Memo

To:	Nicola Banton	From:	Bryan Leece, Tony McKnight-Whitford
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Reference: Sample Calculations

INTRODUCTION

This technical memo has been prepared in response to information requests from the City of Kamloops (COK), Canadian Environmental Assessment Agency (CEAA) and Health Canada (HC) (COK-SLR417, CEAA-031, CEAA-033, HC-006, HC-035, HC-036, HC-038). Collectively, these IRs have requested that sample calculations be provided for the Human Health and Ecological Risk Assessment.

This request appears to be based on gaps of information in Appendix F (Sample Calculations) of the HHERA. This technical memorandum summarizes a full step by step demonstration of:

- an exposure point calculation of copper deposition at (Daycare-Maximum Location in Aberdeen- New Ajax Mine Kamloops);
- followed by calculations of exposure point concentrations in several media (surface water, fish, deer, and berries);
- leading to calculations of both inhalation and ingestion Human Health Risks;
- and the calculations of future Ecological Health Risks of antimony posed to the American Mink;
- with the inclusion of a full list of uptake factors and those used throughout the sample calculations located in Attachment A.

Worked examples of the sample calculations are provided in the following sections.

EXPOSURE POINT CALCULATIONS

Calculation of Metal Accumulation in Soil from Dust Deposition

The method used to estimate the increase in metal concentrations in soil at each of the receptor locations considered in the Human Health and Ecological Risk Assessment Technical Data report (Appendix 10.4-A) is discussed in detail in the Community-Specific Dustfall Calculations Technical Memo. These calculations have not been reproduced in this Technical Memo.

Exposure Point Calculation of Future Arsenic Concentration in Surface Water

Future total metal concentrations in surface water were calculated by applying a ratio derived from measured total metal concentrations in water to dissolved concentrations which were then applied to modelled running averages of future concentrations of dissolved metals.

(1) Calculation of the Future Total Metal Concentration in Surface Water:

$$EPC_{future}\left({}^{mg}/_{L}\right) = EPC_{model}\left({}^{mg}/_{L}\right) \times R\ (\%)$$

Where:

Parameter	Description	Units
EPC $_{future}$	= Exposure point concentration for total metal in future surface water	mg/L
EPC $_{model}$	= Modelled exposure point dissolved metal concentration in surface water	mg/L
R	= Ratio of total metal to dissolved metal in surface water	%

(2) Calculation of the Ratio between Total Metal Concentration and Dissolved Metal Concentration in Surface Water:

$$R(\%) = \frac{EPC_{total}\left({}^{mg}/_{L}\right)}{EPC_{dissolve}\left({}^{mg}/_{L}\right)}$$

Where:

Parameter	Description	Units
R	= Ratio of total metal to dissolved metal in surface water	%
EPC $_{total}$	= Exposure point concentration for metal in measured surface water (Baseline case)	mg/L
EPC $_{dissolve}$	= Exposure point total concentration for metal in measured surface water (Baseline case)	mg/L

The total /dissolved ratios (R(%)) of metals for each surface water location (PC02, PC2.3 and Jacko Lake) were calculated using the baseline data provided in Appendix B (revised version provided in tech memo) and the weighted average approach described in Section 3.3.3.3 of Appendix 10-4 and in a supplemental Tech memo 'Calculation of the Weighted Running Average Concentration for Surface Water under Baseline Conditions'. The baseline surface water samples contain both total concentrations and dissolved concentrations. The ratios were calculated by dividing the Baseline Case total concentration by the Baseline Case dissolved concentration for each metal; these concentrations were based on the annual weighted average of measured samples. Baseline Case and Future Case dissolved concentrations for each location are provided in **Table 1**, which is located at the end of this worked example. Baseline Case and Future Case total concentrations are provided in Table 3.3-9 of Appendix 10.4-A.

Reference: Sample Calculations

A worked example of the ratio between total metal concentration (for arsenic) and dissolved metal concentration in surface water from Jacko Lake is provided below. The total/dissolved ratios used in this HHERA are provided in **Table 2**.

$$R(\%) = \frac{EPC_{total}\left({}^{mg}/_{L}\right)}{EPC_{dissolve}\left({}^{mg}/_{L}\right)}$$

$$R(\%) = \frac{1.35E-03\left({}^{mg}/_{L}\right)}{1.33E-03\left({}^{mg}/_{L}\right)}$$

$$R(\%) = 100\%$$

A worked example of the future total metal concentration (for arsenic) in surface water is provided below.

$$EPC_{future}\left({}^{mg}/_{L}\right) = EPC_{dissolve}\left({}^{mg}/_{L_{water}}\right) \times R(\%)$$

$$EPC_{future}\left({}^{mg}/_{L}\right) = 1.59E-03\left({}^{mg}/_{L_{water}}\right) \times 100\%$$

$$EPC_{future}\left({}^{mg}/_{L}\right) = 1.59E-03$$

Table 1 Dissolved metal surface water concentrations for each location.

