspect of the ERA.

Figure 9 | Results of the Ecological Risk Assessment



Conclusions

In summary, the ERA meets the requirements of CSA N288.6-12. It identifies localized areas of potential impact in the aquatic and terrestrial environment. The results are summarized in Table 3.

Table 3 Summary of ERA Results

Stressor Type	Members of the Public	Aquatic Biota	Terrestrial Biota
Radiological	No adverse effect expected from COPCs associated with PHCF operations.	No adverse effect expected from COPCs associated with PHCF operations.	No adverse effect expected from COPCs associated with PHCF operations.
Non-Radiological	No adverse effect expected from COPCs associated with PHCF operations. Arsenic exposure is below background, but it is recommended to minimize arsenic risk to the extent that it is practical. The facility has restricted the arsenic levels in chemicals it is using (as of 1989).	No adverse effect expected from COPCs associated with PHCF operations.	Potential for adverse effects from Fluoride (F), Petroleum Hydrocarbon (PHCs) in limited area that is not suitable habitat (i.e., the grass patch along the Harbour wall.
Physical	N/A	No impingement and entrainment issues were identified. Thermal exceedances tend to be localized (i.e., localized near the discharge).	No adverse effect expected from stressors associated with PHCF operations.(i.e., noise)

As a result of this ERA, Cameco will act on the following in advance of the next scheduled update of this ERA in 2021:

- Complete a self-assessment regarding fish impingement and entrainment at the cooling water intake.
- Develop and implement the path forward to address the uncertainty in the thermal risk assessment for the cooling water discharge and implement additional measures as needed.
- Remediate the grass strip adjacent to the harbour where potential effects from fluoride and PHCs may exist as part of the VIM and PHAI projects.
- Additional risk assessment should be used where appropriate during the final design and implementation of VIM
- Implementation of additional CSA environmental standard will consider the risk assessment and conclusions.
- Following the remediation activities on the site and in the community as part of the VIM and PHAI projects, the ERA should be re-evaluated and used to update monitoring programs (i.e. soil) as appropriate.