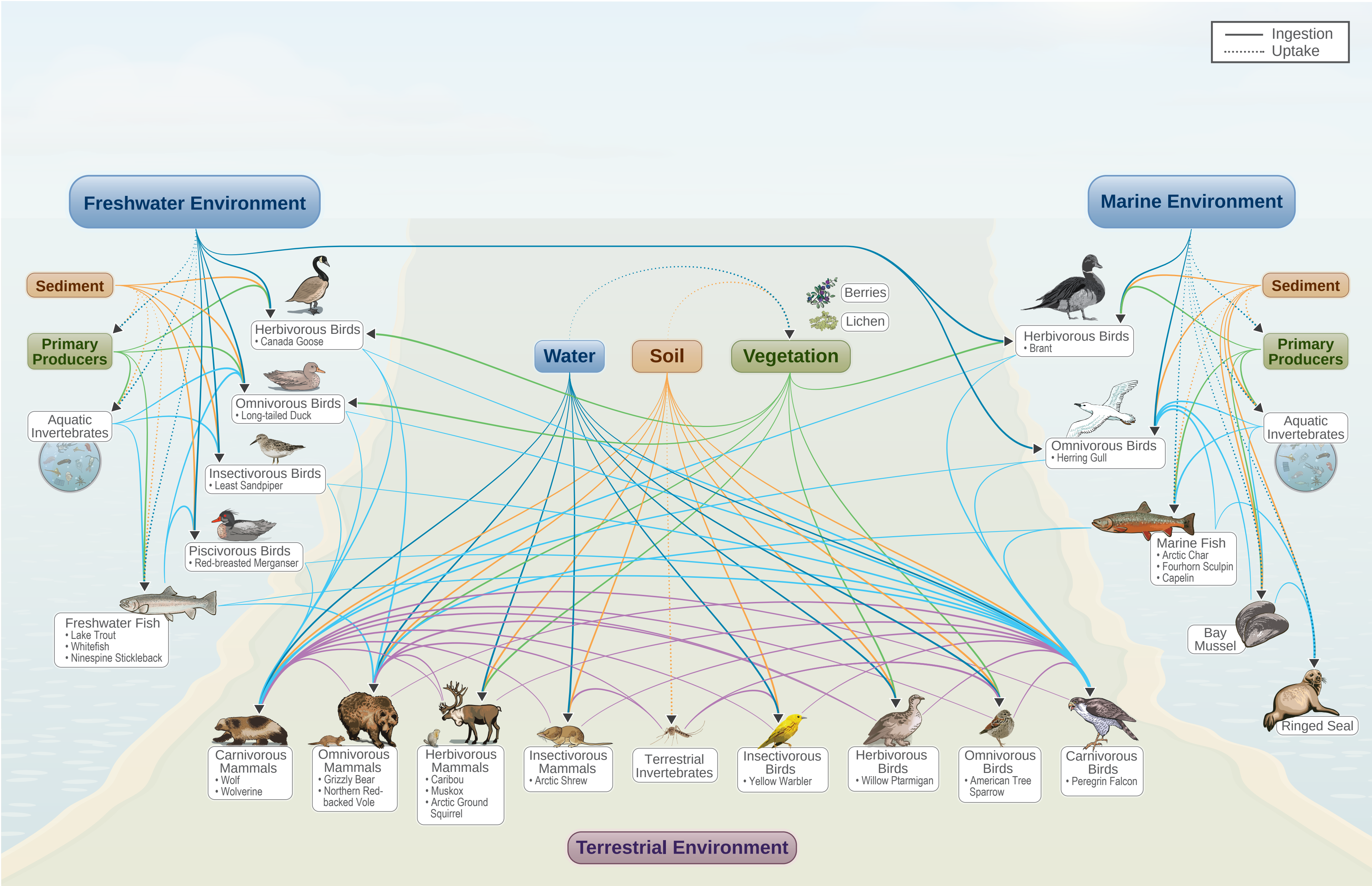
Figure 5.5-2

Conceptual Model for Potential Exposure to Contaminants of Potential Concern for Ecological Receptors under Existing Conditions



The baseline 95th percentile concentrations of COPCs in freshwater sediment (lakes and streams) from sites within the freshwater environment LSA (Table V6-5E4 in Appendix V6-5E) were used as an input in the equation to calculate the EDI of COPCs that freshwater species (i.e., Canada goose, least sandpiper, red-breasted merganser, and long-tailed duck) receive from ingestion of freshwater sediment under baseline conditions.

The baseline 95th percentile concentrations of COPCs in marine sediment from sites within the marine wildlife LSA (Table V6-5E4 in Appendix V6-5E) were used as an input in the equation to calculate the EDI of COPCs that marine species (i.e., brant, herring gull, and ringed seal) receive from ingestion of marine sediment under baseline conditions.

The equation used to calculate terrestrial wildlife exposure to COPCs (mg/kg BW/day) from soil/sediment ingestion was:

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW} \qquad \text{[Equation 13]}$$

where:

C = concentration of COPC in soil or sediment (mg/kg)
IR = receptor soil or sediment ingestion rate (kg/day)
ET = exposure time (days exposed/365 days)
RAF_{Oral} = relative absorption factor from the gastrointestinal tract (unitless)
BW = body weight (kg)

The soil and sediment intake rates and exposure times are presented in Table V6-5E8 of Appendix V6-5E. The COPC EDI via the soil or sediment ingestion exposure route for wildlife species are presented in Table 5.5-8. The assumptions used in the calculation of the EDI of COPCs via ingestion of soil/sediment were as follows:

- baseline soil quality at the 68 sampling sites is representative of baseline soil quality within the terrestrial LSA;
- baseline freshwater sediment quality at the 16 stream sites and 12 lake sites is representative of baseline freshwater sediment quality within the freshwater environment LSA;
- baseline marine sediment quality at the 18 sites in Roberts Bay is representative of baseline marine sediment quality within the marine environment LSA;
- wildlife species are exposed to COPCs for the amount of time they spend in the wildlife LSA, which is the ratio called exposure time (ET; described in Appendix V6-5E);
- wildlife species have the soil or sediment ingestion rates and body weights as presented in Table V6-5E8 of Appendix V6-5E;
- the RAF_{oral} is 1, as it is conservatively assumed that all COPCs ingested are completely bioavailable; and
- COPC concentrations below the MDL were replaced with concentrations of half of the MDL. This may over- or under-estimate the actual COPC concentrations.

A sample calculation of the EDI of aluminum from soil ingestion using Equation 13 is provided below for caribou:

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW}$$

$$EDI_{soil} = \frac{21{,}330 \frac{mg}{kg} \times 0.134 \frac{kg}{day} \times 0.00356 \times 1}{150\ kg\ BW}$$

$$EDI_{soil} = 0.0680\ mg/kg\ BW/day$$

5.5.2.3 Ingestion of Freshwater and Marine Water

The baseline 95th percentile concentration of COPCs from the surface water quality model (14 nodes) was used as an input in the equation to calculate the EDI of COPCs terrestrial wildlife species receive from drinking surface water under baseline conditions. This was done to ensure direct comparisons of water quality in baseline and predicted water quality are possible.

Marine seabirds (i.e., brant and herring gull) have the ability to drink fresh or salt water. Therefore, to be conservative, the higher of the baseline 95th percentile concentrations of COPCs in freshwater or marine water were used as an input in the equation to calculate the EDI of COPCs that seabirds receive from ingestion of drinking water under baseline conditions.

The general equation used to calculate exposure to COPCs (mg/kg BW/day) from freshwater and marine water ingestion is:

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW} \qquad \text{[Equation 14]}$$

where:

- *C* = concentration of COPC in soil or sediment (mg/kg)
- *IR* = receptor water ingestion rate (kg/day)
- *ET* = exposure time (days exposed/365 days)
- RAF_{Oral} = relative absorption factor from the gastrointestinal tract (unitless)
- *BW* = body weight (kg)

The freshwater and marine water ingestion rates and exposure times are presented in Table V6-5E8 of Appendix V6-5E. The COPC EDI via the freshwater and marine water exposure route for wildlife species are presented in Table 5.5-8.

Table 5.5-8. Estimated Daily Intake of Contaminants of Potential Concern for Wildlife Species

COPC	Caribou				Muskox				Wolverine				Grizzly Bear				
	$EDI_{[veg]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$
Aluminum	2.87E-02	6.80E-02	1.29E-05	9.68E-02	6.84E+00	1.62E+01	3.42E-03	2.31E+01	5.66E+00	6.27E+01	4.67E-03	6.84E+01	1.80E+00	1.24E+00	2.77E+01	1.49E-03	8.24E+00
Arsenic	1.68E-05	1.21E-05	5.68E-08	2.89E-05	4.01E-03	2.87E-03	1.50E-05	6.89E-03	4.11E-03	1.11E-02	2.05E-05	1.52E-02	1.05E-03	7.25E-04	4.90E-03	6.55E-06	1.79E-03
Cadmium	1.23E-05	7.98E-07	1.35E-09	1.31E-05	2.93E-03	1.90E-04	3.56E-07	3.12E-03	1.43E-04	7.35E-04	4.87E-07	8.79E-04	7.70E-04	1.14E-04	3.24E-04	1.55E-07	3.24E-04
Chromium	1.21E-03	2.09E-04	9.34E-08	1.42E-03	2.87E-01	4.99E-02	2.47E-05	3.37E-01	1.97E-02	1.93E-01	3.38E-05	2.13E-01	7.55E-02	5.83E-03	8.51E-02	1.08E-05	4.47E-02
Copper	3.25E-04	1.22E-04	3.06E-07	4.48E-04	7.75E-02	2.91E-02	8.08E-05	1.07E-01	1.71E-02	1.13E-01	1.10E-04	1.30E-01	2.04E-02	6.47E-03	4.97E-02	3.52E-05	2.05E-02
Lead	6.46E-05	4.79E-05	1.16E-08	1.12E-04	1.54E-02	1.14E-02	3.07E-06	2.68E-02	3.83E-03	4.41E-02	4.19E-06	4.80E-02	4.04E-03	1.21E-03	1.95E-02	1.34E-06	6.63E-03
Mercury	7.19E-06	1.61E-07	2.85E-10	7.35E-06	1.71E-03	3.85E-05	7.54E-08	1.75E-03	1.48E-03	1.49E-04	1.03E-07	1.63E-03	4.50E-04	1.96E-03	6.57E-05	3.29E-08	2.26E-04
Methylmercury	-	-	-	-	-	-	-	-	-	-	-	-	-	1.06E-04	-	-	4.38E-04
Nickel	6.35E-04	1.11E-04	1.23E-07	7.46E-04	1.52E-01	2.64E-02	3.25E-05	1.78E-01	3.63E-03	1.02E-01	4.45E-05	1.06E-01	3.98E-02	1.63E-03	4.51E-02	1.42E-05	2.32E-02
Selenium	8.77E-06	7.98E-07	5.35E-08	9.62E-06	2.09E-03	1.90E-04	1.41E-05	2.30E-03	3.33E-03	7.35E-04	1.93E-05	4.09E-03	5.49E-04	2.08E-03	3.24E-04	6.16E-06	7.93E-04
Thallium	1.12E-06	1.60E-06	8.70E-10	2.71E-06	2.67E-04	3.80E-04	2.30E-07	6.47E-04	2.21E-03	1.47E-03	3.14E-07	3.68E-03	7.00E-05	3.48E-04	6.49E-04	1.00E-07	2.86E-04
Zinc	2.43E-03	1.89E-04	6.83E-07	2.62E-03	5.80E-01	4.50E-02	1.81E-04	6.26E-01	1.59E-03	1.74E-01	2.47E-04	1.76E-01	1.52E-01	9.51E-02	7.67E-02	7.87E-05	8.70E-02

COPC	Wolf				Arctic Ground Squirrel				Arctic Shrew				Northern Red-backed Vole				
	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$
Aluminum	2.20E-01	4.88E+01	4.06E-03	6.13E-01	4.60E+00	3.82E+01	2.49E-03	4.28E+01	1.33E+03	4.24E+02	1.04E-02	1.76E+03	2.07E+01	9.35E+02	4.69E+02	8.51E-03	1.42E+03
Arsenic	6.09E-05	8.64E-03	1.78E-05	1.09E-04	2.69E-03	6.76E-03	1.10E-05	9.47E-03	1.18E-02	7.51E-02	4.56E-05	8.69E-02	1.21E-02	8.28E-03	8.30E-02	3.74E-05	1.03E-01
Cadmium	1.08E-05	5.72E-04	4.23E-07	7.30E-06	1.97E-03	4.48E-04	2.60E-07	2.42E-03	6.82E-02	4.97E-03	1.08E-06	7.31E-02	8.86E-03	4.78E-02	5.50E-03	8.87E-07	6.22E-02
Chromium	1.17E-02	1.50E-01	2.93E-05	2.02E-03	1.93E-01	1.17E-01	1.80E-05	3.11E-01	1.86E-01	1.30E+00	7.50E-05	1.49E+00	8.68E-01	1.31E-01	1.44E+00	6.15E-05	2.44E+00
Copper	6.72E-03	8.76E-02	9.58E-05	1.18E-03	5.22E-02	6.86E-02	5.89E-05	1.21E-01	4.35E-01	7.61E-01	2.45E-04	1.20E+00	2.34E-01	3.05E-01	8.42E-01	2.01E-04	1.38E+00
Lead	5.07E-05	3.43E-02	3.64E-06	4.30E-04	1.04E-02	2.69E-02	2.24E-06	3.72E-02	1.28E-01	2.98E-01	9.31E-06	4.26E-01	4.65E-02	8.97E-02	3.30E-01	7.63E-06	4.66E-01
Mercury	2.75E-03	1.16E-04	8.94E-08	3.59E-05	1.15E-03	9.06E-05	5.50E-08	1.24E-03	5.75E-04	1.01E-03	2.29E-07	1.58E-03	5.18E-03	4.03E-04	1.11E-03	1.88E-07	6.69E-03
Methylmercury	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	6.71E-03	7.94E-02	3.86E-05	1.08E-03	1.02E-01	6.22E-02	2.37E-05	1.64E-01	1.97E-01	6.90E-01	9.88E-05	8.87E-01	4.57E-01	1.38E-01	7.63E-01	8.10E-05	1.36E+00
Selenium	3.27E-05	5.72E-04	1.68E-05	7.78E-06	1.41E-03	4.48E-04	1.03E-05	1.87E-03	1.56E-02	4.97E-03	4.29E-05	2.06E-02	6.31E-03	1.10E-02	5.50E-03	3.52E-05	2.28E-02
Thallium	1.64E-04	1.14E-03	2.73E-07	1.64E-05	1.79E-04	8.95E-04	1.68E-07	1.08E-03	3.12E-02	9.94E-03	6.98E-07	4.12E-02	8.05E-04	2.19E-02	1.10E-02	5.72E-07	3.37E-02
Zinc	3.54E-04	1.35E-01	2.14E-04	1.70E-03	3.90E-01	1.06E-01	1.32E-04	4.96E-01	9.40E+00	1.18E+00	5.48E-04	1.06E+01	1.75E+00	6.60E+00	1.30E+00	4.49E-04	9.65E+00

