Information Request 43

Response to Information Request 43

IR 43 – Country Foods

References:

EIS Guidelines, Section 2.7.3.3;
EIS, Section 2.7.3.3

Related Comments:

CEAR # 265 (Health Canada)

Rationale:

In Section 2.7.3.3, the EIS Guidelines require the Proponent to provide a quantification of the human health risk from contaminated country foods.

The Proponent indicates in the EIS (Section 2.7.3.3, p. 1209) that "the [hazard quotients] calculated for toddler and adult receptors are shown in Table 2.7.3.3-12." For adults, the indicated toxicity reference value in the table is 0.1 mg/kg-day for all metals that were assessed.

Health Canada acknowledged the models used by the Proponent do predict metal deposition in soils and assess risk from consumption of country foods; however, it noted that the predicted soil concentration model used needs to be both conservative and appropriate. In order to be so, the hazard quotients should be derived as the ratio of the estimated exposure to the tolerable daily intake for each contaminant of potential concern and then summed to determine total dietary exposure. Hazard quotients used in the Human Health and Ecological Risk Assessment done by the Proponent are not calculated based on total dietary exposure.

Health Canada also notes that no reference is provided for the 0.1 mg/kg/d used for adults for all contaminants of potential concern. Health Canada does not consider this an appropriate method to assess human health risks from country food consumption and suggests specific toxicity reference values be employed, when available, for the characterization of potential health risks.

Information Requested:

With regards to the assessment of country food consumption in the Human Health and Ecological Risk Assessment, the Panel requests that Taseko:

a. Reassess the potential risks to human health from the consumption of country foods using hazard quotients that are calculated based on total dietary exposure to contaminants of potential concern.

b. Reassess country foods contaminant exposure using chemical-specific toxicity reference values.

Information Requests #43a and b

With regards to the assessment of country food consumption in the Human Health and Ecological Risk Assessment, the Panel requests that Taseko:

a. Reassess the potential risks to human health from the consumption of country foods using hazard quotients that are calculated based on total dietary exposure to contaminants of potential concern.

b. Reassess country foods contaminant exposure using chemical-specific toxicity reference values

Response Summary

It is noted that in order to estimate hazard quotients for IR43a), toxicological reference values are required as requested in IR43b); therefore, this response will address IR43a and IR43b concurrently.

The potential risks to human health from the consumption of country foods have been calculated based on mean metal concentrations in soil from the regional study area (RSA) (as reported in the original HHERA in the 2009 EIS) and the predicted increases in metal concentrations in soil in the area surrounding Fish Lake (as reported in the 2012 EIS).

The hazard quotients (HQs) have been calculated based on dietary exposures to the potential contaminants of concern and using chemical-specific toxicity reference values.

The risk evaluation in the 2012 EIS following 20 years of operation assumes there was a direct relationship between the increase in the metal concentration in soil and the increase in the potential risk associated with the consumption of country foods. The results of the present assessment confirm that this assumption was valid. For example, the maximum percent increase in the metal concentration in soil after 20 years of mine operation was 2.94% for copper. This predicted increase in soil concentration would result in a proportional increase in the HQ calculated for copper in all country foods.

Based on the calculation of potential risks associated with the consumption of country foods following 20 years of exposure, the predicted increases are sufficiently low to indicate that post closure, both the carcinogenic and non-carcinogenic risks do not differ significantly from those present under baseline conditions. This conclusion is consistent with that provided in the 2012 EIS.

Discussion

To address IR 43, the following is an assessment of the potential risks to human health from the consumption of country foods using hazard quotients that are calculated based on total dietary exposure to contaminants of potential concern. The exposure factors and risk calculations used in this evaluation are consistent with those in the original HHERA presented in the 2009 EIS, including the modelling of tissue concentrations in country food based on concentrations in soil, water and vegetation.

<u>Concentrations in Soil, Vegetation and Country Foods, and Percent Increase from Mine Operations</u>

The risk associated with the consumption of country food is directly proportional to the metal concentration of the food, and it was assumed that changes in concentrations of metals in country food were directly proportional to the changes in concentrations in the soil; therefore, changes in risk from consumption of country food are assumed to be directly proportional to changes in soil concentration.

The projected risks due to consumption of country food following 20 years of operation are estimated based on the maximum predicted increases over baseline in soil concentration for each CoC. The highest magnitude of increase in soil metal concentrations is that from the north end of Fish Lake, which is expected to receive the highest level of deposition of any area in the RSA. For a conservative approach, these predicted increases have been applied to the mean baseline concentrations of metals in soil for the RSA. The increases as well as the total concentration after 20 years mine operation are provided in Table 43-2.

