Technical Reports

Public Summary

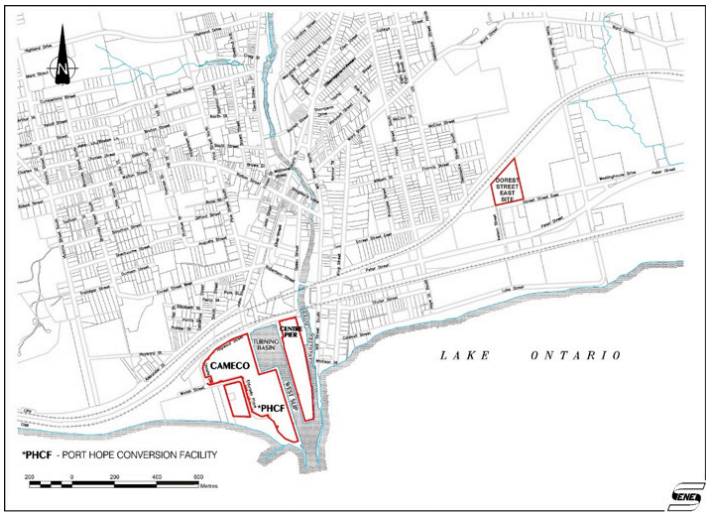
Port Hope Conversion Facility

Calculating Dose to the Public

Derived Release Limits and Operating Release Levels

Cameco Corporation (Cameco) is licensed by the Canadian Nuclear Safety Commission (CNSC) to operate the Port Hope Conversion Facility (PHCF) within the Municipality of Port Hope (Figure 1). Cameco must operate the facility in a manner consistent with the *Nuclear Safety and Control Act*, the associated regulations and with conditions specified in the operating licence and licence conditions handbook issued by the CNSC. Included in these requirements are limits on the annual releases of radioactive material and gamma radiation from the facility into the surrounding environment to ensure that no member of the public receives an annual dose in excess of the regulatory limit of 1 mSv/year.

Figure 1. Port Hope Conversion Facility in the Municipality of Port Hope



Site-specific release limits are referred to as Derived Release Limits (DRLs) and have been calculated for air, water and gamma releases from the PHCF. To ensure consistency within the nuclear industry, standardized guidelines for developing the site-specific limits for air, water and gamma releases that meet the regulatory limit of 1 mSv/year are provided in CSA standard N288.1 *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities.*

DRLs are estimated to determine the releases that would result in a dose equal the regulatory limit (1 mSv/y) to a reasonably maximally exposed member of the public.

The reasonably maximally exposed member of the public would be the member of a relatively small group of people that would have higher doses than the typical member of the public due to a combination of location, lifestyle and consumption patterns. If the maximally exposed member of the public is below the limit then all members of the public will be below the limit.

PHCF has used the DRLs to develop Operating Release Levels (ORLs). ORLs consider releases from the normal operations of the facility, with an aim to control dose to the public to levels well below the regulatory limit of 1 mSv/y. For PHCF, the ORLs for air and water correspond to an annual dose of less than 0.05 mSv/year, while the ORL for gamma radiation corresponds to an annual dose of less than 0.3 mSv/year to the potentially most exposed resident near the PHCF main site and Dorset Street East properties. ORLs represent a good control practice to keep radiation doses to members of the public as low as reasonably achievable, social and economic factors considered, and have been adopted as operating limits for PHCF operations.

ORLs are estimated to determine the release rate that would correspond to the annual dose limits for operating conditions (0.05 mSv/y for air and water; 0.3 mSv/y for gamma radiation emissions) to the most exposed receptor.

The most exposed receptors include residential receptors that live near the facility, full time workers at the facility and recreational receptors using the lands adjacent to the facility. The ORL is used to ensure that the dose to the public from the PHCF is controlled well below the regulatory limit of 1 mSv/year.

The 2016 DRL has been updated from previous work to accommodate changes in plant operations, receptor assumptions and updates to the CSA standard. The conceptual model for the DRL for water releases has been improved in the 2016 work and gamma modelling receptors have been expanded to be consistent with recent work completed for an Environmental Risk Assessment and planning for the Vision in Motion project. This ensures that all potential exposure pathways for the public have been assessed in the current work. These changes have not changed the overall conclusion that the facility operates well within the public dose limit of 1 mSv/year set out in the Nuclear Safety and Control Act and associated regulations. CNSC staff accepted the DRL and ORL studies in 2016.