COPC	Willow Ptarmigan				American Tree Sparrow					Peregrine Falcon				Canada Goose			
	$EDI_{[veg]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[sediment]}$	$EDI_{[water]}$	$EDI_{[total]}$
Aluminum	2.49E+01	5.90E+01	4.18E-03	8.38E+01	3.04E+01	1.37E+03	1.97E+02	4.81E-03	1.60E+03	4.44E+00	7.46E+01	1.59E-03	7.91E+01	5.87E+00	7.67E+01	1.02E-03	8.26E+01
Arsenic	1.46E-02	1.04E-02	1.84E-05	2.50E-02	1.78E-02	1.22E-02	3.49E-02	2.12E-05	6.48E-02	3.21E-03	1.32E-02	7.00E-06	1.64E-02	3.44E-03	4.37E-02	4.47E-06	4.72E-02
Cadmium	1.07E-02	6.91E-04	4.36E-07	1.14E-02	1.30E-02	7.03E-02	2.31E-03	5.02E-07	8.56E-02	1.67E-04	8.75E-04	1.66E-07	1.04E-03	2.52E-03	4.47E-04	1.06E-07	2.96E-03
Chromium	1.04E+00	1.81E-01	3.02E-05	1.23E+00	1.28E+00	1.92E-01	6.06E-01	3.48E-05	2.07E+00	1.09E-02	2.30E-01	1.15E-05	2.40E-01	2.47E-01	2.06E-01	7.35E-06	4.52E-01
Copper	2.82E-01	1.06E-01	9.88E-05	3.88E-01	3.44E-01	4.49E-01	3.54E-01	1.14E-04	1.15E+00	1.19E-02	1.34E-01	3.76E-05	1.46E-01	6.65E-02	1.36E-01	2.40E-05	2.03E-01
Lead	5.60E-02	4.15E-02	3.75E-06	9.75E-02	6.83E-02	1.32E-01	1.38E-01	4.32E-06	3.39E-01	2.97E-03	5.25E-02	1.43E-06	5.55E-02	1.32E-02	3.38E-02	9.13E-07	4.70E-02
Mercury	6.23E-03	1.40E-04	9.22E-08	6.37E-03	7.61E-03	5.93E-04	4.67E-04	1.06E-07	8.67E-03	4.10E-06	1.77E-04	3.51E-08	1.81E-04	1.47E-03	1.65E-04	2.24E-08	1.64E-03
Methylmercury	-	-	-	-	-	-	-	-	-	1.08E-03	-	-	1.08E-03	-	-	-	-
Nickel	5.51E-01	9.60E-02	3.98E-05	6.47E-01	6.72E-01	2.03E-01	3.20E-01	4.58E-05	1.20E+00	5.78E-04	1.21E-01	1.51E-05	1.22E-01	1.30E-01	1.25E-01	9.69E-06	2.55E-01
Selenium	7.60E-03	6.91E-04	1.73E-05	8.31E-03	9.28E-03	1.61E-02	2.31E-03	1.99E-05	2.77E-02	3.66E-03	8.75E-04	6.58E-06	4.54E-03	1.79E-03	1.70E-03	4.21E-06	3.49E-03
Thallium	9.70E-04	1.38E-03	2.81E-07	2.35E-03	1.18E-03	3.22E-02	4.62E-03	3.24E-07	3.80E-02	1.68E-03	1.75E-03	1.07E-07	3.43E-03	2.29E-04	7.97E-04	6.84E-08	1.03E-03
Zinc	2.11E+00	1.63E-01	2.21E-04	2.27E+00	2.58E+00	9.69E+00	5.46E-01	2.54E-04	1.28E+01	6.36E-02	2.07E-01	8.40E-05	2.71E-01	4.98E-01	2.73E-01	5.37E-05	7.71E-01

COPC	Red-breasted Merganser				Least Sandpiper				Long-tailed Duck					Herring Gull			
	$EDI_{[prey]}$	$EDI_{[sediment]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[prey]}$	$EDI_{[sediment]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[prey]}$	$EDI_{[sediment]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[prey]}$	$EDI_{[sediment]}$	$EDI_{[water]}$	$EDI_{[total]}$
Aluminum	2.54E+00	6.94E+01	1.45E-03	7.20E+01	5.75E+00	2.42E+02	5.06E-03	2.48E+02	4.74E-01	1.68E+00	6.99E+01	1.60E-03	7.21E+01	1.12E+01	6.12E+01	1.47E-03	7.24E+01
Arsenic	1.67E-03	3.96E-02	6.38E-06	4.12E-02	7.99E-04	1.38E-01	2.22E-05	1.39E-01	2.77E-04	3.06E-04	3.99E-02	7.04E-06	4.05E-02	4.97E-02	1.38E-02	6.48E-06	6.34E-02
Cadmium	1.96E-03	4.04E-04	1.51E-07	2.36E-03	8.98E-03	1.41E-03	5.27E-07	1.04E-02	2.03E-04	2.50E-03	4.08E-04	1.67E-07	3.11E-03	7.60E-02	3.05E-04	1.54E-07	7.63E-02
Chromium	3.03E-02	1.86E-01	1.05E-05	2.16E-01	5.40E-01	6.49E-01	3.66E-05	1.19E+00	1.99E-02	1.46E-01	1.88E-01	1.16E-05	3.53E-01	1.99E+00	1.68E-01	1.06E-05	2.16E+00
Copper	1.06E-01	1.23E-01	3.43E-05	2.29E-01	2.19E+00	4.30E-01	1.20E-04	2.62E+00	5.37E-03	5.89E-01	1.24E-01	3.78E-05	7.19E-01	1.80E-01	8.35E-02	3.48E-05	2.63E-01
Lead	1.04E-02	3.05E-02	1.30E-06	4.10E-02	1.13E-01	1.07E-01	4.54E-06	2.20E-01	1.07E-03	3.07E-02	3.08E-02	1.44E-06	6.26E-02	1.91E-02	2.37E-02	1.32E-06	4.28E-02
Mercury	-	1.49E-04	3.20E-08	1.49E-04	-	5.21E-04	1.12E-07	5.21E-04	1.19E-04	-	1.50E-04	3.53E-08	2.69E-04	-	3.43E-05	3.25E-08	3.43E-05
Methylmercury	5.94E-02	-	-	5.94E-02	3.02E-01	-	-	3.02E-01	-	6.25E-03	-	-	6.25E-03	2.58E-03	-	-	2.58E-03
Nickel	2.89E-02	1.13E-01	1.38E-05	1.42E-01	6.64E-03	3.95E-01	4.82E-05	4.01E-01	1.05E-02	3.37E-03	1.14E-01	1.52E-05	1.28E-01	1.04E+00	8.21E-02	1.40E-05	1.12E+00
Selenium	5.26E-02	1.53E-03	6.00E-06	5.41E-02	1.30E-01	5.35E-03	2.09E-05	1.35E-01	1.45E-04	3.76E-02	1.55E-03	6.62E-06	3.93E-02	1.22E-01	7.95E-04	6.09E-06	1.23E-01
Thallium	1.22E-03	7.21E-04	9.75E-08	1.94E-03	2.51E-02	2.51E-03	3.40E-07	2.76E-02	1.85E-05	6.77E-03	7.26E-04	1.08E-07	7.51E-03	6.63E-04	7.95E-04	9.91E-08	1.46E-03
Zinc	3.37E+00	2.47E-01	7.66E-05	3.61E+00	6.02E+00	8.60E-01	2.67E-04	6.88E+00	4.02E-02	1.79E+00	2.49E-01	8.45E-05	2.08E+00	2.18E+00	1.82E-01	7.78E-05	2.36E+00

COPC	Yellow Warbler				Brant				Ringed Seal		
	$EDI_{[prey]}$	$EDI_{[soil]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[veg]}$	$EDI_{[sediment]}$	$EDI_{[water]}$	$EDI_{[total]}$	$EDI_{[prey]}$	$EDI_{[sediment]}$	$EDI_{[total]}$
Aluminum	1.98E+03	1.80E+02	6.80E-03	2.16E+03	7.61E+00	1.63E+01	1.30E-03	2.39E+01	6.36E+00	7.34E+01	7.97E+01
Arsenic	1.75E-02	3.19E-02	2.99E-05	4.94E-02	4.46E-03	3.66E-03	5.72E-06	8.12E-03	6.55E-02	1.65E-02	8.20E-02
Cadmium	1.01E-01	2.11E-03	7.09E-07	1.03E-01	3.26E-03	8.12E-05	1.36E-07	3.34E-03	4.73E-02	3.66E-04	4.77E-02
Chromium	2.77E-01	5.54E-01	4.91E-05	8.31E-01	3.20E-01	4.46E-02	9.40E-06	3.64E-01	1.22E+00	2.01E-01	1.42E+00
Copper	6.47E-01	3.23E-01	1.61E-04	9.70E-01	8.63E-02	2.22E-02	3.08E-05	1.08E-01	1.41E-01	1.00E-01	2.42E-01
Lead	1.90E-01	1.27E-01	6.10E-06	3.17E-01	1.71E-02	6.31E-03	1.17E-06	2.35E-02	1.10E-02	2.84E-02	3.95E-02
Mercury	8.54E-04	4.27E-04	1.50E-07	1.28E-03	1.91E-03	9.12E-06	2.87E-08	1.92E-03	-	4.11E-05	4.11E-05
Methylmercury	-	-	-	-	-	-	-	-	2.37E-03	-	2.37E-03
Nickel	2.93E-01	2.93E-01	6.47E-05	5.86E-01	1.69E-01	2.19E-02	1.24E-05	1.90E-01	5.89E-01	9.85E-02	6.88E-01
Selenium	2.32E-02	2.11E-03	2.81E-05	2.53E-02	2.33E-03	2.12E-04	5.38E-06	2.54E-03	1.19E-01	9.53E-04	1.20E-01
Thallium	4.64E-02	4.22E-03	4.57E-07	5.06E-02	2.97E-04	2.12E-04	8.75E-08	5.08E-04	1.11E-03	9.53E-04	2.06E-03
Zinc	1.40E+01	4.99E-01	3.59E-04	1.45E+01	6.46E-01	4.85E-02	6.87E-05	6.94E-01	1.51E+00	2.18E-01	1.73E+00

Notes:

COPC = contaminant of potential concern

BW = body weight

EDI = estimated daily intake

All EDIs are in mg/kg BW/day.

$EDI_{[veg]}$ = estimated daily intake of COPC from vegetation consumption (mg/kg BW/day)

$EDI_{[soil]}$ = estimated daily intake of COPC from soil consumption (mg/kg BW/day)

$EDI_{[sediment]}$ = estimated daily intake of COPC from sediment consumption (mg/kg BW/day)

$EDI_{[water]}$ = estimated daily intake of COPC from water consumption (mg/kg BW/day)

$EDI_{[prey]}$ = estimated daily intake of COPC from prey consumption (mg/kg BW/day)

$EDI_{[total]}$ = total estimated daily intake of COPC an animal receives from soil, sediment, vegetation, prey, and water consumption (mg/kg BW/day)

(-) = not applicable

The assumptions used in the calculation of the EDI of COPC via ingestion of freshwater and marine water were as follows:

- base case baseline surface water quality at the 14 modeling nodes in the surface water quality model is representative of baseline surface water quality within the freshwater environment LSA;
- baseline marine water quality from Roberts Bay is representative of baseline marine water quality within the marine environment LSA;
- wildlife species are exposed to COPCs for the amount of time they spend in the wildlife LSA, which is the ratio called exposure time (ET; described in Appendix V6-5E);
- wildlife species have the freshwater and marine water ingestion rates and body weights as presented in Table V6-5E8 of Appendix V6-5E; and
- the RAF_{oral} is 1, as it is conservatively assumed that all COPCs ingested are completely absorbed.

A sample calculation of the EDI of aluminum from freshwater ingestion using Equation 14 is provided below for caribou:

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW}$$

$$EDI_{water} = \frac{0.0605 \frac{mg}{L} \times \frac{9.00L}{day} \times 0.00356 \times 1}{150\ kg\ BW}$$

$$EDI_{water} = 1.29\ x\ 10^{-5}\ mg/kg\ BW/day$$

5.5.2.4 *Ingestion of Vegetation*

The baseline 95th percentile concentrations of COPCs in vegetation species from 119 sites within the terrestrial LSA (Table V6-5E4 of Appendix V6-5E) were used as an input in the EDI equation to calculate the EDI of COPCs terrestrial wildlife species receive from ingestion of vegetation under baseline conditions.

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW} \qquad \text{[Equation 15]}$$

where:

C	= concentration of COPC in soil or sediment (mg/kg)
IR	= receptor vegetation ingestion rate (kg/day)
ET	= exposure time (days exposed/365 days)
RAF_{Oral}	= relative absorption factor from the gastrointestinal tract (unitless)
BW	= body weight (kg)

The vegetation ingestion rates and exposure times are presented in Table V6-5E8 of Appendix V6-5E. The COPC EDI via the vegetation ingestion exposure route for wildlife species are presented in Table 5.5-8.