Parameter	Units	Jacko		PC02.3		PC02	
		Baseline Case	Future Case	Baseline Case	Future Case	Baseline Case	Future Case
Aluminum	mg/L	1.21E-03	6.39E-03	1.64E-03	1.22E-02	1.55E-03	6.66E-03
Antimony	mg/L	1.07E-04	1.01E-04	1.03E-04	4.71E-04	1.06E-04	3.84E-04
Arsenic	mg/L	1.33E-03	1.59E-03	2.13E-03	3.17E-03	1.78E-03	2.80E-03
Cadmium	mg/L	1.01E-05	8.91E-06	1.00E-05	1.16E-05	1.01E-05	1.01E-05
Chromium	mg/L	1.00E-04	4.81E-04	1.21E-04	8.42E-04	1.24E-04	5.04E-04
Cobalt	mg/L	1.00E-04	2.12E-04	1.05E-04	4.28E-04	1.92E-04	3.63E-04
Copper	mg/L	7.83E-04	2.99E-03	2.47E-03	4.61E-03	2.07E-03	3.73E-03
Lead	mg/L	5.14E-05	7.30E-05	5.00E-05	1.14E-04	5.00E-05	7.41E-05
Manganese	mg/L	3.16E-02	4.15E-02	3.10E-02	3.31E-01	9.43E-02	2.01E-01
Mercury	mg/L	1.00E-05	1.06E-05	1.00E-05	1.45E-05	1.00E-05	1.04E-05
Molybdenum	mg/L	2.18E-03	4.05E-03	1.80E-02	2.19E-02	1.02E-02	1.96E-02
Nickel	mg/L	6.83E-04	1.57E-03	2.17E-03	2.61E-03	3.51E-03	4.43E-03
Selenium	mg/L	1.82E-04	3.22E-04	1.87E-04	9.41E-04	6.90E-04	1.24E-03
Thallium	mg/L	1.00E-05	7.18E-06	1.00E-05	1.03E-05	1.07E-05	8.18E-06
Uranium	mg/L	1.08E-03	1.35E-03	1.26E-03	2.41E-03	2.23E-03	3.79E-03

Table 2 Ratios of total concentration to dissolved concentration for surface water- Baseline Case.

Parameter	Units	Jacko	PC02.3	PC02
		Total / Dissolved	Total / Dissolved	Total / Dissolved
Aluminum	mg/L	451%	7265%	21578%
Antimony	mg/L	117%	116%	121%
Arsenic	mg/L	100%	100%	104%
Cadmium	mg/L	150%	300%	136%
Chromium	mg/L	198%	386%	924%
Cobalt	mg/L	300%	236%	247%
Copper	mg/L	153%	165%	201%
Lead	mg/L	214%	300%	300%
Manganese	mg/L	221%	325%	171%
Mercury	mg/L	300%	300%	300%
Molybdenum	mg/L	111%	103%	105%
Nickel	mg/L	113%	127%	155%
Selenium	mg/L	100%	101%	100%
Thallium	mg/L	300%	300%	300%
Uranium	mg/L	106%	104%	105%

Reference: Sample Calculations

A worked example for Exposure Point Concentration of metal in Fish fillet (for arsenic) using the proportioning approach is provided below.

(1) Calculation of Predicted Future Case Metal Concentration (for Arsenic) in Fish Tissue Using Predicted Future Case Arsenic Concentration in Water:

$$EPC_{fish}\left({}^{mg}/_{kg}\right) = EPC_{water}\left({}^{mg}/_{L_{water}}\right) \times UP\left({}^{mg/\,kg}/_{mg/L}\right)$$

Where:

Parameter	Description	Units
EPC $_{fish}$	= Exposure point concentration for metal in fish tissue	mg/kg
EPC $_{water}$	= Exposure point concentration for metal in surface water	mg/L water
UP	= Uptake Factor of metal from surface water to fish tissue	mg/kg tissue / mg/L water

A worked example for the Future Case metal EPC $_{Fish}$ in fish (for arsenic) is provided below.