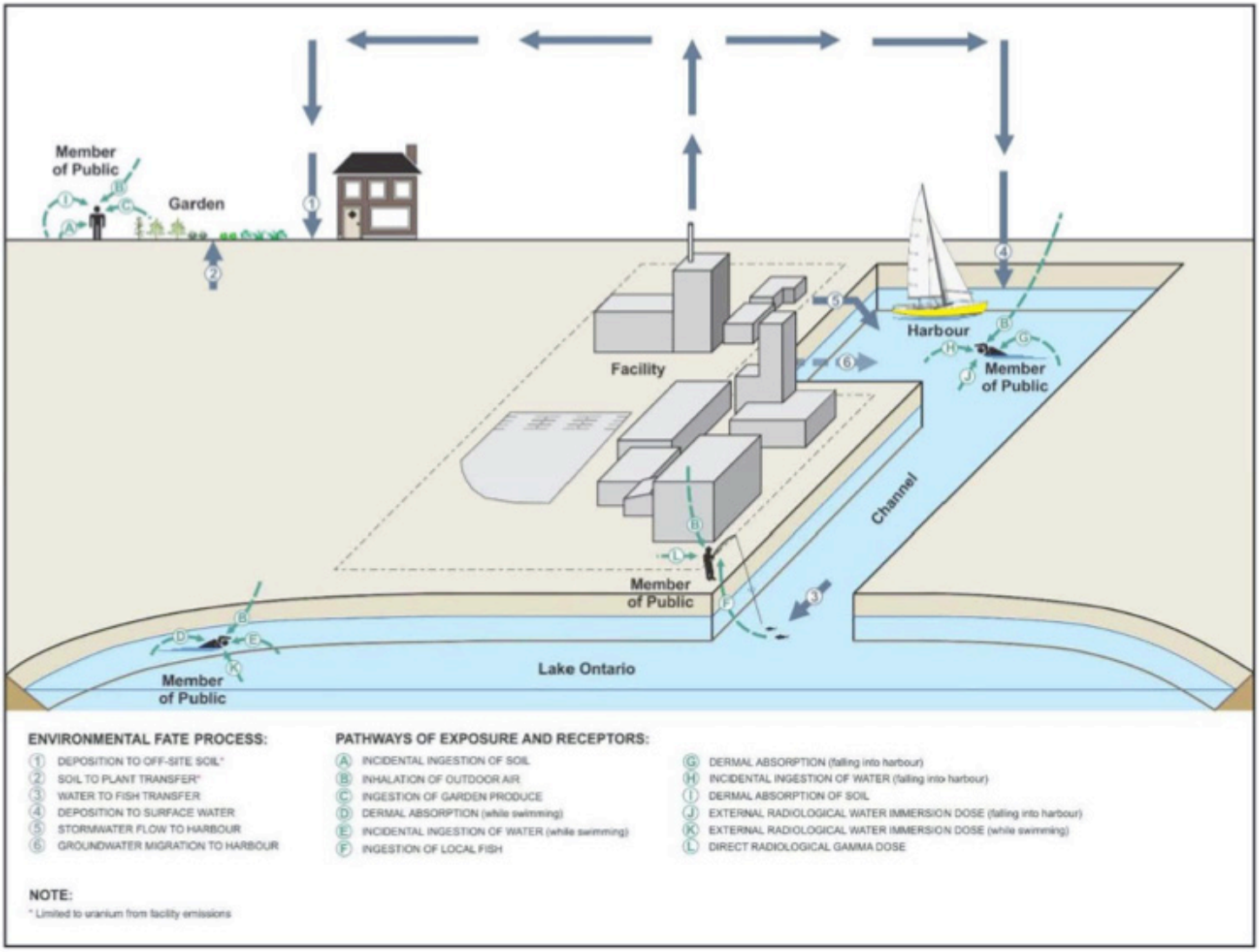
Methodology

The general methodology is:

1. Develop the conceptual site model to identify:
   a) the pathways of exposure to the different sources of uranium (Figure 2)

   b) the various human receptors and their characteristics

Figure 2. Human Health Exposure Pathways



2. Develop the relationship(s) between the source of radioactivity (air, water and gamma) and the receptors to determine the required dose calculations (Figure 3).