The assumptions used in the calculation of the EDI of COPCs via ingestion of vegetation were as follows:

- baseline vegetation quality at the 119 sampling sites is representative of baseline vegetation quality within the terrestrial LSA;
- the diets of wildlife species that consume vegetation include solely the vegetation species that were collected in baseline field studies and in the proportions used in the model (i.e., half berries and half lichen);
- wildlife species are exposed to COPCs for the amount of time they spend in the wildlife LSA, (described in Appendix V6-5E);
- wildlife species have the vegetation ingestion rates and body weights as presented in Table V6-5E8 of Appendix V6-5E;
- the RAF_{oral} is 1.0, as it is conservatively assumed that all COPCs ingested are completely absorbed; and
- COPC concentrations below the MDL were replaced with concentrations of half of the MDL. This may over- or under-estimate the actual COPC concentrations.

A sample calculation of the EDI of aluminum from vegetation ingestion using Equation 15 is provided below for caribou:

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW}$$

$$EDI_{vegetation} = \frac{180\frac{mg}{kg} \times 6.72\frac{kg}{day} \times 0.00356 \times 1}{150\ kg\ BW}$$

$$EDI_{vegetation} = 0.0287\ mg/kg\ BW/day$$

5.5.2.5 *Ingestion of Prey (Ingestion via the Food Chain)*

Terrestrial Wildlife Prey

Tissue concentrations of COPCs for terrestrial prey species were estimated using a food chain model described in Golder and Associates (2005) and recommended by Health Canada (2010a). The food chain model is described and the prey tissue COPC concentrations are provided in Appendix V6-5E. The modeled baseline COPC concentrations in prey species were used as an input in the EDI equation to calculate the EDI of COPCs that carnivores and omnivores receive from ingestion of prey under baseline conditions. Some carnivores and omnivores consume several prey species, thus the EDI of COPCs from all the applicable prey species were summed for each carnivore and omnivore, depending on which prey items are consumed. The prey items consumed by each carnivore and omnivore species are listed in Table V6-5E7 and Table V6-5E8 of Appendix V6-5E.

For calculations of EDI, the arsenic concentration in diet items was adjusted to account for the amount of inorganic arsenic that is likely to be present, as that is the most toxic form. The inorganic arsenic fraction was used in the calculation of EDI from diet items. For mammalian diet items it was assumed that 70% of the total arsenic was inorganic and for bird diet items it was assumed that 50% of the total arsenic was inorganic (EFSA 2009, 2014). For vegetation it was assumed that 100% of the arsenic was inorganic (Nicholson 2002). For fish and aquatic invertebrates it was assumed that 10% of the arsenic was inorganic (Slejkovec, Bajc, and Doganoc 2004). For soil, water, and terrestrial invertebrate ingestion, it was assumed that 100% of the arsenic was inorganic.

$$EDI = \frac{C \times IR \times ET \times RAF_{Oral}}{BW}$$ [Equation 16]

where:

C	= concentration of COPC in soil or sediment (mg/kg)
IR	= receptor prey or food item ingestion rate (kg/day)
ET	= exposure time (days exposed/365 days)
RAF_{Oral}	= relative absorption factor from the gastrointestinal tract (unitless)
BW	= body weight (kg)

The terrestrial prey intake rates and exposure times are presented in Table V6-5E8 of Appendix V6-5E. The COPC EDI via the terrestrial prey ingestion exposure route for carnivores and omnivores are presented in Table 5.5-8.

The assumptions used in the calculation of the EDI of COPCs via ingestion of terrestrial prey species were as follows:

- modeled baseline terrestrial prey quality is representative of baseline terrestrial prey quality within the wildlife LSA and that the carnivores and omnivores only consume those terrestrial prey species;
- carnivores and omnivores are exposed to COPCs for the amount of time they spend in the wildlife LSA (described in Appendix V6-5E);
- carnivores and omnivores have the vegetation ingestion rates and body weights as presented in Table V6-5E8 of Appendix V6-5E;
- the RAF_{oral} is 1.0, as it is conservatively assumed that all COPCs ingested are completely absorbed; and
- COPC concentrations below the MDL were replaced with concentrations of half of the MDL. This may over- or under-estimate the actual COPC concentrations.

A sample calculation of the EDI of aluminum from caribou ingestion using Equation 16 is provided below for wolverine:

$$EDI_{from\ caribou\ to\ wolverine} = \frac{C \times IR \times ET \times RAF_{Oral}}{BW}$$

$$EDI_{from\ caribou\ by\ wolverine} = \frac{0.0218\,\frac{mg}{kg} \times 0.147\,\frac{kg}{day} \times 1 \times 1}{12.0\ kg\ BW}$$

$$EDI_{from\ caribou\ by\ wolverine} = 0.000267\ mg/kg\ BW/day$$

<u>Aquatic Life Prey</u>

The baseline 95th percentile concentrations of COPCs in tissue of Lake Trout, Whitefish, Arctic Char, and Ninespine Stickleback sampled from within the freshwater fish LSA (Table V6-5E4 in Appendix V6-5E) were used as an input in the EDI equation to calculate the dose of COPCs piscivorous wildlife species (i.e., grizzly bear, peregrine falcon, red-breasted merganser, long-tailed duck, herring gull, and ringed seal) receive from ingestion of fish under baseline conditions. It was assumed that grizzly bear and peregrine falcon would consume both freshwater and marine fish species, while red-breasted merganser and long-tailed duck would only consume freshwater fish species, and herring gull and ringed seal would only consume marine fish species.

The baseline 95th percentile concentrations of COPCs in bay mussels sampled from three sites within the marine environment RSA (Table V6-5E4 in Appendix V6-5E) were used as an input in the EDI equation to calculate the dose of COPCs wildlife species that consume bivalves (i.e., herring gull and ringed seal) receive from ingestion of bivalves under baseline conditions.

The general equation used to calculate exposure to COPCs (mg/kg BW/day) from fish or bivalve ingestion was the same as that presented in Section 5.5.2.2 (Equation 16).

The fish or bivalve ingestion rates and receptor exposure times are presented in Table V6-5E8 of Appendix V6-5E. The COPC EDI via the fish or bivalve ingestion exposure route for piscivorous wildlife species are presented in Table 5.5-8.

The assumptions used in the calculation of the EDI of COPCs via ingestion of fish or bivalves were as follows:

- baseline fish quality at the 12 freshwater sampling sites is representative of baseline fish quality within the freshwater environment LSA;
- baseline bivalve quality at the three sampling sites is representative of baseline bivalve quality within the marine environment LSA;
- piscivorous wildlife species are exposed to COPCs for the amount of time they spend in the freshwater environment LSA (described in Appendix V6-5E);
- piscivorous wildlife species have the fish ingestion rates and body weights as presented in Table V6-5E8 of Appendix V6-5E;
- the RAF_{oral} is 1, as it is conservatively assumed that all COPCs ingested are completely absorbed; and
- COPC concentrations below the MDL were replaced with concentrations of half of the MDL. This may over- or under-estimate the actual COPC concentrations.

A sample calculation of the EDI of aluminum from fish ingestion using Equation 16 is provided below for grizzly bear:

$$EDI_{from\,fish\,for\,grizzly\,bear} = \frac{C \times IR \times ET \times RAF_{Oral}}{BW}$$

$$EDI_{\,from\,fish\,for\,grizzly\,bear} = \frac{16.3\,\frac{mg}{kg} \times 4.22\frac{kg}{day} \times 0.458 \times 1}{450\;kg\;BW} 1$$

$$EDI_{fish} = 0.0699\;mg/kg\;BW/day$$

5.5.2.6 Total Estimated Daily Intake

The COPC EDI from each exposure route and the total summed EDI for each wildlife species is presented in Table 5.5-8.

5.5.3 Toxicity Assessment

5.5.3.1 Introduction

Protection goals for ecological receptors can be described and operationalized in the form of assessment and measurement endpoints used to guide the ERA process. With the exception of listed species (e.g., Threatened, Endangered, or of Special Concern), an ERA is concerned with estimating effects on populations, communities, and ecosystems. For the consideration of Species at Risk, effects on an individual level are considered relevant. Every effort was made to obtain low-effects threshold TRVs. Further information on receptor specific protection goals, measurement and assessment endpoints used to guide the ERA are provided in Table 5.5-9.

The TRVs used in this assessment are typically NOAELs, which are the highest concentration used in a toxicity test that results in no observed or measured chronic health effects. The TRVs for mammalian and avian wildlife species in this assessment are presented as the amount of COPC per unit body weight that can be taken into the body each day (e.g., mg/kg BW/day) without appreciable risk of adverse health effects. For aquatic life, TRVs are usually based on concentrations (e.g., mg/L in water, or mg/kg of sediment) in environmental media to which the receptors are directly exposed.

A database and literature search provided appropriate TRVs for each COPC identified in environmental media (i.e., soil, fresh and marine water, fresh and marine sediment, and fish tissue). The database and literature search for TRVs considered the following sources:

- technical appendices included in the CCME guidelines (CCME 2016a);
- US EPA Ecotox Database (US EPA 2016a);
- US EPA Integrated Risk Information System (US EPA 2016b);
- US EPA Ecological Soil Screening Level (Eco SSL) documents (US EPA 2003b);
- Oak Ridge National Laboratory (ORNL) toxicological benchmarks for wildlife (Sample, Opresko, and Suter 1996); and
- primary literature.

The sections below provide a summary of the TRVs selected for ecological receptors and the applicable environmental media.

5.5.3.2 Toxicity Reference Values

<u>Aquatic Life</u>

For freshwater and marine life (i.e., primary producers, pelagic and benthic invertebrates, and fish), to initially evaluate risk, the 95th percentile concentrations of the COPCs were compared to the freshwater and marine water long-term CCME (2016a) water quality guidelines for the protection of aquatic life (Table 5.5-10). In sediments, the 95th percentile of the COPCs were compared to the CCME (2016a) PELs. Use of the PELs to define the potential for toxicity is justified because the protection goals and assessment endpoints for aquatic life (Table 5.5-9) are at the population or community level.

These comparisons differ from the COPC screening step described in Section 5.5.1.3 (where maximum concentrations were used) since it uses the 95th percentile of COPC concentrations.

Table 5.5-9. Protection Goals for Ecological Receptors

Representative Species	Protection Goal	Assessment Endpoint	Measurement Endpoints - Lines of Evidence
Freshwater			
Phytoplankton community, periphyton community, plant/algal community	Maintain primary producer biomass at the community level as a food source for higher level organisms.	Primary producer community biomass	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in surface water to appropriate media assessment criteria (water quality guidelines or effects based toxicity thresholds).
Pelagic and benthic invertebrates	Maintain invertebrate community biomass at the community level as a food source for higher level organisms.	Invertebrate community biomass	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in surface water to appropriate media assessment criteria (water quality guidelines or effects based toxicity thresholds for mortality, growth, or reproduction).
Ninespine Stickleback (*Pungitius pungitius*) Lake Whitefish (*Coregonus clupeaformis*) Lake Trout (*Salvelinus namaycush*)	Maintain abundance of fish populations as a food source for humans and higher level organisms (e.g., piscivorous fish and wildlife).	Fish population abundance	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in surface water to appropriate media assessment criteria (water quality guidelines or effects based toxicity thresholds for mortality, growth, or reproduction).
Grizzly bear (*Ursus arctos horribilis*) [a]	Maintain abundance of individual organisms, since this is listed by COSEWIC as a species of Special Concern.	Organism level effects on listed species	**Food Chain Model** - Comparison of estimated exposure from all routes for COPC to dose-based TRVs relevant to effects on growth, survival, and reproduction.
Canada goose (*Branta canadensis*) Least sandpiper (*Calidris minutilla*) Red-breasted merganser (*Mergus serrator*) Long-tailed duck (*Clangula hyemalis*)	Maintain abundance of bird populations as a food source for humans and higher level organism (e.g., wildlife).	Avian population abundance	**Food Chain Model** - Comparison of estimated exposure from all routes for COPC to dose-based TRVs relevant to effects on growth, survival, and reproduction.
Marine Water			
Phytoplankton community, plant/algal community	Maintain primary producer biomass at the community level as a food source for higher level organisms.	Primary producer community biomass	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in marine water to appropriate media assessment criteria (water quality guidelines or effects based toxicity thresholds).
Pelagic and benthic invertebrates	Maintain invertebrate community biomass at the community level as a food source for higher level organisms.	Invertebrate community biomass	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in marine water to appropriate media assessment criteria (water quality guidelines or effects based toxicity thresholds for mortality, growth, or reproduction).