The reassessment indicates that the maximum predicted increases in concentrations range from a minimum increase of 0.0001% for zinc to a maximum increase of 2.94% for copper. The percent increases are slightly higher than those reported in Table 2.7.3.3-6 of the EIS. For example, the predicted percent increase for copper reported in the 2012 EIS was 0.65% compared to 2.94% in this reassessment (Table 43-1). The increases in soil concentration reported in this reassessment are still sufficiently low to indicate that post-closure, the levels of these metals in soil in the RSA will not differ from what currently exists prior to development.

Table 43-1. Changes in Soil Quality as a Result of 20 years of Operation

Metal	Baseline Concentration (RSA) (mg/kg)[a]	Maximum Predicted Increase after 20 Years[b]	Predicted Concentration after 20 Years (mg/kg)	% Increase over Baseline
Antimony	6.69000E-01	4.00000E-04	6.69400E-01	0.0598%
Arsenic	7.10700E+00	3.13000E-03	7.11013E+00	0.0440%
Barium	8.67210E+01	1.08800E-02	8.67319E+01	0.0125%
Chromium (Total)	1.16900E+00	2.12200E-02	1.19022E+00	1.8152%
Cobalt	5.70810E+01	2.98000E-03	5.70840E+01	0.0052%
Copper	1.50770E+01	4.42630E-01	1.55196E+01	2.9358%
Lead	3.09400E+00	8.50000E-04	3.09485E+00	0.0275%
Mercury - Inorganic	4.60000E-02	8.00000E-05	4.60800E-02	0.1739%
Nickel	5.99420E+01	3.27000E-03	5.99453E+01	0.0055%
Selenium	4.63000E-01	4.60000E-04	4.63460E-01	0.0994%
Silver	1.17000E-01	8.00000E-05	1.17080E-01	0.0684%
Zinc	6.01310E+01	8.00000E-05	6.01311E+01	0.0001%

Notes:

[a] Baseline mean metal concentrations for the RSA reported in the original Human Health Environmental Risk Assessment (May 2007).

[b] Increases in metal concentrations for the north end of Fish Lake reported in the 2012 Environmental Impact Statement.

The concentrations of metals in vegetation following 20 years of operation were estimated by assuming the metal concentration in plants is related to the metal concentration in soil through an uptake factor (UF) (Equation 1). This approach assumes that the concentration of a CoC in vegetation is a linear function of the concentration in soil, which is expected to be the case over the limited range of the modelled increases in soil concentrations. The UFs used in this evaluation were those provided in US EPA Human Health Risk Assessment Protocols (HHRAP) (1984 and 2005).

Equation 1: $$\frac{\boldsymbol{mg\ CoC}}{\boldsymbol{kg\ vegetation}} = \frac{\boldsymbol{mg\ CoC}}{\boldsymbol{kg\ Soil}} \times \boldsymbol{UF}$$

The magnitude of the increase in vegetation concentrations was determined by evaluating the percent difference between the predicted metal concentration in vegetation after 20 years and the predicted metal concentration in vegetation under baseline conditions. This percent increase was applied to the mean concentration in vegetation measured under baseline conditions in order to predict the concentrations in vegetation after 20 years.

The data provided in Table 43-2 indicate that the maximum predicted increases in concentrations of these metals in vegetation over baseline concentrations range from a minimum increase of 0% for mercury (inorganic) to a maximum increase of 2.94% for copper. These percent increases are sufficiently low to indicate that post closure, the levels of these metals in vegetation in the RSA will not differ from what currently exists prior to development.

Table 43-2. Changes in Vegetation Quality as a Result of 20 Years of Operation

Metal	Baseline Concentration (mg/kg)	UF	Predicted Concentration After 20 Years (mg/kg)	% Increase over Baseline
Antimony	4.37000E+00	2.000E-01	4.37261E+00	0.0598%
Arsenic	5.32463E-02	3.600E-02	5.32697E-02	0.0440%
Barium	8.79519E+00	1.500E-01	8.79629E+00	0.0125%
Chromium (Total)	5.72388E-01	8.000E-03	5.82778E-01	1.8152%
Cobalt	4.97761E-01	2.000E-02	4.97787E-01	0.0052%
Copper	5.79560E+00	4.000E-01	5.96574E+00	2.9358%
Lead	9.21642E-02	4.500E-02	9.21895E-02	0.0275%
Mercury – Inorganic	5.41176E-03	0.000E+00	5.41176E-03	0%
Nickel	2.28806E+00	3.200E-02	2.28818E+00	0.0055%
Selenium	3.35811E-02	1.600E-02	3.36144E-02	0.0994%
Silver	1.32353E-02	4.000E-01	1.32443E-02	0.0684%
Zinc	5.22414E+01	2.500E-01	5.22415E+01	0.0001%