$$EPC_{fish}\left({}^{mg}/_{kg}\right) = EPC_{water}\left({}^{mg}/_{L_{water}}\right) \times UP\left({}^{mg/\,kg}/_{mg/L}\right)$$

$$EPC_{fish}\left({}^{mg}/_{kg}\right) = 1.59E-03\left({}^{mg}/_{L_{water}}\right) \times 5.0E+01\left({}^{mg/\,kg}/_{mg/L}\right)$$

$$EPC_{fish}\left({}^{mg}/_{kg}\right) = 7.95E-02$$

(2) Calculation of Predicted Baseline Case Metal Concentration in Fish Tissue Using Baseline Case Metal Concentration in Water:

$$EPC_{fish}\left({}^{mg}/_{kg}\right) = EPC_{water}\left({}^{mg}/_{L_{water}}\right) \times UP\left({}^{mg/\,kg}/_{mg/L}\right)$$

Where:

Parameter	Description	Units
EPC $_{fish}$	= Exposure point concentration for metal in fish tissue	mg/kg
EPC $_{water}$	= Predicted exposure point concentration for metal in surface water	mg/L water
UP	= Uptake Factor of metal from surface water to fish tissue	mg/kg tissue / mg/L water

Reference: Sample Calculations

A worked example for Baseline metal EPC $_{Fish}$ in fish tissue (for arsenic) is provided below.

$$EPC_{fish}\left({mg}/{kg}\right) = EPC_{water}\left({mg}/{L_{water}}\right) \times UP\left({mg/\,kg}/{mg/L}\right)$$

$$EPC_{fish}\left({mg}/{kg}\right) = 1.33E-03\left({mg}/{L_{water}}\right) \times 5.0E+01\left({mg/\,kg}/{mg/L}\right)$$

$$EPC_{fish}\left({mg}/{kg}\right) = 6.63E-02$$

(3) Calculation of Expected Magnitude of Change in Metal Concentrations (for Arsenic) in Fish Tissue Based on Predicted Change in Arsenic Concentrations in Water:

$$EMC = \frac{EPC_{\ fish-future}\left({mg}/{kg}\right)}{EPC_{\ fish-baseline}\left({mg}/{kg}\right)}$$

Where:

Parameter	Description	Units
EMC	= Expected Magnitude Change	unitless
EPC $_{fish}$	= Exposure point concentration for metal in fish tissue	mg/kg
EPC $_{water}$	= Predicted exposure point concentration for metal (arsenic used in this example) in surface water	mg/L water

A worked example for metal EMC in fish (for arsenic) is provided below.

$$EMC = \frac{EPC_{\ fish-future}\left({mg}/{kg}\right)}{EPC_{\ fish-baseline}\left({mg}/{kg}\right)}$$

$$EMC = \frac{7.95E-02\left({mg}/{kg}\right)}{6.60E-02\left({mg}/{kg}\right)}$$

$$EMC = 1.20E+00$$

Reference: Sample Calculations

(4) Calculation of Predicted Future Case Arsenic Concentration in Trout Muscle Tissue Based on Measured Baseline Case Metal Concentrations (for Arsenic) and Expected Magnitude Change (Proportioning Approach):

$$EPC_{\ fish}\left({}^{mg}/_{kg}\right) \ = \ EMC \times EPC_{\ fish-baseline}\left({}^{mg}/_{kg}\right)$$

Where:

Parameter	Description	Units
EPC $_{fish}$	= Exposure point concentration for metal in fish tissue	mg/kg
EPC $_{water}$	= Measured exposure point concentration for metal in surface water	mg/L water
EMC	= Expected Magnitude Change	unitless

A worked example for metal EPC $_{fish}$ in fish tissue (for arsenic) is provided below.

$$EPC_{\ fish}\left({}^{mg}/_{kg}\right) \ = \ EMC \times EPC_{\ fish-baseline}\left({}^{mg}/_{kg}\right)$$

$$EPC_{\ fish}\left({}^{mg}/_{kg}\right) \ = \ 1.20E+00 \times 1.44E-02\left({}^{mg}/_{kg}\right)$$

$$EPC_{\ fish}\left({}^{mg}/_{kg}\right) \ = \ 1.73E-02\left({}^{mg}/_{kg}\right)$$

Note: The EPC calculations above were based strictly on fish consumed by humans, specifically the fish filet. Additionally, metal concentrations in whole fish from the Jacko location at baseline were based on a 95% UCL as sufficient data (n=9) were provided, the max concentrations were used for Peterson Creek (n=3) due to the lower availability of data.

A worked example for metal Exposure Point Concentrations in Berries (for arsenic) is provided below.