Representative Species	Protection Goal	Assessment Endpoint	Measurement Endpoints - Lines of Evidence
Fourhorn Sculpin (*Myoxocephalus quadricornis*) Capelin (*Mallotus villosus*) Arctic Char (*Salvelinus alpinus*)	Maintain abundance of fish populations as a food source for humans and higher level organisms (e.g., piscivorous fish and wildlife).	Fish population abundance	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in marine water to appropriate media assessment criteria (water quality guidelines or effects based toxicity thresholds for mortality, growth, or reproduction).
Ringed Seal (*Phoca hispida*)	Maintain abundance of marine mammal populations as a food source for higher level organism (e.g., wildlife).	Marine mammal population abundance	**Food Chain Model** - Comparison of estimated exposure from all routes for COPC to dose-based TRVs relevant to effects on growth, survival, and reproduction.
Brant (*Branta bernicla*) Herring gull (*Larus smithsonianus*)	Maintain abundance of bird populations as a food source for humans and higher level organism (e.g., wildlife).	Avian population abundance	**Food Chain Model** - Comparison of estimated exposure from all routes for COPC to dose-based TRVs relevant to effects on growth, survival, and reproduction.
Terrestrial			
Terrestrial Plant community	Maintain primary producer biomass at the community level as a food source for higher level organisms.	Primary producer community biomass	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in soil to appropriate media assessment criteria (soil quality guidelines or effects based toxicity thresholds).
Terrestrial invertebrate community	Maintain invertebrate community biomass at the community level as a food source for higher level organisms	Invertebrate community biomass	**Chemistry** - Evaluate receptor exposure via comparison of COPC concentrations in soil to appropriate media assessment criteria (soil quality guidelines or effects based toxicity thresholds for mortality, growth, or reproduction).
Grizzly bear (*Ursus arctos horribilis*) [a] Caribou (*Rangifer tarandus*) [b] Wolverine (*Gulo gulo*) [c]	Maintain survival, growth, and fecundity of individuals of federally listed species (caribou, grizzly bear, and wolverine).	Organism level effects on listed species	**Food Chain Model** - Comparison of estimated exposure from all routes for COPC to dose-based TRVs relevant to effects on growth, survival, and reproduction.
Muskox (*Ovibos moschatus*) Arctic ground squirrel (*Spermophilus parryii*) Wolf (*Canis lupus arctos*) Northern red-backed vole (*Myodes rutilus*) Arctic Shrew (*Sorex arcticus*)	Maintain abundance of mammal populations as a food source for humans and higher level organism (e.g., wildlife)	Mammal population abundance	

Representative Species	Protection Goal	Assessment Endpoint	Measurement Endpoints - Lines of Evidence
Willow ptarmigan (*Lagopus lagopus*) Yellow warbler (*Setophaga petechia*) American tree sparrow (*Spizella arborea*)	Maintain abundance of bird populations as a food source for humans and higher level organism (e.g., wildlife).	Avian population abundance	**Food Chain Model** - Comparison of estimated exposure from all routes for COPC to dose-based TRVs relevant to effects on growth, survival, and reproduction.
Peregrine falcon (*Falco peregrinus*) [d]	Maintain survival, growth, and fecundity of individuals of federally listed species. Maintain abundance of carnivorous bird populations as a regulator of lower level aquatic and/or terrestrial populations of ecological receptors.	Organism level effects on listed species	

Notes:

[a] *Grizzly bear are listed by* COSEWIC (2016) *as of Special Concern.*

[b] *The Dolphin-Union caribou herd is listed on SARA (*2002*) Schedule 1 and by* COSEWIC (2016) *as of Special Concern.*

[c] *Wolverine are listed by* COSEWIC (2016) *as of Special Concern.*

[d] *Peregrine falcon are listed on SARA (*2002*) Schedule 1 and by* COSEWIC (2016) *as of Special Concern.*

Table 5.5-10. CCME Water Quality Guidelines for Aquatic Life Receptors used for Initial Evaluation of Risk

COPCs in Water	CCME Water Quality Guideline for Freshwater [a] (mg/L)	CCME Water Quality Guideline for Marine Water [b] (mg/L)
Aluminum	0.1	NA
Arsenic	NA	0.0125
Chloride	120	NA
Chromium	0.001	0.0015
Copper	0.004	NA
Fluoride	0.12	NA
Iron	0.3	NA
Mercury	NA	0.000016
Selenium	0.001	NA
Zinc	0.03	NA
COPCs in Sediment	**CCME PEL for Freshwater Sediments [a] (mg/kg dw)**	**CCME PEL for Marine Sediments [b] (mg/kg dw)**
Arsenic	17	41.6
Chromium	90	160
Copper	197	108

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment
PEL = probable effects level
NA = exposure route is not applicable and a toxicity reference value is not required
[a] Includes primary producers (phytoplankton, periphyton, and plant/algae communities), pelagic and benthic invertebrate communities, and fish (Ninespine Stickleback, Lake Whitefish, and Lake Trout).
[b] Includes primary producers (phytoplankton and plant/algae communities), pelagic and benthic invertebrate communities, and fish (Fourhorn Sculpin, Capelin, and Arctic Char).

Terrestrial Plants and Invertebrates

For terrestrial plants and invertebrates, to initially evaluate risk, the 95th percentile concentrations of the COPCs were compared to the CCME (2016a) soil quality guidelines for the protection of ecological and human health - agricultural (Table 5.5-11). This differs from the COPC screening step described in Section 5.5.1.3 (where maximum concentrations were used) since it uses the 95th percentile of COPC concentrations.

Table 5.5-11. CCME Soil Quality Guidelines for Terrestrial Plant and Invertebrate Receptors used for Initial Evaluation of Risk

COPCs in Soil	CCME Soil Quality Guideline for Terrestrial Plant and Invertebrate Ecological Receptors (mg/kg dw)
Chromium	64
Copper	63
Nickel	45

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment

Mammalian and Avian Wildlife

Of the mammalian and avian ecological receptors considered, grizzly bear, caribou, wolverine, and peregrine falcon are listed species under the SARA (2002) or by COSEWIC (2016). The effects thresholds chosen (including the listed species; Tables 5.5-12 and 5.5-13) are appropriate as they are based on the lowest no-observed-adverse-effects-levels (NOAELs) available in the published literature. The only exception was methylmercury for birds, as the TRV is based on the geometric mean of the lowest-observed-adverse-effects-level (LOAEL) and NOAEL.

Wildlife TRVs for COPCs were preferentially obtained from the US EPA *Ecological Soil Screening Level* documents (Eco-SSLs; US EPA 2010), which are a commonly used source of systematic and conservative wildlife toxicity information. The methodologies used to develop oral TRVs for avian and mammalian wildlife are described in detail in the US EPA's *Guidance for Developing Ecological Soil Screening Levels* (Eco-SSLs) document (US EPA 2003b). In all cases, the Eco-SSL TRV for a specific contaminant is lower than the lowest bound LOAEL reported across all studies within a taxonomic class (i.e., birds or mammals). The toxicological studies contributing to the development of a TRV are referenced in each contaminant-specific Eco-SSL document.

Eco-SSL documents were not available for all COPCs, thus wildlife TRVs were also obtained from the Oak Ridge National Laboratory (ORNL) *Toxicological Benchmarks for Wildlife* (Sample, Opresko, and Suter 1996). If a chronic NOAEL was not provided for a specific COPC in the Sample, Opresko, and Suter (1996) document, a general literature search was conducted to find the most recent and robust toxicological data available. The mammalian and avian wildlife TRVs used in this existing conditions ERA are presented in Tables 5.5-12 and 5.5-13. The toxicity studies on which the mammalian and avian wildlife TRVs were based and the rationale for their selection is briefly summarized in this section.

Aluminum

The Eco-SSL document for aluminum (US EPA 2003a) lacks toxicity data for both mammalian and avian wildlife. However, the ORNL *Toxicological Benchmarks for Wildlife* (Sample, Opresko, and Suter 1996) document references studies that have investigated the chronic toxicity of aluminum exposure in laboratory test organisms. A chronic NOAEL of 109.7 mg/kg BW/day is provided for reproductive effects in birds, which is based on a 4-month exposure of orally-administered $Al_2(SO_4)_3$ in ringed dove (*Streptopelia risoria*) conducted by Carriere et al. (1986). In addition, a chronic NOAEL of 1.93 mg/kg BW/day is provided for reproductive effects in mammals, which is based on a 3-generation exposure of orally-administered $AlCl_3$ in mice (*Mus musculus*) by Ondreicka, Ginter, and Kortus (1966). Thus the avian and mammalian TRVs for aluminum adopted in this assessment were 109.7 and 1.93 mg/kg BW/day, respectively.

Arsenic

The Eco-SSL document for arsenic (US EPA 2005a) provides an avian TRV of 2.24 mg/kg BW/day, which is based on an orally-administered exposure of arsenic to chicken (*Gallus domesticus*) over 19 days. This avian TRV was the lowest NOAEL reported in the literature for reproduction, growth, and survival effects in either *G. domesticus* or Mallard duck (*Anas platyrynchos*). The Eco-SSL document for arsenic also provides an oral mammalian TRV of 1.04 mg/kg BW/day, which is the geometric mean of NOAELs reported for reproduction and growth effects in rodents (*M. musculus*, *Rattus norvegicus*, and *Sigmodon hispidus*), dog (*Canis familiaris*), and rabbit (*Oryctolagus cuniculus*) at various life stages. The mammalian TRV is based on toxicological data from orally-administered arsenic exposures ranging in duration from 9 days (*M. musculus*) to 2 years (*C. familiaris*). Thus the avian and mammalian TRVs for arsenic adopted in this assessment were 2.24 and 1.04 mg/kg BW/day, respectively. The majority of avian and mammalian studies reported in the Eco-SSL document for arsenic were conducted with inorganic arsenic (US EPA 2005a).

Table 5.5-12. Toxicity Reference Values for Mammalian Wildlife Receptors

COPC	Test Species	Effect	Endpoint	TRV (mg/kg BW/day)	Reference
Aluminum	Mouse	Reproduction	Chronic NOAEL	1.93	Ondreicka, Ginter, and Kortus (1966) in Sample, Opresko, and Suter (1996)
Arsenic	Various	Reproduction, Growth	Geometric mean of NOAELs [a]	1.04	Eco-SSL for arsenic (US EPA 2005a)
Cadmium	Rat	Reproduction, Growth, Survival	NOAEL [a]	0.77	Eco-SSL for cadmium (US EPA 2005c)
Chromium	Various	Reproduction, Growth	Geometric mean of NOAELs [b]	2.4	Eco-SSL for chromium (US EPA 2008)
Copper	Pig	Reproduction, Growth, Survival	NOAEL [a]	5.6	Eco-SSL for copper (US EPA 2007a)
Lead	Rat	Reproduction, Growth, Survival	NOAEL [a]	4.7	Eco-SSL for lead (US EPA 2005d)
Mercury	Mink	Reproduction	Chronic NOAEL	1.01	Aulerich, Ringer, and Iwamoto (1974) in Sample, Opresko, and Suter (1996)
Methylmercury	Mink	Survival	$TRV=((LOAEL*NOAEL)^{0.5})/UF$; (UF=5)	0.022	Chamberland et al. (1996) in CCME (2000)
Nickel	Mouse	Reproduction, Growth, Survival	NOAEL [a]	1.70	Eco-SSL for nickel (US EPA 2007b)
Selenium	Pig	Reproduction, Growth, Survival	NOAEL [a]	0.143	Eco-SSL for selenium (US EPA 2007c)
Thallium	Rat	Reproduction	Chronic NOAEL	0.074	Formigli et al. (1986) in Sample, Opresko, and Suter (1996)
Zinc	Various	Reproduction, Growth	Geometric mean of NOAELs [a]	75.4	Eco-SSL for zinc (US EPA 2007d)

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight
NOAEL = no observed adverse effects level
LOAEL = lowest observed adverse effects level
UF = uncertainty factor
[a] *NOAEL to derive TRV based on highest NOAEL lower than lowest bound LOAEL reported in literature (as per US EPA's Eco-SSL methodology).*
[b] *This is the TRV for trivalent chromium, which is more conservative than the TRV for hexavalent chromium.*

Table 5.5-13. Toxicity Reference Values for Avian Wildlife Receptors

COPC	Test Species	Effect	Endpoint	TRV (mg/kg BW/day)	Reference
Aluminum	Ringed dove	Reproduction	Chronic NOAEL	109.7	Carriere et al. (1986) in Sample, Opresko, and Suter (1996)
Arsenic	Chicken	Reproduction, Growth, Survival	Lowest NOAEL	2.24	Eco-SSL for arsenic (US EPA 2005a)
Cadmium	Various	Reproduction, Growth	Geometric mean of NOAELs	1.47	Eco-SSL for cadmium (US EPA 2005c)
Chromium	Various	Reproduction, Growth	Geometric mean of NOAELs	2.66	Eco-SSL for chromium (US EPA 2008)
Copper	Chicken	Reproduction, Growth, Survival	Highest bounded NOAEL	4.05	Eco-SSL for copper (US EPA 2007a)
Lead	Chicken	Reproduction, Growth, Survival	Highest bounded NOAEL	1.63	Eco-SSL for lead (US EPA 2005d)
Mercury	Japanese quail	Reproduction	Chronic NOAEL	0.45	Hill and Schaffner (1976) in Sample, Opresko, and Suter (1996)
Methylmercury	Mallard	Growth, Survival	Geometric mean of LOAEL and NOAEL	0.031	Heinz (1976a, 1976b, 1979) in CCME (2000)
Nickel	Various	Reproduction, Growth	Geometric mean of NOAELs	6.71	Eco-SSL for nickel (US EPA 2007b)
Selenium	Chicken	Reproduction, Growth, Survival	Highest bounded NOAEL	0.290	Eco-SSL for selenium (US EPA 2007c)
Thallium	European Starling	Survival	NOAEL	0.35	Schafer (1972); US EPA (1999a)
Zinc	Various	Reproduction, Growth	Geometric mean of NOAELs	66.1	Eco-SSL for zinc (US EPA 2007d)

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight
NOAEL = no observed adverse effects level
LOAEL = lowest observed adverse effects level

Cadmium

The Eco-SSL document for cadmium (US EPA 2005c) provides an oral mammalian TRV of 0.77 mg/kg BW/day, which is based on the numerous NOAELs reported in the literature for reproduction, growth, and survival in various life stages of rodents (*M. musculus*, *R. norvegicus*, *Microtus pennsylvanicus*, *Clethrionomys glareolos*, *Sorex araneus*), dog (*C. familiaris*), sheep (*Ovis aires*), pig (*Sus scrofa*), and cattle (*Bos Taurus*). The toxicological data from which the TRV was determined include orally-administered exposures ranging in duration from 4 days (*M. musculus* and *R. norvegicus*) to approximately 4.8 years (*C. familiaris*). Further details on the specific criteria used to select this mammalian TRV are provided in the Eco-SSL document for cadmium (US EPA 2005c).

The Eco-SSL document for cadmium also provides an avian oral TRV of 1.47 mg/kg BW/day, which is the geometric mean of NOAELs reported for reproduction and growth effects in juvenile or adult chicken (*G. domesticus*), mallard (*A. platyrynchos*), Japanese quail (*Coturnix japonica*), and woodduck (*Aix sponsa*). The avian TRV for cadmium is based on toxicological data from orally-administered exposures ranging in duration from 2 weeks (*G. domesticus*) to 1 year (*G. domesticus*). Thus the avian and mammalian TRVs for cadmium adopted in this assessment were 1.47 and 0.77 mg/kg BW/day, respectively.

Chromium

The Eco-SSL document for chromium (US EPA 2008) provides an avian TRV for trivalent chromium (Cr III) of 2.66 mg/kg BW/day, which is the geometric mean of NOAELs reported for reproduction and growth effects in juvenile or adult chicken (*G. domesticus*), turkey (*Meleagris gallopavo*), and black duck (*Anas rubripes*). The avian TRV for Cr(III) is based on toxicological data from orally-administered exposure periods ranging in duration from 14 days (*G. domesticus* and *M. gallopavo*) to 190 days (*A. rubripes*). Neither the chromium Eco-SSL nor the ORNL *Toxicological Benchmarks for Wildlife* (Sample, Opresko, and Suter 1996) documents provide an avian TRV for hexavalent chromium (Cr VI). Therefore the avian TRV for chromium adopted in this assessment is equivalent to the TRV for Cr(III).