The concentration of metals in the tissue of moose, muskrat and willow ptarmigan after 20 years was modelled using the predicted concentration in soil and vegetation under an operations scenario, the concentrations in water under the baseline scenario and the equations described in Section 5.3.3 of the original HHERA. Modeled metal concentrations are equivalent for both moose and muskrat. Table 43-3 and Table 43-4 provide a summary of the metal concentrations predicted under baseline and operational conditions for the mammals (i.e. moose and muskrat) and the willow ptarmigan. The data provided in Table 43-3 and Table 43-4 indicates that the maximum predicted increases in concentrations of these metals in moose, muskrat and willow ptarmigan over baseline concentrations range from a minimum increase of 0.0001% for zinc to a maximum increase of 2.9353% for copper. These percent increases are sufficiently low to indicate that post closure, the levels of these metals in moose, muskrat and willow ptarmigan in the RSA will not differ from what currently exists prior to development.

Table 43-3. Changes in Mammalian (Moose and Muskrat) Metal Concentrations as a Result of 20 Years of Operation

Metal	Baseline Concentration (mg/kg)	Predicted Concentration after 20 Years (mg/kg)	% Increase over Baseline
Antimony	1.0312E-04	1.0318E-04	0.0593%
Arsenic	3.1193E-03	3.1207E-03	0.0439%
Barium	1.3607E-02	1.3609E-02	0.0125%
Chromium (Total)	2.8699E-02	2.9220E-02	1.8144%
Cobalt	2.6214E-01	2.6216E-01	0.0052%
Copper	5.3315E-01	5.4880E-01	2.9353%
Lead	3.8544E-04	3.8554E-04	0.0275%
Mercury - Inorganic	2.8561E-04	2.8568E-04	0.0223%
Nickel	1.7581E-01	1.7582E-01	0.0055%
Selenium	8.4477E-04	8.4559E-04	0.0976%
Silver	4.0929E-04	4.0957E-04	0.0673%
Zinc	4.2204E-02	4.2204E-02	0.0001%

Table 43-4. Changes in Willow Ptarmigan Metal Concentrations as a Result of 20 Years of Operation

Metal	Baseline Concentration (mg/kg)	Predicted Concentration after 20 Years (mg/kg)	% Increase over Baseline
Antimony	7.5984E-05	7.6029E-05	0.0593%
Arsenic	2.2984E-03	2.2994E-03	0.0439%
Barium	1.0026E-02	1.0027E-02	0.0126%
Chromium (Total)	2.1147E-02	2.1531E-02	1.8144%
Cobalt	1.9316E-01	1.9317E-01	0.0052%
Copper	3.9284E-01	4.0438E-01	2.9353%
Lead	2.8401E-04	2.8408E-04	0.0275%
Mercury - Inorganic	2.1045E-04	2.1050E-04	0.0223%
Nickel	1.2955E-01	1.2955E-01	0.0054%
Selenium	6.2246E-04	6.2307E-04	0.0976%
Silver	3.0158E-04	3.0178E-04	0.0673%
Zinc	3.1097E-02	3.1097E-02	0.0001%

The concentrations of metals in Labrador tea after 20 years were modelled using the same assumptions as for other vegetation in the RSA (Table 43-2). Table 43-5 provides a summary of the metal concentration in Labrador tea under baseline conditions and after 20 years. The data provided in Table 43-5 indicate that the maximum predicted increases in concentrations of these metals in Labrador tea over baseline concentrations range from a minimum increase of 0.0001% for zinc to a maximum increase of 2.9353% for copper. These increases are sufficiently low to indicate that post closure, the levels of these metals in moose, muskrat and willow ptarmigan in the RSA will not differ from what currently exists prior to development.