Calculation of Predicted Future Case Arsenic Concentration in Berries Using Predicted Future Case Arsenic Concentration in Soil:

$$EPC_{berry}\left({}^{mg}/_{kg}\right) = \ EPC_{soil}\left({}^{mg}/_{kg}\right) \times UP\ \left({}^{mg/\,kg}/_{mg/kg}\right) \times CF(1-\ \%\,moisture)$$

Where:

Parameter	Description	Units
EPC $_{berry}$	= Exposure point concentration for metal in berries	mg/kg dw $_{berry}$
EPC $_{soil}$	= Predicted exposure point concentration for metal in soil	mg/kg $_{soil}$
UP	= Uptake Factor from soil to berries	mg/kg / mg/L soil
CF	=Conversion Factor (wet weight to dry weight)	1- % moisture

Reference: Sample Calculations

A worked example for Future Case metal EPC $_{berry}$ in berries (for arsenic) is provided below.

$$EPC_{berry}\left({}^{mg}/_{kg}\right) = EPC_{soil}\left({}^{mg}/_{kg}\right) \times UP\left({}^{mg/\,kg}/_{mg/kg}\right) \times CF\ (\%)$$

$$EPC_{berry}\left({}^{mg}/_{kg}\right) = 5.85E+00\left({}^{mg}/_{kg}\right) \times 1.10E-02\left({}^{mg/\,kg}/_{mg/kg}\right) \times (1 - 82\%\ moisture)$$

$$EPC_{berry}\left({}^{mg}/_{kg}\right) = 1.16E-02$$

A worked example for metal uptake (for chromium) into Deer (similar calculation for wild hare, grouse and cattle) is provided below.

Calculation of the Concentration of Chromium in Deer under Baseline Conditions:

$$A_{deer}\left({}^{mg\ CoC}/_{kg\ fw\ tissue}\right) = \left(\left(F_{forage,browse} \times Qp\left({}^{kg\ dw\ plant}/_{day}\right) \times P_{forage,browse}\left({}^{mg}/_{kg\ dw}\right)\right)\right)$$
$$+\left(\left(Qs\left({}^{kg}/_{day}\right) \times Cs\left({}^{mg\ CoC}/_{kg\ soil}\right) \times Bs\right)\right)$$
$$+\left(Qw\left({}^{L}/_{day}\right) \times F_w \times Cw\left({}^{mg}/_{L}\right) \times Ba_{deer}\left({}^{day}/_{kg\ fw\ tissue}\right) \times MF\right)$$

Where:

Parameter	Description	Units
A_{deer}	CoC concentration in deer	mg CoC / kg FW tissue
F_{forage}	Fraction of forage grown on contaminated soil and ingested by the deer	unitless
F_{browse}	Fraction of browse grown on contaminated soil and ingested by the deer	unitless
Qp	Quantity of plant (forage or browse) eaten by the deer per day	(kg DW plant / day)
P_{forage}	Concentration of CoC in forage eaten by the deer	mg/kg DW
P_{browse}	Concentration of CoC in browse eaten by the deer	mg/kg DW
Q_s	Quantity of soil eaten by the animal (deer) each day	(kg/day)
C_s	Average soil concentration over exposure duration	mg CoC/kg soil
B_s	Soil bioavailability factor	unitless
Q_w	Quantity of water ingested by the deer per day	L/day
F_W	Fraction of water contaminated and ingested by the deer	unitless
C_w	CoC concentration in water (maximum concentration of water taken either Jacko Lake or Peterson Creek at PCO2)	mg/L
Ba_{deer}	CoC biotransfer factor for deer	day/kg FW tissue
MF	Metabolism factor	unitless

A worked example for metal tissue concentration (for chromium) in deer (A deer) is provided below.

$$A_{deer}\left({}^{mg\ CoC}/_{kg\ fw\ tissue}\right) = \left(\left(\left(F_{forage,browse} \times Qp\ \left({}^{kg\ dw\ plant}/_{day}\right)\right.\right.\right.$$
$$\left.\left.\left.\times\ P_{forage,browse}\left({}^{mg}/_{kg\ dw}\right)\right)\right) + \left(\left(Qs\ \left({}^{kg}/_{day}\right) \times Cs\ \left({}^{mg\ CoC}/_{kg\ soil}\right) \times Bs\right)\right)\right.$$
$$\left. + \left(Qw\ \left({}^{L}/_{day}\right) \times F_w \times Cw\left({}^{mg}/_{L}\right) \times Ba_{deer}\left({}^{day}/_{kg\ fw\ tissue}\right) \times MF\right)\right.$$