The Eco-SSL document for chromium provides mammalian oral TRVs for Cr(III) and Cr(VI), which were calculated as 2.4 and 9.24 mg/kg BW/day, respectively. The TRV for Cr(III) is the geometric mean of NOAELs reported for reproduction and growth in juvenile and adult rodents (*M. musculus*, *R. norvegicus*), pig (*S. scrofa*), and cattle (*B. Taurus*). The toxicological data from which the mammalian TRV for Cr(III) is based involve orally-administered exposure periods ranging in duration from 4 days (*M. musculus* and *R. norvegicus*) to approximately 4.8 years (*C. familiaris*). The TRV for Cr(VI) is the geometric mean of NOAELs reported for reproduction and growth in juvenile and adult rodents (*M. musculus*, *R. norvegicus*). The toxicological data from which the mammalian TRV for Cr(VI) is based on involves orally-administered exposure periods ranging in duration from 6 days (*M. musculus*) to 1 year (*M. musculus* and *R. norvegicus*). Since the TRV for Cr(III) is lower, it was adopted as the mammalian TRV for chromium in this assessment.

Copper

The Eco-SSL document for copper (US EPA 2007a) provides an avian oral TRV of 4.05 mg/kg BW/day, which is based on numerous NOAELs reported in the literature for reproduction, growth, and survival in various life stages of chicken (*G. domesticus*), duck (*A. platyrynchos*), turkey (*M. gallopavo*), and Japanese Quail (*C. japonica*). Toxicological data from orally-administered copper exposures ranging in duration from 5 days (*G. domesticus*) to 336 days (*G. domesticus*) were used in the determination of the avian TRV.

The Eco-SSL document for copper also provides an oral mammalian TRV of 5.6 mg/kg BW/day, which is based on the numerous NOAELs reported in the literature for reproduction, growth, and survival in juvenile or gestating adult rodents (*M. musculus*, *R. norvegicus, S. araneus, Cavia porcellus*) sheep (*O. aires*), pig (*S. scrofa*), cattle (*B. Taurus*), rabbit (*O. cuniculus*), pony (*Equus caballus*), and mink (*Mustela vision*). The toxicological data from which the TRV is based involve orally-administered exposures ranging in duration from 1 week (*R. norvegicus*) to 783 days (*S. scrofa*). Further details on the specific criteria used to select the avian and mammalian TRVs are provided in the Eco-SSL document for copper (US EPA 2007a). Thus the avian and mammalian TRVs for copper adopted in this assessment were 4.05 and 5.6 mg/kg BW/day, respectively.

Lead

The Eco-SSL document for lead (US EPA 2005d) provides an avian oral TRV of 1.63 mg/kg BW/day, which is based on numerous NOAELs reported in the literature for reproduction, growth, or survival in various life stages of chicken (*G. domesticus*), duck (*A. platyrynchos*), turkey (*M. gallopavo*), Japanese quail (*C. japonica*), dove (*S. risoria*), American kestrel (*Falco sparverius*), pigeon (*Columba livia*), goose (*Anser cygnides*), and mallard (*A. platyrynchos*). Toxicological data from orally-administered lead exposures ranging in duration from 7 days (*C. japonica*) to 6 months (*F. sparverius*) were used in the determination of the avian TRV.

The Eco-SSL document for lead also provides an oral mammalian TRV of 4.7 mg/kg BW/day, which is based on the numerous NOAELs reported in the literature for reproduction, growth, or survival in various life stages of rodents (*M. musculus, R. norvegicus, S. hispidus, Mesocricetus auratus, C. porcellus*), dog (*C. familiaris*), sheep (*O. aires*), pig (*S. scrofa*), cattle (*B. Taurus*), rabbit (*O. cuniculus*), and horse (*E. caballus*). The toxicological data on which the TRV is based involve orally-administered exposures ranging in duration from 4 days (*R. norvegicus*) to 669 days (*M. musculus*). Further details on the specific criteria used to select the avian and mammalian TRVs are provided in the Eco-SSL document for lead (US EPA 2005d). Thus the avian and mammalian TRVs for lead adopted in this assessment were 1.63 and 4.7 mg/kg BW/day, respectively.

Mercury

There is currently no Eco-SSL document for mercury. However, the ORNL *Toxicological Benchmarks for Wildlife* (Sample, Opresko, and Suter 1996) document references studies that have investigated the chronic toxicity of mercury exposure in laboratory test organisms. A chronic NOAEL of 0.45 mg/kg BW/day is provided for reproductive effects in birds, which is based on a 1-year exposure of orally-administered mercuric chloride in Japanese quail (*C. japonica*) by Hill and Schaffner (1976). In addition, a chronic NOAEL of 1.01 mg/kg BW/day is provided for reproductive effects in mammals, which is based on a 6-month exposure of orally-administered mercuric chloride in mink (*Mustela vison*) by Aulerich, Ringer, and Iwamoto (1974). Thus the avian and mammalian TRVs used in this assessment for mercury are 0.45 and 1.0 mg/kg BW/day, respectively.

The CCME (2000) provides an avian TRV for methylmercury of 0.031 mg/kg BW/day, which is based on the geometric mean of LOAELs and NOAELs from studies conducted on mallard ducks with growth and survival as the endpoints (Heinz 1976a, 1976b, 1979). The CCME (2000) also provides a mammalian TRV for methylmercury of 0.022 mg/kg BW/day, from a study conducted on mink with survival as the endpoint (Chamberland et al. 1996). The avian and mammalian TRVs used in this assessment for methylmercury are 0.031 and 0.022 mg/kg BW/day, respectively, and will be used for wildlife receptors that consume fish and aquatic invertebrates (i.e., peregrine falcon, red-breasted merganser, least sandpiper, long-tailed duck, herring gull, and ringed seal).

Nickel

The Eco-SSL document for nickel (US EPA 2005a) provides an avian TRV of 6.71 mg/kg BW/day, which is the geometric mean of NOAELs reported in the literature for reproduction and growth effects in juvenile and egg-laying chicken (*G. domesticus*) and duck (*A. platyrhynchos*). The avian TRV is based on toxicological data from orally-administered nickel exposures ranging in duration from 3 weeks (*G. domesticus*) to 90 days (*A. platyrhynchos*).

The Eco-SSL document for nickel also provides an oral mammalian TRV of 1.70 mg/kg BW/day, which is based on the numerous NOAELs reported in the literature for reproduction, growth, and survival in juvenile or gestating adult rodents (*M. musculus*, *R. norvegicus, M. pennsylvanicus*), dog (*C. familiaris*), and cattle (*B. Taurus*). The toxicological data from which the TRV is based involve orally-administered exposures ranging in duration from 4 days (*M. musculus*) to 1,217 days (*R. norvegicus*). Further details on the specific criteria used to select the avian and mammalian TRVs are provided in the Eco-SSL document for nickel (US EPA 2007b). Thus the avian and mammalian TRVs used in this assessment for nickel are 6.71 and 1.70 mg/kg BW/day, respectively.

Selenium

The Eco-SSL document for selenium (US EPA 2007c) provides an avian oral TRV of 0.29 mg/kg BW/day, which is based on numerous NOAELs reported in the literature for reproduction, growth, or survival in various life stages of chicken (*G. domesticus*), Mallard (*A. platyrynchos*), Japanese quail (*C. japonica*), heron (*Nycticorax nycticorax*), and American kestrel (*F. sparverius*). Toxicological data from orally-administered selenium exposures ranging in duration from 7 days (*G. domesticus* and *A. platyrynchos*) to 105 weeks (*G. domesticus*) were used in the determination of the avian TRV.

The Eco-SSL document for selenium also provides an oral mammalian TRV of 0.143 mg/kg BW/day, which is based on the numerous NOAELs reported in the literature for reproduction, growth, or survival in various life stages of rodents (*M. musculus*, *R. norvegicus, S. hispidus, M. auratus*), sheep (*O. aires*), pig (*S. scrofa*), cattle (*B. Taurus*), rabbit (*O. cuniculus*), pronghorn (*Antilocarpa americana*), and goat (*Capra hircus*). The toxicological data on which the TRV is based involve orally-administered exposures ranging in duration from 4 days (*M. musculus*) to 360 days (*M. musculus*). Further details on the specific criteria used to select the avian and mammalian TRVs are provided in the Eco-SSL document for selenium (US EPA 2007c). The avian and mammalian TRVs used in this assessment for selenium are 0.29 and 0.143 mg/kg BW/day, respectively.

Thallium

There is currently no Eco-SSL document for thallium. Furthermore, no chronic toxicity studies for thallium are available in the literature. However, the ORNL *Toxicological Benchmarks for Wildlife* (Sample, Opresko, and Suter 1996) document references a mammalian study that provides a subchronic LOAEL of 0.74 mg/kg BW/day for reproductive effects. This LOAEL is based on the 60-day exposure of orally-administered thallium sulfate in rat (*R. norvegicus*) by Formigli et al. (1986). The chronic NOAEL provided in Sample, Opresko, and Suter (1996) is 0.0074 mg/kg BW/day following the application of a UF for LOAEL to NOAEL extrapolation. The mammalian TRV for thallium adopted in this assessment is 0.074 mg/kg BW/day.

The ORNL document (Sample, Opresko, and Suter 1996) does not provide thallium toxicity data for birds. However, the US EPA (1999a) provides an avian TRV for thallium of 0.35 mg/kg BW/day, which is based on a NOAEL in European starling (*Sturnus vulgaris*) with survival as the endpoint (Schafer 1972). Thus, the avian TRV for thallium adopted in this assessment is 0.35 mg/kg BW/day.

Zinc

The Eco-SSL document for zinc (US EPA 2007d) provides an avian TRV of 66.1 mg/kg BW/day, which is the geometric mean of NOAELs reported in the literature for reproduction and growth effects in juvenile and adult chicken (*G. domesticus*), turkey (*M. gallopavo*), and Japanese quail (*C. japonica*).

The avian TRV is based on toxicological data from orally-administered zinc exposures ranging in duration from 1 day (*G. domesticus*) to 44 weeks (*G. domesticus*).

The Eco-SSL document for zinc also provides an oral mammalian TRV of 75.4 mg/kg BW/day, which is the geometric mean of NOAELs reported for reproduction and growth effects in juvenile and gestating rodents (*M. musculus*, *R. norvegicus*, *M. auratus*), rabbit (*O. cuniculus*), mink (*M. vison*), water buffalo (*Bubalus bubalis*), pig (*S. scrofa*), and cattle (*B. Taurus*). The mammalian TRV is based on toxicological data from orally-administered zinc exposures ranging in duration from 4 days (*R. norvegicus*) to 1 year (*S. scrofa*). The avian and mammalian TRVs used in this assessment for zinc are 66.1 and 75.4 mg/kg BW/day, respectively.

5.5.4 Risk Characterization

5.5.4.1 Introduction

In a screening level risk assessment, such as this existing conditions ERA, it is common to make a number of conservative assumptions which will tend to overestimate the actual risk to ecological health. If no unacceptable risks are identified using this conservative approach, then it is unlikely that ecological health will be affected. However, identification of potential risks due to existing conditions does not necessarily mean that ecological receptor health will be adversely affected, since the risk has been overestimated intentionally.

Using the results of the exposure assessment and TRV assessment, ecological health risks were quantified using HQs. The HQ is the ratio between the total EDI and the TRV and provides a measure of exposure to a COPC through the various exposure pathways. Environment Canada (2012) states that an HQ of less than 1.0 indicates that the existence of adverse effects to ecological health is unlikely, while an HQ greater than 1.0 indicates a possibility of adverse effects to ecological health. It is likely that the risk is significantly overestimated due to the conservative assumptions made throughout the existing conditions ERA.

5.5.4.2 Estimation of Risk to Aquatic Life Ecological Receptors from Contaminants of Potential Concern

Hazard quotients for aquatic life ecological receptors were calculated for freshwater and marine water exposure, as well as freshwater and marine sediment exposure. The HQ was calculated by dividing the baseline 95th percentile concentration of the COPC in environmental media (i.e., water or sediment) by the CCME guideline for the protection of aquatic life. Hazard quotients for aquatic life ecological receptors are shown in Table 5.5-14.

As shown in Table 5.5-14, HQs for aquatic life ecological receptors were lower than 1.0 except for chromium, where the HQ for aquatic life ecological receptors in marine water was greater than 1.0. This is because the CCME marine water quality guideline for hexavalent chromium was used (0.0015 mg/L). Hexavalent chromium is likely to be the most predominant form of chromium in marine environments and it is known to be more toxic than trivalent chromium.

Based on data provided in CCME (1999), chronic toxicity of hexavalent chromium to marine fish could occur at concentrations between 0.5 and 44.0 mg/L. CCME (1999) also indicates that chronic toxicity to marine invertebrates has been reported at concentrations of hexavalent chromium as low as 0.01 mg/L. The 95th percentile baseline concentration of total chromium is 0.00169 mg/L (Table 5.5-14). If it were assumed that all of the chromium is in the hexavalent form, the marine water concentration is still well below the concentrations at which toxicity may occur in marine life due to hexavalent chromium. Therefore, the risk to aquatic life from total chromium (assumed to be 100% hexavalent chromium) in marine water is overestimated and no adverse effects in marine life would be expected.