Table 43-5. Changes in Labrador Tea Metal Concentrations as a Result of 20 Years of Operation

Metal	Baseline Concentration (mg/kg)	Predicted Concentration in Labrador Tea After 20 Years (mg/kg)	% Increase over Baseline
Antimony	5.00000E-02	5.00299E-02	0.0598%
Arsenic	5.00000E-02	5.00220E-02	0.0440%
Barium	8.18000E+01	8.18103E+01	0.0125%
Chromium (Total)	9.00000E-01	9.16337E-01	1.8152%
Cobalt	1.00000E-01	1.00005E-01	0.0052%
Copper	5.50000E+00	5.66147E+00	2.9358%
Lead	1.00000E-01	1.00027E-01	0.0275%
Manganese	1.41000E+03	1.41000E+03	0.0000%
Mercury – Inorganic	5.00000E-03	5.00000E-03	0%
Nickel	1.70000E+00	1.70009E+00	0.0055%
Silver	1.00000E-02	1.00068E-02	0.0684%
Zinc	2.74000E+01	2.74000E+01	0.0001%

Chronic Daily Intake Rates

The chronic daily intake (CDI) rates of metals due the consumption of country foods were determined using the receptor daily intake rates reported in the original HHERA (reproduced in Table 43-6) and the concentrations country foods after 20 years (Table 43-3 to Table 45-5).

Table 43-6. Receptor Daily Intake Rate for a Variety of Country Foods.

Food	Daily Intake Rate-Toddler Receptor	Daily Intake Rate-Adult Receptor	Reference
Moose (major body parts)	72 g/day	168 g/day	Derived from Galore 2006 Galore Creek Country Foods baseline Assessment for moose major body parts consumption (Rescan 2006)
Muskrat	2 g/day	5 g/day	Derived from Galore 2006 for hoary marmot major body parts consumption (Rescan 2006)
Ptarmigan (major body parts)	7 g/day	16 g/day	Derived from Galore 2006 for grouse major body parts consumption (Rescan 2006)
Labrador Tea	1 g/day	2 g/day	Derived from Galore 2006 for caribou weed usage (Rescan 2006)

CDI rates for non-carcinogenic metals from ingestion of country food are calculated using Equation 2 (Equation 6-1 in the original HHERA). CDI rates for carcinogenic metals (i.e., arsenic) were calculated using Equation 3. Equation 3 includes a prorating factor of 56/75 which accounts for the fact that carcinogenic risks are only evaluated for the adult life-stage (56 years). This was the approach used in the original HHERA to estimate the adult CDI of carcinogenic metals from ingestion of country foods.

Equation 2: $CDI_{non-carcinogenic} = \frac{IR\ x\ C}{BW}$

Where:

IR= ingestion rate of country food (kg/day)
C= metal concentration in country food (mg/kg)
BW= body weight (kg)
$BW_{Toddler}$ = 16.5 kg
BW_{Adult} = 70.7 kg

Equation 3: $CDI_{carcinogenic} = \frac{IR\ x\ C}{BW} \times \frac{56\ years}{75\ years}$

The non-carcinogenic CDI rates of metals due to consumption of country foods for the toddler and adult receptor after 20 years are provided in Table 43-7 to Table 43-10. The data provided in Table 43-7 and Table 43-10 indicate that the maximum predicted increases over baseline conditions of the CDI of these non-carcinogenic metals due to consumption of country foods range from a minimum increase of 0.0001% for zinc to a maximum increase of 2.9353% for copper. These increases are sufficiently low to indicate that post closure, the CDI of these metals in moose, muskrat, willow ptarmigan and Labrador tea in the RSA will not differ from what currently exists prior to development.

Table 43-7. Chronic Daily Intake of Non-Carcinogenic Metals from Ingested Moose

Metal	Toddler			Adult		
	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference
Antimony	4.4998E-07	4.5025E-07	0.0593%	2.4504E-07	2.4519E-07	0.0593%
Arsenic	1.3611E-05	1.3617E-05	0.0439%	7.4122E-06	7.4154E-06	0.0439%
Barium	5.9376E-05	5.9383E-05	0.0125%	3.2333E-05	3.2337E-05	0.0125%
Chromium (Total)	1.2523E-04	1.2751E-04	1.8144%	6.8197E-05	6.9434E-05	1.8144%
Cobalt	1.1439E-03	1.1440E-03	0.0052%	6.2292E-04	6.2295E-04	0.0052%
Copper	2.3265E-03	2.3947E-03	2.9353%	1.2669E-03	1.3041E-03	2.9353%
Lead	1.6819E-06	1.6824E-06	0.0275%	9.1589E-07	9.1614E-07	0.0275%
Mercury – Inorganic	1.2463E-06	1.2466E-06	0.0223%	6.7868E-07	6.7884E-07	0.0223%
Nickel	7.6719E-04	7.6723E-04	0.0055%	4.1778E-04	4.1780E-04	0.0055%
Selenium	3.6863E-06	3.6899E-06	0.0976%	2.0074E-06	2.0093E-06	0.0976%
Silver	1.7860E-06	1.7872E-06	0.0673%	9.7257E-07	9.7322E-07	0.0673%
Zinc	1.8416E-04	1.8416E-04	0.0001%	1.0029E-04	1.0029E-04	0.0001%