3. Calculate the DRL for each source type (air, water and gamma) – The intake of radioactivity by all potential receptors is calculated using the exposure habits (e.g. times spent at various locations, amount of backyard produce consumed, quantity of air inhaled) and the modelled concentrations in the corresponding environmental media in a pathways assessment (as illustrated in Figure 2). This is then used to determine annual doses to the receptors based on their intake and the corresponding dose conversion factors (from the CSA standard or scientific literature) as illustrated in Figure 3. The DRLs calculated for the PHCF and Dorset Street East sites are shown in Table 1.

Considerations for Human Receptors

To identify the maximally exposed member of the public, various receptors and receptor characteristics were considered in the assessment including:

1. Age - adult, child and infant residential receptors were considered;
2. Occupation - an adult person working full-time near the facility (but not a Cameco employee or contractor) was considered;
3. Recreational activities – different activities such as walking along the fenceline, fishing, using the beach or boating in the harbor were considered;
4. Residential, recreational and commercial receptors were considered for the Main Site and the Dorset Street Warehouse; and,
5. Compound receptors - receptors who are both Port Hope residents and undertake the recreational activities such as fenceline walking or boating were considered.

Figure 3. Overview of Methodology for Dose Calculations for Facility Releases

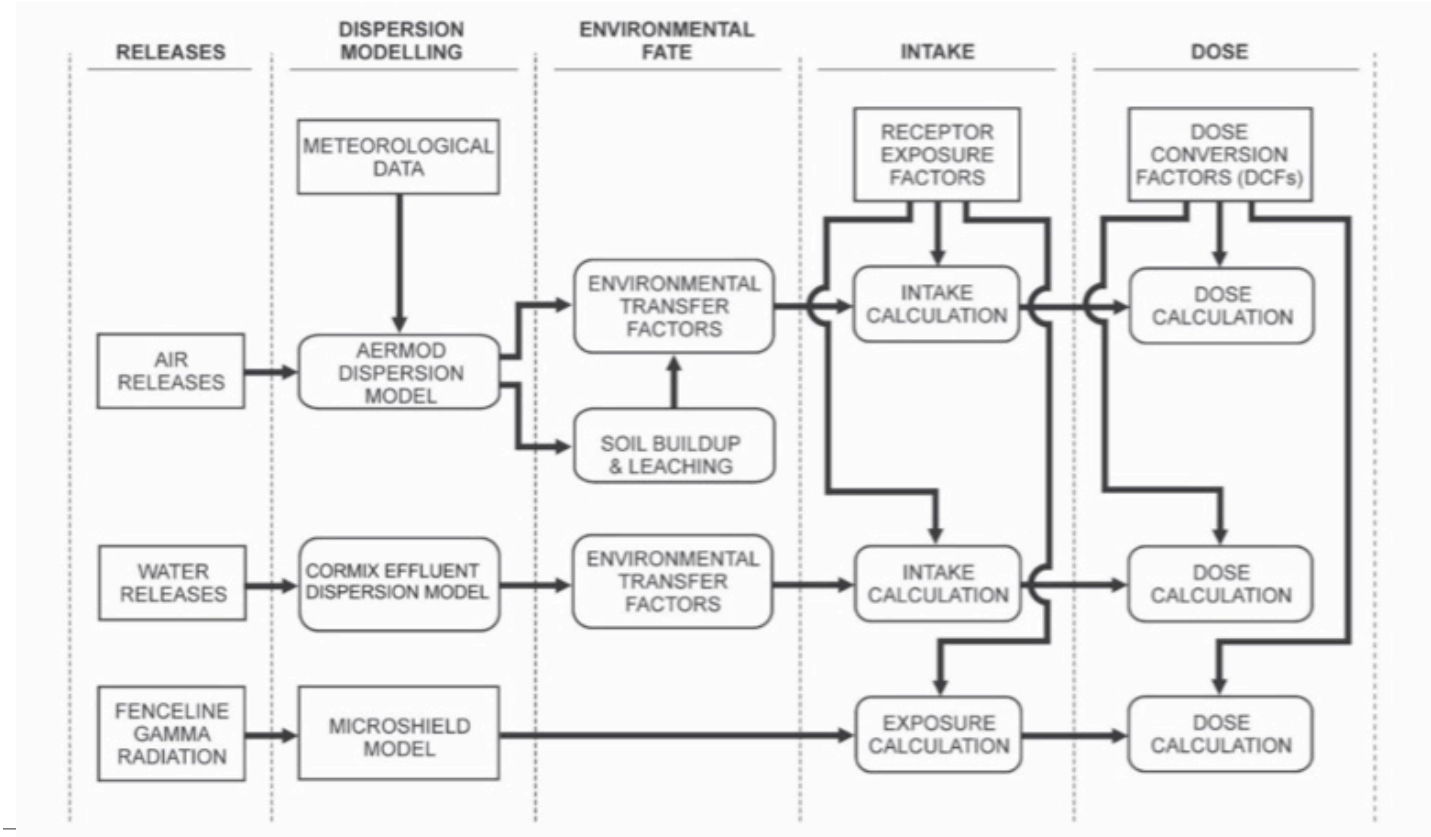


Table 1 DRLs for PHCF and Dorset Street East Sites

Source	Receptor with Max. Dose	Max Dose (mSv/ year)	2016 DRL (for this Source or TLD grouping)	Comments
Air	Resident, Hayward/ Alexander + Commercial Worker - PHCF	0.004	8,035 kg/year	Based on 2014 air emissions. All PHCF air emissions were treated as one single source.
Water	Resident - all locations	0.005	36,492 kg/year	Based on 2014 measured WTP effluent U conc., 2014 PHCF loading to sewer. Assumes that loading from PHCF contributes to drinking water and no U removal in STP.
Gamma	Fisherperson	0.115	0.78 µSv/hour	For Tier 2 Dose: Selected max estimated dose of TLDs in Fisherperson Grouping fenceline TLD 1, 2, 3, 4, 11, 12, 15, 33).
	Resident - Dorset	0.063	0.87 µSv/hour	For Tier 2 Dose: Selected max estimated dose of TLDs in Resident – Dorset Grouping (TLD20, 21, 22 & 23).