Table 5.5-14. Hazard Quotients for Contaminants of Potential Concern in Fresh and Marine Waters

COPCs in Water	95th Percentile Baseline Freshwater Concentration (mg/L; n=14 modeling nodes)	95th Percentile Baseline Marine Water Concentration (mg/L; n=214)	CCME Water Quality Guideline (mg/L)		Hazard Quotient for Water	
			Freshwater [a]	Marine [b]	Freshwater Aquatic Life Receptors [a]	Marine Life Receptors [b]
Aluminum	0.0605	NA	0.1	NA	0.61	NA
Arsenic	NA	0.00130	NA	0.0125	NA	0.10
Chloride	29.4	NA	120	NA	0.25	NA
Chromium	0.000437	0.00169	0.001	0.0015	0.44	1.1 [c]
Copper	0.00143	NA	0.004	NA	0.36	NA
Fluoride	0.0450	NA	0.12	NA	0.37	NA
Iron	0.159	NA	0.3	NA	0.53	NA
Mercury	NA	0.00000500	NA	0.000016	NA	0.31
Selenium	0.000250	NA	0.001	NA	0.25	NA
Zinc	0.00320	NA	0.03	NA	0.11	NA
COPCs in Sediment	**95th Percentile Baseline Freshwater Sediment Concentration (mg/kg; n=271)**	**95th Percentile Baseline Marine Sediment Concentration (mg/kg; n=84)**	**CCME Probable Effects Level (mg/kg)**		**Hazard Quotient for Sediment**	
			Freshwater [a]	**Marine [b]**	**Freshwater Aquatic Life Receptors [a]**	**Marine Life Receptors [b]**
Arsenic	16.8	4.32	17	41.6	0.99	0.10
Chromium	78.9	52.7	90	160	0.88	0.33
Copper	52.3	26.2	197	108	0.27	0.24

Notes:
COPC = contaminant of potential concern
CCME = Canadian Council of Ministers of the Environment
NA = not applicable
Shaded cells indicate hazard quotients greater than 1.0.
[a] Includes primary producers (phytoplankton, periphyton, and plant/algae communities), pelagic and benthic invertebrate communities, and fish (Ninespine Stickleback, Lake Whitefish, and Lake Trout).
[b] Includes primary producers (phytoplankton and plant/algae communities), pelagic and benthic invertebrate communities, and fish (Fourhorn Sculpin, Capelin, and Arctic Char).
[c] This HQ is based on the CCME guideline. However, if the HQ is calculated based on the lowest toxicity threshold reported by CCME (1999), the HQ = 0.169 and no risk would occur for marine primary producers, invertebrates, or fish. See text for additional details.

5.5.4.3 Estimation of Risk to Terrestrial Plant and Invertebrate Terrestrial Receptors from Contaminants of Potential Concern

Hazard quotients for terrestrial plant and invertebrate ecological receptors were calculated for soil exposure. The HQ was calculated by dividing the baseline 95th percentile concentration of the COPC in soil by the CCME guideline for the protection of terrestrial plants and invertebrates. Hazard quotients for terrestrial plant and invertebrate ecological receptors are shown in Table 5.5-15.

Table 5.5-15. Terrestrial Plant and Invertebrate Toxicity Reference Values and Hazard Quotients for Contaminants of Potential Concern in Soil

COPCs in Soil	95th Percentile Baseline Soil Concentration (mg/kg dw; n=100)	Soil TRVs for Terrestrial Plant and Invertebrate Ecological Receptors (mg/kg)	Soil HQs for Terrestrial Plant and Invertebrate Ecological Receptors
Chromium	65.6	64	1.0
Copper	38.3	63	0.61
Nickel	34.7	45	0.77

Notes:
COPC = contaminant of potential concern
dw = dry weight
TRV = toxicity reference value
HQ = hazard quotient

As shown in Table 5.5-15, HQs for terrestrial plant and invertebrate ecological receptors were all equal to or below the threshold of 1.0; therefore, existing COPC concentrations in soil do not pose a risk to the health of terrestrial plant and invertebrate ecological receptors.

5.5.4.4 Estimation of Risk to Mammalian and Avian Receptors from Contaminants of Potential Concern

The total EDI of COPCs (in mg/kg BW/day) for each wildlife species was calculated by summing the EDI from all applicable exposure pathways (Table 5.5-8). The total EDI from all routes was then divided by the TRV (in mg/kg BW/day) to obtain the existing conditions HQ, as follows:

$$HQ_{existing} = \frac{EDI_{Total}}{TRV}$$ [Equation 17]

Table 5.5-16 shows the HQ for each COPC for each wildlife species considered in the assessment.

The HQs for aluminum and methylmercury were greater than 1.0 for several wildlife receptors (Table 5.5-16):

- aluminum for muskox, wolverine, grizzly bear, Arctic ground squirrel, Arctic shrew, northern red-backed vole, American tree sparrow, least sandpiper, yellow warbler, and ringed seal; and
- methylmercury for red-breasted merganser and least sandpiper.

Table 5.5-16. Wildlife Toxicity Reference Values and Hazard Quotients for Contaminants of Potential Concern

	TRV (mg/kg BW/day)		Hazard Quotients																		
COPC	Mammal	Bird	Caribou	Muskox	Wolverine	Grizzly Bear	Wolf	Arctic Ground Squirrel	Arctic Shrew	Northern Red-backed Vole	Willow Ptarmigan	American Tree Sparrow	Peregrine Falcon	Canada Goose	Red-breasted Merganser	Least Sandpiper	Long-tailed Duck	Herring Gull	Yellow Warbler	Brant	Ringed Seal
Aluminum	1.93	109.7	0.050	12	35	4.3	0.32	22	910	738	0.76	15	0.72	0.75	0.66	2.3	0.66	0.66	20	0.22	41
Arsenic	1.04	2.24	0.000028	0.0066	0.015	0.0017	0.00010	0.0091	0.084	0.099	0.011	0.029	0.0073	0.021	0.018	0.062	0.018	0.028	0.022	0.0036	0.079
Cadmium	0.77	1.47	0.000017	0.0041	0.0011	0.00042	0.0000095	0.0031	0.095	0.081	0.0077	0.058	0.00071	0.0020	0.0016	0.0071	0.0021	0.052	0.070	0.0023	0.062
Chromium	2.4	2.66	0.00059	0.14	0.089	0.019	0.00084	0.13	0.62	1.0	0.46	0.78	0.090	0.17	0.081	0.45	0.13	0.81	0.31	0.14	0.59
Copper	5.6	4.05	0.000080	0.019	0.023	0.0037	0.00021	0.022	0.21	0.25	0.096	0.28	0.036	0.050	0.057	0.65	0.18	0.065	0.24	0.027	0.043
Lead	4.7	1.63	0.000024	0.0057	0.010	0.0014	0.000092	0.0079	0.091	0.099	0.060	0.21	0.034	0.029	0.025	0.13	0.038	0.026	0.19	0.014	0.0084
Mercury	1.01	0.45	0.0000073	0.0017	0.0016	0.00022	0.000036	0.0012	0.0016	0.0066	0.014	0.019	0.00040	0.0036	0.00033	0.0012	0.00060	0.000076	0.0028	0.0043	0.000041
Methylmercury	0.022	0.031	-	-	-	0.020	-	-	-	-	-	-	0.035	-	1.9	9.7	0.20	0.083	-	-	0.11
Nickel	1.7	6.71	0.00044	0.10	0.062	0.014	0.00063	0.097	0.52	0.80	0.096	0.18	0.018	0.038	0.021	0.060	0.019	0.17	0.087	0.028	0.40
Selenium	0.143	0.29	0.000067	0.016	0.029	0.0055	0.000054	0.013	0.14	0.16	0.029	0.096	0.016	0.012	0.19	0.47	0.14	0.43	0.087	0.0088	0.84
Thallium	0.0740	0.35	0.000037	0.0087	0.050	0.0039	0.00022	0.015	0.56	0.46	0.0067	0.11	0.0098	0.0029	0.0055	0.079	0.021	0.0042	0.14	0.0015	0.028
Zinc	75.4	66.1	0.000035	0.0083	0.0023	0.0012	0.000023	0.0066	0.14	0.13	0.034	0.19	0.0041	0.012	0.055	0.10	0.031	0.036	0.22	0.011	0.023

Notes:
COPC = contaminant of potential concern
TRV = toxicity reference value
BW = body weight
Shaded cells indicated hazard quotients greater than 1.0.

The potential risk to terrestrial ecological receptors due to aluminum is associated with exposure via ingestion of soil, vegetation, or terrestrial invertebrates. The assumptions used in the food chain modeling and ingestion exposure calculations were very conservative and likely substantially overestimate the risk to ecological receptors. For aluminum, the assumption of 100% bioavailability in ingested food, water, and soil is likely contributing to the elevated HQs. Based on data provided in ATSDR (2008), the forms of aluminum found in drinking water and in food are much less bioavailable than the forms that are used in the laboratory studies for determining TRVs. Bioavailability of aluminum is food or water can be as less than 1% relative to the forms used in toxicity studies (e.g., aluminum lactate, aluminum citrate). Therefore, it is likely that the risk to ecological receptors due to aluminum is substantially overestimated by not accounting for the differences between laboratory- and field-based exposures.

Elevated HQs for fish-eating (red-breasted merganser) or aquatic invertebrate-eating (least sandpiper) birds due to methylmercury were identified, suggesting potential risks for adverse effects. This result is not unexpected since mercury is known to bioaccumulate through the aquatic food chain. It can accumulate to high concentrations in fish that are older, larger, or at the top of the food chain, and this can be seen by the concentrations of total mercury measured in fish such as Lake Trout (maximum concentration of 1.80 mg/kg ww; Table 5.5-4). Mercury also tends to bioaccumulate to a greater degree in foods chains in lakes, particularly when sediments are anoxic, have higher organic carbon content, and if sulphate concentrations are high. This is because inorganic mercury can be converted to methylmercury by bacteria present in sediments, which can then be taken up more readily by biota in the aquatic the food chain.

Since a conservative statistic (95th percentile concentrations) was used in the risk calculations, there is potential for risk is overestimated for fish-eating birds. However, even if lower concentrations (e.g., a mean or median concentration) were used in the calculations the HQ for fish-eating birds would still be elevated, particularly if they were consuming Lake Trout. For invertebrate-eating birds, the concentration of methylmercury in prey items was modeled using a BCF from US EPA (1999b). It is possible that the BCF is too high, resulting in predictions of methylmercury in tissue that are not representative of invertebrates in Arctic lake environments. However, given that fish tissue mercury concentrations were measured to be elevated in baseline studies, it is likely that concentrations are also elevated in invertebrates.

All other HQs for all other wildlife species and COPCs were below 1.0.

5.5.4.5 Summary of Risk to Ecological Receptors

Overall, it is concluded that under existing conditions several COPCs may affect the health of ecological receptors, due to HQs greater than 1.0:

- aluminum for muskox, wolverine, grizzly bear, Arctic ground squirrel, Arctic shrew, northern red-backed vole, American tree sparrow, least sandpiper, yellow warbler, and ringed seal; and
- methylmercury for red-breasted merganser and least sandpiper.

However, there is uncertainty in the assessment for the reasons outlined in Section 5.5.5, and due to assumptions made in the assessment (Sections 5.5.2.2, 5.5.2.3, 5.5.2.4, and 5.5.2.5). The existing conditions ERA is conservative and is likely to substantially overestimate the potential for risk to the health of ecological receptors that may use the Phase 2 Project area. Also, the 95th percentile of COPC concentrations in environmental media were used in the assessment, leading to a conservative estimate of risk.

5.5.5 Uncertainty Analysis

5.5.5.1 Introduction

The process of evaluating the potential risk to the health of ecological receptors from exposure to COPCs in environmental media (e.g., water, sediment, soil) involves multiple steps, each containing inherent uncertainties that ultimately affect the final risk estimates. These uncertainties exist in numerous areas, including the collection of samples, laboratory analysis, estimation of potential exposures, assumptions used in food chain modeling, and derivation of TRVs. These uncertainties can result in either an over- or under-estimation of risk. However, for the existing conditions ERA, where uncertainties existed, a conservative approach was adopted to overestimate rather than underestimate potential exposure and related risks. Some of the uncertainties have been mentioned in the preceding sections; however, the following uncertainty analysis is a qualitative discussion of the key sources of uncertainty in the existing conditions ERA.

5.5.5.2 Contaminants of Potential Concern

The COPCs selected for this assessment were metals, since the proposed Phase 2 Project involves development of a metal mine. Metals naturally occur in environmental media (i.e., soil, sediment, water, and plant and animal tissue) and have been monitored during baseline studies to support Phase 2 Project planning and processes. By screening measured baseline metal concentrations against environmental quality guidelines it is likely that all relevant metal COPCs have been selected for inclusion in the existing conditions ERA.

However, there exists a possibility that other COPCs (e.g., other metals, organic chemicals, etc.) could be associated with Phase 2 Project activities in the future, but do not occur or were not measured under existing conditions.

The 95th percentile of baseline concentrations were used to represent the exposure concentrations in this assessment. This concentration represents the upper bound of concentrations that may be present in the LSA. It is an overly conservative statistic and would result in overestimation of risks, particularly for organisms with larger home ranges who may receive exposure across a larger area where concentrations of COPCs in environmental media would not be at the 95th percentile level. Overall, it is highly probable that the risks to ecological receptors have been overestimated in this existing conditions ERA.

5.5.5.3 Tissue Concentrations

<u>Aquatic and Terrestrial Invertebrates</u>

The COPC concentrations in freshwater and terrestrial invertebrate prey were calculated using published BCFs (Appendix V6-5E, Section 1.2.3), since measured tissue concentrations for invertebrates were not available. There is uncertainty around the use of generic BCFs for determining site-specific invertebrate tissue concentrations; therefore, tissue concentrations may be under- or over-predicted.

<u>Terrestrial Species</u>

The same uncertainties presented in Section 5.3.6.3 for terrestrial country food species included in the existing conditions HHRA also apply to the existing conditions ERA. These include uncertainties around the use of domestic animal BTFs for wildlife species, derived ingestion rates, assumed exposure times in the study areas, and the composition of the diet. However, there were additional species that required modeling as the ERA was not limited to the three representative country food species (caribou, Arctic ground squirrel, and Canada goose). The additional wildlife species that required modeling were those that are consumed as prey items by carnivores and omnivores. It was assumed that the beef BTFs would apply to mammalian prey species and that the chicken BTFs would apply to avian prey species.

Aquatic Species

The same uncertainties presented in the existing conditions HHRA Section 5.3.6.3 for aquatic species are applicable for the existing conditions ERA and thus will not be repeated here.

Vegetation Species

The same uncertainties presented in the existing conditions HHRA Section 5.3.6.3 for vegetation species are applicable for the existing conditions ERA and thus will not be repeated here.

Quality Assurance and Quality Control

The same uncertainties presented in the existing conditions HHRA Section 5.3.6.3 for quality assurance and quality control applies to the existing conditions ERA and thus will not be repeated here.