Table 43-8. Chronic Daily Intake of Non-Carcinogenic Metals from Ingested Muskrat

Metal	Toddler			Adult		
	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference
Antimony	1.2500E-08	1.2507E-08	0.0593%	7.2929E-09	7.2972E-09	0.0593%
Arsenic	3.7810E-07	3.7826E-07	0.0439%	2.2060E-07	2.2070E-07	0.0439%
Barium	1.6493E-06	1.6495E-06	0.0125%	9.6230E-07	9.6242E-07	0.0125%
Chromium (Total)	3.4787E-06	3.5418E-06	1.8144%	2.0297E-06	2.0665E-06	1.8144%
Cobalt	3.1775E-05	3.1777E-05	0.0052%	1.8539E-05	1.8540E-05	0.0052%
Copper	6.4624E-05	6.6521E-05	2.9353%	3.7705E-05	3.8812E-05	2.9353%
Lead	4.6720E-08	4.6732E-08	0.0275%	2.7259E-08	2.7266E-08	0.0275%
Mercury – Inorganic	3.4620E-08	3.4628E-08	0.0223%	2.0199E-08	2.0203E-08	0.0223%
Nickel	2.1311E-05	2.1312E-05	0.0055%	1.2434E-05	1.2435E-05	0.0055%
Selenium	1.0240E-07	1.0250E-07	0.0976%	5.9743E-08	5.9802E-08	0.0976%
Silver	4.9611E-08	4.9644E-08	0.0673%	2.8946E-08	2.8965E-08	0.0673%
Zinc	5.1156E-06	5.1156E-06	0.0001%	2.9847E-06	2.9847E-06	0.0001%

Table 43-9. Chronic Daily Intake of Non-Carcinogenic Metals from Ingested Willow Ptarmigan

Metal	Toddler			Adult		
	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference
Antimony	3.2236E-08	3.2255E-08	0.0593%	1.7196E-08	1.7206E-08	0.0593%
Arsenic	9.7509E-07	9.7552E-07	0.0439%	5.2015E-07	5.2038E-07	0.0439%
Barium	4.2535E-06	4.2540E-06	0.0125%	2.2690E-06	2.2693E-06	0.0125%
Chromium (Total)	8.9715E-06	9.1342E-06	1.8144%	4.7857E-06	4.8726E-06	1.8144%
Cobalt	8.1946E-05	8.1951E-05	0.0052%	4.3713E-05	4.3716E-05	0.0052%
Copper	1.6666E-04	1.7155E-04	2.9353%	8.8904E-05	9.1514E-05	2.9353%
Lead	1.2049E-07	1.2052E-07	0.0275%	6.4273E-08	6.4291E-08	0.0275%
Mercury – Inorganic	8.9283E-08	8.9303E-08	0.0223%	4.7627E-08	4.7638E-08	0.0223%
Nickel	5.4960E-05	5.4963E-05	0.0055%	2.9318E-05	2.9319E-05	0.0055%
Selenium	2.6407E-07	2.6433E-07	0.0976%	1.4087E-07	1.4101E-07	0.0976%
Silver	1.2794E-07	1.2803E-07	0.0673%	6.8250E-08	6.8296E-08	0.0673%
Zinc	1.3193E-05	1.3193E-05	0.0001%	7.0376E-06	7.0376E-06	0.0001%

Table 43-10. Chronic Daily Intake of Non-Carcinogenic Metals from Ingested Labrador Tea

Metal	Toddler			Adult		
	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference	Baseline (mg/kg-day)	After 20 Years of Operation (mg/kg-day)	Percent Difference
Antimony	6.0606E-06	6.0642E-06	0.0598%	2.8289E-06	2.8305E-06	0.0598%
Arsenic	6.0606E-06	6.0633E-06	0.0440%	2.8289E-06	2.8301E-06	0.0440%
Barium	9.9152E-03	9.9164E-03	0.0125%	4.6280E-03	4.6286E-03	0.0125%
Chromium (Total)	1.0909E-04	1.1107E-04	1.8152%	5.0919E-05	5.1844E-05	1.8152%
Cobalt	1.2121E-05	1.2122E-05	0.0052%	5.6577E-06	5.6580E-06	0.0052%
Copper	6.6667E-04	6.8624E-04	2.9358%	3.1117E-04	3.2031E-04	2.9358%
Lead	1.2121E-05	1.2125E-05	0.0275%	5.6577E-06	5.6593E-06	0.0275%
Mercury – Inorganic	6.0606E-07	6.0606E-07	0.0000%	2.8289E-07	2.8289E-07	0.0000%
Nickel	2.0606E-04	2.0607E-04	0.0055%	9.6181E-05	9.6186E-05	0.0055%
Selenium	-	-	-	-	-	-
Silver	1.2121E-06	1.2130E-06	0.0684%	5.6577E-07	5.6616E-07	0.0684%
Zinc	3.3212E-03	3.3212E-03	0.0001%	1.5502E-03	1.5502E-03	0.0001%