The DRL equation is then used to compare maximum receptor dose for each source component to the public dose limit of 1 mSv/ year. This approach is a conservative assessment that represents the worst case scenario that may not exist in real life. The DRL calculates a dose to the public that is higher than the actual public exposure during normal facility operations. The DRLs calculated in 2016 for the PHCF main site and the Dorset Street East were 0.344 and 0.349 mSv/year, respectively. These limits show that the worst case scenario from the facility remains below the public dose limit of 1 mSv/year.

The DRL equation for the PHCF combines the air and water component using the most-exposed potential DRLs with the most restrictive sub-component for gamma radiation emitted from the:

$$F_{air,water} + \max(F_{\gamma(Dorset)}, F_{\gamma(PHCF)}) <= 1$$

where:

F air, water is the fraction of allowable dose from air and water releases

Fγ (Dorset) is the fraction of allowable dose from gamma radiation for the Dorset Street East site

Fγ (PHCF) is the fraction of allowable dose from gamma radiation for the PHCF main site arising from Nearby Residential activity on Mill Street

Calculate the ORL for each source – The maximum emission rate that would result in a total dose of 0.3 mSv (based on the DRL calculations for each source) with the additional constraint that the dose from air and water releases do not exceed 0.05 mSv to the most exposed receptors. The ORL control equation is for the theoretically most exposed receptors, to be calculated separately for the main site and Dorset Street East site. It is important to note that this combines the most exposed receptors for each dose component and therefore represents a dose to the public which is more conservative than the dose any typical person would receive from PHCF operations. This defines the release limits for the facility.

The ORL equation for the PHCF controls total dose to the public from all sources:

$$D_{air} + D_{water} + D_{gamma} < 0.3mSv/y$$

D air, Dose from air for an adult compound receptor (resident who is also a commercial worker)

D water Dose from releases to water for an adult resident

D gamma Dose from gamma radiation for a fisherperson near the PHCF main site and an infant resident near the Dorset Street East site

D air and D water Limited individually, to be lower than 0.05 mSv/y.

Summary

Through the methodology described above, the following uranium release limits are determined for PHCF based upon the 2016 DRL/ORL calculations:

Source	Updated ORL	
	(kg U/year)	(kg U/hour)
Air: UO_2 (Building 24 Main Stack) **UF_6** (Building 50 Main Stack)		0.24 0.28
Water: (Sanitary Sewer, Groundwater and Stormwater)	1825	
Gamma Radiation	(µSv/hour)	
PHCF main site – Fisherperson at TLD 2	0.57	
PHCF main site – Resident at TLD 13	0.40	
Dorset site – Resident at TLD 21	0.26	