5.5.5.4 Wildlife Characteristics

Many of the characteristics required for modeling tissue COPC concentrations and total EDIs in wildlife species were based on values provided by scientific literature, allometric equations for ingestion rates, and best professional judgement. However, efforts were made to use conservative estimates, which would result in overestimates of risk rather than underestimates. For example, it was assumed that several species would spend all their time in the terrestrial wildlife LSA and consume all of their food and water from within the area.

5.5.5.5 Toxicity Reference Values

The TRVs for aquatic life ecological receptors were the CCME (2016a) freshwater and marine water quality guidelines and the freshwater and marine sediment PELs. These guidelines are based on toxicity thresholds in the most sensitive species and have UFs or safety factors applied, thus are conservative values to use in the calculation of HQs. When risk was identified (i.e., due to chromium), additional assessment indicated that adverse effects in marine aquatic life would not be expected. The assessment was conservative, using the lowest reported toxicity threshold and an upper statistic (95^{th} percentile) to represent the marine water quality.

The TRVs for mammalian and avian ecological receptors were obtained from studies primary conducted on laboratory or domesticated species due to a lack of information on toxicity thresholds in wildlife. Therefore, the risk to the health of mammalian and avian receptors may be under- or over-predicted due to the uncertainties surrounding the applicability of these TRVs to wildlife species. However, because the TRVs for mammalian and avian receptors were based on NOAELs rather than effects based thresholds, the risks to these receptors are likely over-predicted.

5.5.6 Conclusions

This existing conditions ERA integrated the results of the environmental media baseline studies, ecological receptor characteristics, and regulatory-based TRVs. The quality of the different environmental media was conservatively representative of existing conditions at the Phase 2 Project site. This study evaluated potential risks to the health of ecological receptors associated with the summed exposure to COPCs from several exposure pathways (i.e., exposure to water and sediment for aquatic life receptors, ingestion of soil, ingestion of drinking water, and ingestion of diet items).

Based on the multi-media ERA described in Sections 5.2 and 5.5, risk from existing conditions to ecological health has been evaluated. The existing conditions ERA identified the following baseline COPCs that were considered to pose a risk (i.e., HQ > 1) to aquatic, mammalian, or avian ecological receptors using or foraging in the freshwater, marine, or terrestrial environments of the terrestrial or aquatic LSAs:

- aluminum for muskox, wolverine, grizzly bear, Arctic ground squirrel, Arctic shrew, northern red-backed vole, American tree sparrow, least sandpiper, yellow warbler, and ringed seal; and
- methylmercury for red-breasted merganser and least sandpiper.

This suggests that there could be risk to the health of ecological receptors due to the COPCs identified above, although it is likely that the risk has been overestimated and adverse effects may not occur. For all other ecological receptors (e.g., terrestrial plant and invertebrate ecological receptors), there is negligible potential risk to health from existing conditions.

There are uncertainties in this assessment, as described in Section 5.5.5 and throughout Section 5.5.2. However, this assessment was conducted in a manner that used multiple conservative assumptions, thus, the existing conditions ERA is likely to substantially overestimate risk to ecological receptors.

The risk from existing conditions is due to naturally-occurring or existing conditions within the respective LSAs since the Phase 2 Project has not been developed or approved for development at this time. It is noted that there has been development of other projects in the area (e.g., Doris), so the existing conditions may not be fully representative of naturally occurring conditions. Nevertheless, this existing conditions ERA provides the foundation for assessing the incremental changes on the health of ecological receptors due to Phase 2 Project-related effects. The same data, approaches, and assumptions used in the existing conditions ERA was also used in the models for predicting environmental quality during the Phase 2 Project (so that all predictions include existing conditions plus Phase 2 Project), which enables direct comparison of existing conditions and predicted environmental quality to determine incremental changes due to the Phase 2 Project.

5.6 PHASE 2 PROJECT-RELATED ENVIRONMENTAL RISK ASSESSMENT

Many of the features of the Phase 2 Project-related ERA are the same as the existing conditions ERA (Section 5.5), thus much of the text applies to both assessments and will not be repeated here and instead the existing conditions ERA is referred to. Features that are the same in both ERAs include: the approach that contains the six stages (Section 5.2; Environment Canada 2012); the LSA and RSA boundaries for the ecological receptors (Section 5.2.1); the exposure pathways (Section 5.5.1.2); the ecological receptors considered (Section 5.5.1.1); the ecological receptor characteristics (Section 5.5.1.1); and the toxicity reference values (Section 5.5.3.2). The methodology for the Phase 2 Project-related ERA is the same as for the existing conditions ERA (see Section 5.2); however, predictive modeling is used to determine Phase 2 Project-related noise levels and COPC concentrations in environmental media.

The potential Project-related effects of noise on wildlife species (i.e., ecological receptors) is described in Volume 4, Section 9 (Terrestrial Wildlife and Wildlife Habitat) and Volume 5, Section 11 (Marine Wildlife).

5.6.1 Problem Formulation

As stated in Section 5.5.1, the purpose of the problem formulation stage of an ERA is to create a conceptual model for the ERA and identify data requirements to accurately assess the potential for health effects to ecological receptors due to exposure to Phase 2 Project-related emissions. The purpose of the problem formulation stage are the same as those listed in Section 5.5.1; however, the assessment will establish whether there is a reasonable possibility that there is a linkage between a Phase 2 Project-related source of contaminants and ecological receptors.

5.6.1.1 Ecological Receptors

The same ecological receptors and ecological receptor characteristics that were used in the existing conditions ERA (Section 5.5.1.1) will be used in the Phase 2 Project-related ERA.

5.6.1.2 Ecological Receptor Exposure Pathways

Since ecological health can be affected by changes in fresh and marine water quality, soil quality, sediment quality, vegetation quality, or prey quality, potential Phase 2 Project-related sources of contaminants were identified that could lead to changes in these pathways. There are two main potential sources of Phase 2 Project-related contaminants: atmospheric emissions and liquid effluent.

Atmospheric emissions (e.g., metals in dust) have the potential to enter the atmosphere, travel some distance, and settle where they can reside in different media such as soil, vegetation, and prey. Liquid effluent has the potential to enter the terrestrial environment due to direct discharges, or enter the marine and freshwater environments (water and sediment) through runoff from the terrestrial environment.

Air quality can be affected by the generation of atmospheric emissions from Phase 2 Project components or activities. Freshwater could be affected by Phase 2 Project components or activities that affect freshwater. Marine water could be affected by Phase 2 Project components or activities that affect marine water. Soil, vegetation, and prey quality could be affected by Phase 2 Project-related sources of contaminants released to the atmospheric, freshwater, marine, or terrestrial environments. The exposure pathways are described in more detail in the following sections.

<u>Soil</u>

Fugitive dust will arise from several Phase 2 Project activities such as rock blasting, vehicle movement, and handling of fine materials. Generally dust will occur sporadically and be suspended for a relatively short time prior to deposition. Dust particles can be a carrier of metals naturally occurring in rocks and can deposit onto soils. Ecological receptors could be exposed to the COPCs in soil via incidental soil ingestion.

<u>Water</u>

Freshwater

Discharge of effluent from water management structures during the Operational phase could introduce contaminants to the freshwater environment. Ecological receptors could be exposed to the COPCs in freshwater via water ingestion.

The potential effects to freshwater quality from the Phase 2 Project sources of effluent are described in Volume 5, Sections 4.5.2 and 4.5.4. The surface water quality model considered all of the Phase 2 Project-related sources of effluent to the freshwater environment. The potential effects to freshwater sediment quality from the Phase 2 Project sources of effluent are described in Volume 5, Sections 5.5.2 and 5.5.4.

Marine Water

Discharge of effluent from water management structures during the Operational phase could introduce contaminants to the marine environment. Ecological receptors could be exposed to the COPCs in marine water via water ingestion.

The potential effects to marine water quality from the Phase 2 Project sources of effluent are described in Volume 5, Sections 9.5.2 and 9.5.4. The marine water quality assessment considered all of the Phase 2 Project-related sources of effluent to the marine environment. The potential effects to marine sediment quality from the Phase 2 Project sources of effluent are described in Volume 5, Sections 10.5.2 and 10.5.4.

<u>Vegetation and Prey Quality</u>

Fugitive dust will arise from several Phase 2 Project activities such as rock blasting, vehicle movement, and handling of fine materials. Generally dust will occur sporadically and be suspended for a relatively short time prior to deposition. Dust particles can be a carrier of metals naturally occurring in rocks and can deposit onto vegetation. The COPCs could then be taken up by terrestrial wildlife and could accumulate in prey items.

Discharge of effluent from water management structures during the Operational phase could introduce contaminants to the terrestrial environment where soil and vegetation could take up COPCs. The COPCs could then be taken up by terrestrial wildlife and prey items.

5.6.1.3 Selection of Phase 2 Project-related Contaminants of Potential Concern

A description and inventory of the types of materials and chemicals likely to be present at the Phase 2 Project is provided in the Project Description (see Table 4.4-11 in Volume 3 and Section 4.4.11). Potential sources of Phase 2 Project-related COPCs could be from fuel, mining and milling process chemicals, explosives, inert chemical fire suppression systems, and other chemicals that may be used around the Phase 2 Project site. However, these chemicals and materials are likely to reach the terrestrial or freshwater environments only in the event of unusual circumstances such as spills or malfunctions. Mitigation and management plans (e.g., Environmental Protection Plan, Risk Management and Emergency Response, Fuel Management, Spill Contingency, Tailings Management, Waste Management, and Hazardous Materials Management) are provided (see Volume 8, Section 1) to ensure the safe handling and storage of these materials to prevent their release to the environment where exposures to ecological receptors could occur. Therefore, the contaminants that may come from these potential sources were not considered further in this assessment.

Consistent with the existing conditions ERA (Section 5.5.1.3), the focus of this assessment is the metals and non-metals (e.g., ions, nutrients) that could be present in Phase 2 Project atmospheric emissions or discharges.

To select COPCs for evaluation in the Phase 2 Project-related ERA, the same screening methodology described in Section 5.5.1.3 was used, with one important additional criterion. In order to identify COPCs that occur as a result of Phase 2 Project components or activities, the predicted concentrations were compared to both environmental quality guidelines (as described in Section 5.5.1.3) and baseline concentrations. Only COPCs that had concentrations higher than applicable environmental quality guidelines and higher than baseline concentrations were retained for further evaluation as Phase 2 Project-related COPCs.

The reason for comparing predicted concentrations to baseline concentrations was to exclude COPCs that had concentrations that naturally exceeded environmental quality guidelines, where the concentrations were not notably changed by Phase 2 Project components and activities. For these parameters, although environmental quality guidelines were exceeded, the potential for risk is not associated with Phase 2 Project components or activities and the risks to ecological receptors would be equivalent to those described in the existing conditions ERA in Section 5.5.4.

Contaminants of Potential Concern in Soil

The soil quality screening that was conducted for the Project-related HHRA (Section 5.4.1.3 and Table 5.4-4) also applies to the Project-related ERA, thus the screening procedure is not repeated here.

During the Construction and Operational phases, predicted maximum metal concentrations in soil were lower than CCME Guidelines for the Protection of Environmental and Human Health for agricultural land (residential parkland for barium), except for chromium, copper, and nickel (Table 5.4-4).

The baseline concentrations of these three metals also exceeded the soil quality guidelines. The predicted concentrations are almost identical to the baseline concentrations and the largest percent change relative to baseline concentrations for these parameters is only 0.66% (for chromium) in the Construction phase and 0.51% (for chromium) in the Operational phase (Table 5.4-4). A change in soil concentrations of less than 1% (and likely up to 10%) compared to existing background levels is not measurable and is not likely to translate into a measurable change in tissue quality in terrestrial organisms (i.e., vegetation and prey items) that may be consumed by ecological receptors.

Therefore, based on the soil quality predictions provided in Appendices V6-5H and V6-5I and the comparison of these predictions to guidelines and baseline concentrations, no Phase 2 Project-related COPCs were identified in soil.

Tailings Contained within the Tailings Impoundment Area

Terrestrial wildlife could be exposed to tailings solids contained within the TIA during the Operational phase. Only floatation tailings will be deposited in the TIA, as detoxified tailings are expected to be backfilled underground as described in the Project Description (Volume 3, Section 2).

Tailings chemistry (metal concentrations) was obtained from analyses conducted on tailings samples (N=14) generated from the various deposits (SRK 2015, 2016b). The maximum metal concentration reported for floatation tailings was used in the COPC screening. Tailings metal concentrations were compared to the CCME Guidelines for the Protection of Environmental and Human Health for agricultural land (CCME 2016a). Results of the COPC screening for tailings are provided in Table 5.6-1.

Table 5.6-1. Screening Results for Selection of Contaminants of Potential Concern in Tailings for Terrestrial Wildlife

Parameters	CCME Soil Quality Guidelines - Agricultural [a] (mg/kg)	Maximum Concentration in Tailings [b] (mg/kg)	COPC (Yes/No)
Arsenic	12	338	**Yes**
Antimony	20	5.00	No
Barium [b]	500	192	No
Beryllium	4	20.0	**Yes**
Cadmium	1.4	0.500	No
Chromium	64	274	**Yes**

Parameters	CCME Soil Quality Guidelines - Agricultural [a] (mg/kg)	Maximum Concentration in Tailings [b] (mg/kg)	COPC (Yes/No)
Cobalt	40	34.9	No
Copper	63	86.8	**Yes**
Lead	70	17.0	No
Mercury	6.6	3.00	No
Molybdenum	5	9.50	**Yes**
Nickel	45	323	**Yes**
Selenium	1	5.00	**Yes**
Silver	20	1.20	No
Thorium	1	0.400	No
Tin	5	1294	**Yes**
Uranium	23	0.100	No
Vanadium	130	75.0	No
Zinc	200	73.0	No

Notes:
All concentrations are dry weight.
CCME = Canadian Council of Ministers of the Environment
[a] (CCME 2016a)
[b] Tailings metal data included five samples from the Doris Mine, three samples from the Madrid North deposit, five samples from the Madrid South deposit, and one sample from the Boston deposit.
[c] The CCME soil quality guideline for barium is lower for residential parkland use (500 mg/kg) than it is for agricultural use (750 mg/kg); therefore, the residential parkland guideline was adopted for COPC screening.
Grey shading indicates exceedance of the CCME soil quality guidelines - agricultural or residential/parkland.