The carcinogenic CDI rates of arsenic due to consumption of country foods for the adult receptor after 20 years are provided in Table 43-11. The data provided in Table 43-11 indicate that the maximum predicted increase in chronic daily intake of carcinogenic metals (i.e. arsenic) in country foods over baseline concentrations was 0.0439%. The magnitude of this increase indicates that post closure, the CDI of carcinogenic metals in country foods in the RSA will not differ from what currently exists prior to development.

Table 43-11. Adult Chronic Daily Intake of Carcinogenic Metals (i.e. arsenic) from Country Foods

Country Food	$CDI_{carcinogenic}$ (mg/kg-day)	
Moose	Baseline	5.5344E-06
	After 20 Years of Operation	5.5369E-06
	Percent Difference	0.0439%
Muskrat	Baseline	1.6472E-07
	After 20 Years of Operation	1.6479E-07
	Percent Difference	0.0439%
Willow Ptarmigan	Baseline	3.8838E-07
	After 20 Years of Operation	3.8855E-07
	Percent Difference	0.0439%
Labrador Tea	Baseline	2.1122E-06
	After 20 Years of Operation	2.1131E-06
	Percent Difference	0.0440%

Risk to Human Health - Non-Carcinogenic metals

The approach used to estimate non-carcinogenic risk associated with the intake of country foods after 20 years was consistent with the approach in the original HHERA. Risk characterization includes estimation of hazard quotients (HQ), which are calculated by taking the ratio of the CDI (non-carcinogenic) and the tolerable daily intake (TDI) (Equation 4). TDIs used in this evaluation are consistent with those used in the original HHERA and are provided in Table 43-12. During the selection of TDIs for the original HHERA preference was given to those recommended by Health Canada. Where the TDI for a particular metal was not provided by Health Canada, other reputable agencies were consulted.

Equation 4: $HQ = \frac{CDI_{non-carcinogenic}}{TDI}$

Where:

HQ= Hazard Quotient (unitless)
CDI= chronic daily intake (mg/kg-day) (non-carcinogenic)
TDI= tolerable daily intake (mg/kg-day)

Table 43-12. Chemical-Specific Toxicity Reference Values (for non-cancer effects)

Metal	TDI	
	mg/kg-d	Reference
Antimony	0.0004	EPA 2007
Arsenic	0.0003	EPA 2007
Barium	0.0160	HC 2004b
Chromium (Total)	0.0010	HC 2004b
Cobalt	0.0200	EPA 2004a
Copper	0.0300	HC2004b
Lead	0.0036	HC 2004b
Mercury – Inorganic	0.0003	HC 2004b
Nickel	0.0200	EPA 2007
Selenium	0.0050	EPA 2007
Silver	0.0050	EPA 2007
Zinc	0.3000	EPA 2007

In the original HHERA an HQ benchmark of 0.2 was selected based on the assumption that 80% of the dose of a particular metal would come from off-site sources. An HQ greater than 0.2, was assumed to indicate the potential for adverse health effects. However, this evaluation does not focus on the value of the HQ after 20 years, but rather on the incremental increase above the HQ calculated under baseline conditions. The HQs for non-carcinogenic metals due to consumption of country foods for the toddler and adult receptor after 20 years are provided in Table 43-13 to Table 43-16. The data provided in Table 43-13 and Table 43-16 indicate that the maximum predicted increases over baseline conditions of the HQ of these non-carcinogenic metals due to consumption of country foods range from a minimum increase of 0.0001% for zinc to a maximum increase of 2.9353% for copper. These increases are sufficiently low to indicate that post closure, the HQ related to the consumption of the moose, muskrat, willow ptarmigan and Labrador tea in the RSA will not differ from what currently exists prior to development.