Based on the screening results (Table 5.6-1), multiple COPCs were identified for terrestrial wildlife including arsenic, beryllium, chromium, copper, molybdenum, nickel, selenium, and tin.

It is expected that most wildlife would be deterred from using the TIA due to mining activities that would be ongoing during the Operational phase. In addition, mitigation measures have been proposed to minimize the potential for terrestrial wildlife to be exposed to the tailings contained within the TIA during the Operational phase. These mitigation measures are described in Volume 4, Section 9. Monitoring and mitigation measures may include: monitoring of the TIA for wildlife (including caribou) usage, excluding caribou (or other wildlife) if water quality does not meet acceptable standards, or the use of water cannons or other types of deterrents to exclude wildlife from the TIA. Taking into consideration these monitoring and mitigation measures, it is considered unlikely that wildlife would spend appreciable amounts of time within the TIA and exposures to tailings is expected to be minimal; further consideration of this potential exposure route would not be warranted.

However, concerns regarding the potential for caribou to eat tailings from the TIA were raised in an information request

from the KIA on the Doris North Type A Water License Amendment, during the hearings for the Water License, and during the Caribou Workshop held in Cambridge Bay in September 2016. Therefore, the potential risk to caribou health from this exposure route was evaluated in the Exposure Assessment (Section 5.6.2), Toxicity Assessment (Section 5.6.3), and Risk Characterization (Section 5.6.4)

Contaminants of Potential Concern in Water

Freshwater

Consistent with the approach used in the characterization of existing conditions freshwater quality (Section 5.4.1.3), maximum predicted concentrations at the 14 surface water quality modeling nodes located within the terrestrial environment LSA were compared to the CCME guidelines for the protection of freshwater aquatic life (CCME 2016a) for fish and aquatic life, and CCME guidelines for the protection of agriculture or livestock (CCME 2016a) for all other wildlife VECs.

Predicted surface water quality at the water quality modeling nodes is provided in Appendix V3-2D. The 14 surface water quality modeling nodes were used to represent water quality that ecological receptors would potentially ingest and forage in. Appendix V3-2D describes the methodology and assumptions used in the surface water quality model for the Phase 2 Project. Water quality modeling provided quantitative estimates of predicted surface water quality at 14 surface water quality modeling nodes located downstream of the Phase 2 Project (described in Section 5.3.3.5 of the existing conditions ERA).

Fugitive dust from the Phase 2 Project can also be deposited on surface waters as dustfall. For freshwater lakes and streams, water quality changes due to dustfall (i.e., air emissions) were evaluated in Volume 5, Section 4.5.4.8. Due to the low predicted total suspended solid loads from dustfall (0.003 to 0.02 mg/L), there are negligible effects to freshwater lakes and streams from dustfall (Volume 5, Section 4.5.4.8).

The maximum predicted concentrations of the non-metal parameters in surface water at the 14 surface water quality model nodes during the Construction and Operational phases were used to determine if the parameter was a COPC. The COPC screening of surface water quality is provided in Volume 5, Section 4.5.4.2.

Predicted maximum concentrations of some metals and nutrients exceeded the CCME freshwater quality guidelines during the Construction and Operational phases (e.g., in Stickleback Lake during the under-ice season; Volume 5, Section 4.5.4.2). However, the predicted concentrations of these parameters were within the range of natural variability and are not the result of Phase 2 Project activities and infrastructure (Volume 5, Section 4.5.4.2). Therefore, no parameters were carried forward as COPCs in the Phase 2 Project-related ERA.

Water Contained within the Tailings Impoundment Area

Terrestrial wildlife could be exposed to water contained within the TIA during the Operational phase. No fish or aquatic life are expected to be present within the TIA so they are not considered further.

Water quality within the TIA was predicted in the surface water quality model (Appendix V3-2D). Predictions were compared to the CCME water quality guidelines for the protection of livestock and agriculture (CCME 2016a). Results of the COPC screening are provided in Table 5.6-2.

Based on the screening results (Table 5.6-2), only two COPCs were identified for terrestrial wildlife: sulphate and arsenic.

Table 5.6-2. Screening Results for Selection of Contaminants of Potential Concern in Tailings Impoundment Area Water for Terrestrial Wildlife

Parameters	CCME Water Quality Guidelines For the Protection of Agriculture - Livestock [a] (mg/L)	Maximum Concentration Predicted in TIA during the Operational Phase [b] (mg/L)	COPC (Yes/No)
Physical Parameters			
Total Suspended Solids	3,000	8.19	No
Major Anions			
Fluoride	2	0.372	No
Sulphate	1,000	1158	Yes
Nutrients			
Nitrite	10	3.38	No
Total Metal			
Aluminum	5	1.75	No
Arsenic	0.025	1.27	Yes
Beryllium	0.1	0.0307	No
Boron	5	0.432	No
Cadmium	0.08	0.000778	No
Calcium	1,000	724	No
Chromium	0.05	0.0203	No
Cobalt	1	0.0211	No
Copper	0.5	0.0444	No
Lead	0.1	0.00324	No
Mercury	0.003	0.000108	No
Molybdenum	0.5	0.256	No
Nickel	1	0.0973	No
Silver	0.05	0.00212	No
Uranium	0.2	0.00326	No
Vanadium	0.1	0.0386	No
Zinc	50	0.0972	No

Notes:
CCME = Canadian Council of Ministers of the Environment
TIA = tailings impoundment area
[a] *(CCME 2016a)*
[b] *Equivalent to the Tail Lake node output results from the surface water quality model.*
Grey shading indicates exceedance of the CCME freshwater quality guidelines for the protection of agriculture/livestock.

It is expected that most wildlife would be deterred from using the TIA due to mining activities that would be ongoing during the Operational phase. In addition, mitigation measures have been proposed to minimize the potential for terrestrial wildlife (including birds) to be exposed to the water contained within the TIA during the Operational phase. These mitigation measures are described in Volume 4, Section 9. Monitoring and mitigation measures may include: monitoring of TIA water quality as part of the Aquatic Effects Monitoring Program; monitoring of the TIA for wildlife (including caribou) usage, excluding caribou (or other wildlife) if water quality does not meet acceptable standards, or the use of water cannons or other types of deterrents to exclude wildlife from the TIA. Taking into consideration these monitoring and mitigation measures, it is considered unlikely that wildlife would spend appreciable amounts of time within the TIA and exposures to TIA water is expected to be minimal; further consideration of this potential exposure route would not be warranted.

However, concerns regarding the potential for caribou to drink water from the TIA were raised in an information request from the KIA on the Doris North Type A Water License Amendment, during the hearings for the Water License, and during the Caribou Workshop held in Cambridge Bay in September 2016. Therefore, the potential risk to caribou health from this exposure was evaluated in the Exposure Assessment (Section 5.6.2), Toxicity Assessment (Section 5.6.3), and Risk Characterization (Section 5.6.4)

Marine Water

Potential Phase 2 Project-related effects on marine water quality during the Construction and Operational phases were assessed in Volume 5, Section 8.5.4. Marine water quality will meet all CCME marine water quality guidelines; therefore, there are no COPCs for marine water during the Construction and Operational phases and potential residual effects to marine water quality were identified as being Not Significant (Volume 5, Section 8.5.4).

Fugitive dust from the Phase 2 Project can also be deposited on marine waters as dustfall. For freshwater marine waters, water quality changes due to dustfall (i.e., air emissions) were evaluated in Volume 5, Section 4.5.4.8. Due to the low predicted total suspended solid loads from dustfall (0.003 to 0.02 mg/L), there are negligible effects to marine water quality from dustfall (Volume 5, Section 4.5.4.8).

Contaminants of Potential Concern in Sediment

Freshwater sediment quality was assessed in the EIS Volume 5, Section 5 (Freshwater Sediment Quality) as part of the freshwater environment assessment. Effects on freshwater sediment quality were informed by the analysis of effects to freshwater quality (Volume 5, Section 4), which was based on the quantitative water balance model (Volume 3, Appendix V3-2D). Marine sediment quality was assessed in the EIS Volume 5, Section 9 (Marine Sediment Quality) as part of the marine environment assessment. Effects on marine sediment quality were informed by the analysis of effects to marine water quality (Volume 5, Section 8).

Metals, nutrients, and organic material are continuously exchanged between the water column and sediments depending on the specific environmental conditions and the properties of the constituents of water or sediments. It is conservative to assume that increases in metal and nutrient concentrations in the water would lead to increases in metal and nutrient concentrations in sediments.

Since COPCs were not identified in predicted fresh or marine waters and residual effects to fresh and marine waters were determined to be Not Significant, the residual effects to freshwater or marine sediment quality were also concluded to be Not Significant (Volume 5, Sections 5.5.5 and 9.5.5.3). Therefore, no parameters were carried forward as COPCs in sediments in the Phase 2 Project-related ERA.

Vegetation and Prey Quality

Since there were no Phase 2 Project-related COPCs identified in the predicted environmental media data (i.e., surface water, marine water, fresh and marine sediment, and soil), there will be no COPCs in vegetation. Because there are no Project-related COPCs identified in the environmental media data used in the food chain model (i.e., fresh and marine water, fresh and marine sediment, and soil), predicted concentrations of COPCs in prey items for ecological receptors are not required and will not be considered further in the Phase 2 Project-related ERA.

Final List of Contaminants of Potential Concern Selected for Evaluation

The same screening criteria used in the existing conditions ERA (i.e., screening against guidelines; Section 5.5.1.3) was used in the Phase 2 Project-related ERA. Comparison to baseline concentrations was also done to identify those parameters where increased concentrations are due to the Phase 2 Project (and not due solely to naturally-elevated baseline concentrations).

There were no Phase 2 Project-related COPCs identified when considering the predicted environmental media data (i.e., surface water, marine water, fresh and marine sediment, and soil). Therefore, a Phase 2 Project-related ERA is not required as Project-related changes to the health of ecological receptors are not expected.

However, for the assessment of caribou consumption of tailings and TIA water, several COPCs were identified. The COPCs identified in tailings included: arsenic, beryllium, chromium, copper, molybdenum, nickel, selenium, and tin. The COPCs identified in TIA water included: arsenic and sulphate. Therefore, the final list of COPCs considered for caribou were: arsenic, beryllium, chromium, copper, molybdenum, nickel, selenium, sulphate, and tin.

5.6.1.4 Mitigation Measures

No additional mitigation measures were considered in the Project-related ERA beyond what was outlined in the previous effects assessment chapters. Mitigation and management strategies will be in place for a number of VECs that will serve to minimize the potential effects of the Phase 2 Project on ecological receptors since the health of ecological receptors is dependent on the quality of the surrounding environmental media (i.e., water, soil, sediment, and vegetation). In addition, strategies to minimize the potential for Phase 2 Project-related effects to wildlife and have also been developed. Mitigation and adaptive management strategies for VECs can be found in the following volumes and chapters:

- Air Quality: Volume 4, Section 2;
- Landforms and Soils: Volume 4, Section 7;
- Vegetation and Special Landscape Features: Volume 4, Section 8;
- Terrestrial Wildlife and Wildlife Habitat: Volume 4, Section 9;
- Freshwater Water Quality: Volume 5, Section 4;
- Freshwater Sediment Quality: Volume 5, Section 5;
- Freshwater Fish: Volume 5, Section 6;
- Marine Water Quality: Volume 5, Section 8;
- Marine Sediment Quality: Volume 5, Section 9;
- Marine Fish: Volume 5, Section 10; and
- Marine wildlife: Volume 5, Section 11.

5.6.1.5 Conceptual Model

A simplified schematic diagram of the sources of COPCs and pathways by which ecological receptors may be exposed to Phase 2 Project-related emissions is depicted in Figure 5.6-1. There are two general sources of emissions from the Phase 2 Project: atmospheric emissions (e.g., fugitive dust with associated COPCs) and liquid effluent (e.g., effluent discharge and treated waste water). Fugitive dust and emission particulates have the potential to enter the atmosphere, travel some distance, and settle, where they can reside in different media such as soil and vegetation. These media can be taken up by wildlife through the ingestion exposure route.

Phase 2 Project-related ERA is presented in Figure 5.6-1, which shows how COPCs released from the Phase 2 Project could enter the environment (i.e., air, surface water, vegetation, and soil) and move into ecological receptors via ingestion and gill uptake.

5.6.1.6 Identification of Disease Vectors

Certain infectious diseases have the ability to be transmitted between species (sometimes by a vector) from non-human animals to humans, or from humans to other animals, and are known as zoonotic diseases. Disease vectors are biological agents (e.g., person, animal, or microorganism) that can carry and transmit infectious diseases to other living hosts. Harmful diseases can be transmitted to humans via disease vectors such as arthropods (e.g., mites, ticks, lice, fleas, mosquitoes, and flies) and wildlife (e.g., bats, raccoons, and rodents).

It is possible to consider zoonotic diseases as contaminants if (Leighton 2003):

- they are introduced into an ecosystem for the first time by humans;
- human activity causes them to concentrate in specific areas;
- human activities alter the ecosystem in a way that changes the occurrence of diseases due to changes in relationships between pathogens and their hosts; or
- genetic engineering technology results in the creation of new man-made pathogen strains.

Arctic host species can transmit several zoonotic diseases, such as trichinella in walrus and polar bear and cryptosporidium in marine and terrestrial mammals (NRCan 2014). A lack of information exists on specific hosts and modes of transmission in the Arctic environment. Furthermore, climate change is rapidly changing the situation as a link exists between zoonotic diseases and temperature (NRCan 2014). Environmental temperature significantly affects vectors that have developmental stages that occur outside warm blooded hosts, for example cooler northern climates inhibit the developmental rate of insects and nematodes (Bradley et al. 2005). Two important zoonotic diseases that occur in Canada (i.e., Lyme disease spread by ticks and West Nile virus spread by mosquitoes and wild birds) have not been detected in the Arctic due to cold temperatures (Leighton 2011). However, as temperatures in the north increase the distribution of these zoonotic diseases may move north. Zoonotic disease transmission via wildlife is likely the predominant method of exposure for people residing in Nunavut.