Table 43-13. HQ Estimates for Non-Carcinogenic Metals from Ingested Moose

Metal	HQ					
	Toddler			Adult		
	Baseline	After 20 Years of Operation	Percent Difference	Baseline	After 20 Years of Operation	Percent Difference
Antimony	1.1250E-03	1.1256E-03	0.0593%	6.1260E-04	6.1296E-04	0.0593%
Arsenic	4.5372E-02	4.5391E-02	0.0439%	2.4707E-02	2.4718E-02	0.0439%
Barium	3.7110E-03	3.7114E-03	0.0125%	2.0208E-03	2.0211E-03	0.0125%
Chromium (Total)	1.2523E-01	1.2751E-01	1.8144%	6.8197E-02	6.9434E-02	1.8144%
Cobalt	3.8130E-02	3.8132E-02	0.0052%	3.1146E-02	3.1147E-02	0.0052%
Copper	7.7549E-02	7.9825E-02	2.9353%	4.2229E-02	4.3469E-02	2.9353%
Lead	4.6720E-04	4.6732E-04	0.0275%	2.5441E-04	2.5448E-04	0.0275%
Mercury – Inorganic	4.1544E-03	4.1553E-03	0.0223%	2.2623E-03	2.2628E-03	0.0223%
Nickel	3.8360E-02	3.8362E-02	0.0055%	2.0889E-02	2.0890E-02	0.0055%
Selenium	7.3725E-04	7.3797E-04	0.0976%	4.0147E-04	4.0187E-04	0.0976%
Silver	3.5720E-04	3.5744E-04	0.0673%	1.9451E-04	1.9464E-04	0.0673%
Zinc	6.1387E-04	6.1387E-04	0.0001%	3.3429E-04	3.3429E-04	0.0001%

Table 43-14. HQ Estimates for Non-Carcinogenic Metals from Ingested Muskrat

Metal	HQ					
	Toddler			Adult		
	Baseline	After 20 Years of Operation	Percent Difference	Baseline	After 20 Years of Operation	Percent Difference
Antimony	3.1249E-05	3.1267E-05	0.0593%	1.8232E-05	1.8243E-05	0.0593%
Arsenic	1.2603E-03	1.2609E-03	0.0439%	7.3533E-04	7.3566E-04	0.0439%
Barium	1.0308E-04	1.0310E-04	0.0125%	6.0144E-05	6.0151E-05	0.0125%
Chromium (Total)	3.4787E-03	3.5418E-03	1.8144%	2.0297E-03	2.0665E-03	1.8144%
Cobalt	1.5888E-03	1.5888E-03	0.0052%	9.2696E-04	9.2701E-04	0.0052%
Copper	2.1541E-03	2.2174E-03	2.9353%	1.2568E-03	1.2937E-03	2.9353%
Lead	1.2978E-05	1.2981E-05	0.0275%	7.5718E-06	7.5739E-06	0.0275%
Mercury – Inorganic	1.1540E-04	1.1543E-04	0.0223%	6.7330E-05	6.7345E-05	0.0223%
Nickel	1.0655E-03	1.0656E-03	0.0055%	6.2169E-04	6.2173E-04	0.0055%
Selenium	2.0479E-05	2.0499E-05	0.0976%	1.1949E-05	1.1960E-05	0.0976%
Silver	9.9222E-06	9.9289E-06	0.0673%	5.7891E-06	5.7930E-06	0.0673%
Zinc	1.7052E-05	1.7052E-05	0.0001%	9.9490E-06	9.9490E-06	0.0001%

Table 43-15. HQ Estimates for Non-Carcinogenic Metals from Ingested Ptarmigan

Metal	HQ					
	Toddler			Adult		
	Baseline	After 20 Years of Operation	Percent Difference	Baseline	After 20 Years of Operation	Percent Difference
Antimony	8.0589E-05	8.0637E-05	0.0593%	4.2990E-05	4.3015E-05	0.0593%
Arsenic	3.2503E-03	3.2517E-03	0.0439%	1.7338E-03	1.7346E-03	0.0439%
Barium	2.6584E-04	2.6588E-04	0.0125%	1.4181E-04	1.4183E-04	0.0125%
Chromium (Total)	8.9715E-03	9.1342E-03	1.8144%	4.7857E-03	4.8726E-03	1.8144%
Cobalt	4.0973E-03	4.0975E-03	0.0052%	2.1857E-03	2.1858E-03	0.0052%
Copper	5.5554E-03	5.7184E-03	2.9353%	2.9635E-03	3.0505E-03	2.9353%
Lead	3.3469E-05	3.3478E-05	0.0275%	1.7854E-05	1.7858E-05	0.0275%
Mercury – Inorganic	2.9761E-04	2.9768E-04	0.0223%	1.5876E-04	1.5879E-04	0.0223%
Nickel	2.7480E-03	2.7481E-03	0.0055%	1.4659E-03	1.4660E-03	0.0055%
Selenium	5.2815E-05	5.2866E-05	0.0976%	2.8174E-05	2.8201E-05	0.0976%
Silver	2.5589E-05	2.5606E-05	0.0673%	1.3650E-05	1.3659E-05	0.0673%
Zinc	4.3976E-05	4.3976E-05	0.0001%	2.3459E-05	2.3459E-05	0.0001%

Table 43-16. HQ Estimates for Non-Carcinogenic Metals from Ingested Labrador Tea

Metal	HQ					
	Toddler			Adult		
	Baseline	After 20 Years of Operation	Percent Difference	Baseline	After 20 Years of Operation	Percent Difference
Antimony	1.5152E-02	1.5161E-02	0.0598%	7.0721E-03	7.0764E-03	0.0598%
Arsenic	2.0202E-02	2.0211E-02	0.0440%	9.4295E-03	9.4337E-03	0.0440%
Barium	6.1970E-01	6.1977E-01	0.0125%	2.8925E-01	2.8929E-01	0.0125%
Chromium (Total)	1.0909E-01	1.1107E-01	1.8152%	3.3900E-05	3.4515E-05	1.8152%
Cobalt	6.0606E-04	6.0609E-04	0.0052%	2.8289E-04	2.8290E-04	0.0052%
Copper	2.2222E-02	2.2875E-02	2.9358%	1.0372E-02	1.0677E-02	2.9358%
Lead	3.3670E-03	3.3679E-03	0.0275%	1.5716E-03	1.5720E-03	0.0275%
Mercury – Inorganic	2.0202E-03	2.0202E-03	0.0000%	7.8600E-05	7.8600E-05	0.0000%
Nickel	1.0303E-02	1.0304E-02	0.0055%	7.4000E-02	7.4004E-02	0.0055%
Silver	2.4242E-04	2.4259E-04	0.0684%	1.1315E-04	1.1323E-04	0.0684%
Zinc	1.1071E-02	1.1071E-02	0.0001%	5.1674E-03	5.1674E-03	0.0001%

Risk to Human Health - Carcinogenic Metals (Arsenic)

The approach used to estimate carcinogenic risk associated with the intake of arsenic in country foods after 20 years was consistent with the approach used in the original HHERA. Risk characterization includes estimation of the incremental lifetime cancer risk (ILCR), which is calculated by multiplying the CDI (carcinogenic) by the cancer slope factor (CSF) (Equation 5). Arsenic was the only carcinogenic metal evaluated for this assessment and the CSF was 2.80 $(mg/kg\text{-}day)^{-1}$ as recommended by Health Canada (HC 2004b).

Equation 5: $ILCR = CDI_{carcinogenic} \times CSF$

Where:

ILCR= chronic daily intake (mg/kg-day)
$CDI_{carcinogenic}$= tolerable daily intake (mg/kg-day) (carcinogenic)
CSF=cancer slope factor $(mg/kg\text{-}day)^{-1}$

In the original HHERA an ILCR benchmark of 1.0E-05 was selected based on an incremental lifetime cancer risk of 1 in 100 000. ILCR greater than 1.0E-05 indicate the potential for adverse health effects. Similar to the non-carcinogenic evaluation, the carcinogenic risk evaluation does not focus on the value of the ILCR after 20 years, but rather on the incremental increase above the ILCR calculated under baseline conditions. The ILCRs of metals (i.e., arsenic) due to consumption of country foods for the adult receptor after 20 years are provided in Table 43-17. The data provided in Table 43-17 indicate that the predicted increases over baseline conditions of the ILCRs of arsenic due to consumption of country foods were 0.0439%. The magnitude of this percent increase indicates that post closure, the ILCR of carcinogenic metals in country foods in the RSA will not differ from what currently exists prior to development.

Table 43-17. ILCR Estimates for Ingestion of Carcinogenic Metals (i.e. Arsenic) in Country Foods.

Country Food	ILCR	
Moose	Baseline	1.55E-05
	After 20 Years of Operation	1.55E-05
	Percent Difference	0.0439%
Muskrat	Baseline	4.61E-07
	After 20 Years of Operation	4.61E-07
	Percent Difference	0.0439%
Willow Ptarmigan	Baseline	1.09E-06
	After 20 Years of Operation	1.09E-06
	Percent Difference	0.0439%
Labrador Tea	Baseline	5.91E-06
	After 20 Years of Operation	5.92E-06
	Percent Difference	0.0440%