$$A_{deer}\left({}^{mg\ CoC}/_{kg\ fw\ tissue}\right)$$
$$= \left(6.50E-01\ \times\ 5.48E-01\ \times\ 9.75E-01\ \left({}^{kg\ dw\ plant}/_{day}\right)\right)$$
$$+ \left(3.5E-01\ \times\ 5.91E+00\ \left({}^{mg}/_{kg\ dw}\right) \times\ 9.75E-01\ \left({}^{kg\ dw\ plant}/_{day}\right)\right)$$
$$+ \left(5.0E-02\ \left({}^{kg}/_{day}\right)\ \times\ 6.67E+01\ \left({}^{mg\ CoC}/_{kg\ soil}\right) \times\ 1.0E+00\right)$$
$$+ \left(6.0E+00\ \left({}^{L}/_{day}\right) \times\ 1.0E+00\ \times\ 8.61E-04\ \left({}^{mg}/_{L}\right)\right)$$
$$\times \left(2.89E-03\ \left({}^{day}/_{kg\ fw\ tissue}\right) \times 1.0E+00\right)$$

$$A_{deer}\left(\frac{mg\ Coc}{kg\ FW\ tissue}\right) = 1.73E-02$$

HUMAN HEALTH RISK

Health Risks from Inhalation to all Life Stages

Two worked examples for inhalation non-carcinogenic human health risk (concentration ratio) to all life stages are provided below.

(1) Calculation of Non-Carcinogenic Health Risk for Inhalation (for Sulfur Dioxide 1-hour) at Discrete Receptor 52, the Location of the Maximum Concentration, in Aberdeen (Day Care Future Case):

$$CR = \left(\frac{EPC_{\ future\ case}\left({}^{\mu g}/_{m^3}\right)}{AQC\left({}^{\mu g}/_{m^3}\right)}\right)$$

Where:

Parameter	Description	Units
CR	= Concentration Ratio	dimensionless
$EPC_{future\ case}$	= Exposure point concentration	µg/m³
AQC	= Air Quality Guidelines	µg/m³

A worked example for non-carcinogenic human health risk for inhalation (for sulfur dioxide) to all life stages under the Day Care Future Case is provided below.

$$CR = \left(\frac{EPC_{\ future\ case} \left({}^{\mu g}/_{m^3} \right)}{AQC \left({}^{\mu g}/_{m^3} \right)} \right)$$

$$CR = \left(\frac{1.26E + 01 \left({}^{\mu g}/_{m^3} \right)}{2.0E + 02 \left({}^{\mu g}/_{m^3} \right)} \right)$$

$$CR = 6.30E - 02$$

(2) Calculation of Non-Carcinogenic Health Risk for Inhalation (for Arsenic) at Discrete Receptor 9 in Aberdeen (Future Case):

$$CR = \left(\frac{EPC_{\ future\ case} \left({}^{mg}/_{m^3} \right)}{TRV \left({}^{mg}/_{m^3} \right)} \right)$$

Where:

Parameter	Description	Units
CR	= Concentration Ratio	Dimensionless
$EPC_{future\ case}$	= Exposure point concentration	mg/m³
TRV	= Toxic Reference Value- Reference Concentrations	mg/m³

A worked example for non-carcinogenic human health risks of inhalation (for arsenic) in air under Future Case is provided below.

$$CR = \left(\frac{EPC_{\ future\ case} \left({}^{mg}/_{m^3} \right)}{TRV \left({}^{mg}/_{m^3} \right)} \right)$$

$$CR = \left(\frac{2.94E - 07 \ \left({}^{mg}/_{m^3} \right)}{1.0E - 03 \ \left({}^{mg}/_{m^3} \right)} \right)$$

$$CR = 2.94E - 04$$

A worked example for the calculation of the cancer health risk of inhalation (for arsenic) under $PM_{2.5}$ is provided below.

(1) Calculation of the Lifetime Average Daily Dose from Inhalation (for Arsenic) in Dust under $PM_{2.5}$:

$$LADD_{inhal} \left({}^{mg}/_{m^3} \right) = C_{PM2.5} \left({}^{kg}/_{m^3} \right) \times C_{COC\ in\ dust} \left({}^{mg}/_{kg\ dw} \right) \times \left(\frac{Years_{operation}}{Years_{lifetime}} \right)$$

Where:

Parameter	Description	Units
$LADD_{inhal}$	= Lifetime averaged daily dose (inhalation)	mg/m^3
$C_{PM2.5}$	= Concentration of $PM_{2.5}$ in air	kg/m^3
$C_{COC\ in\ dust}$	= Concentration of CoC in dust	mg/kg dw
$Years_{operation}$	= Years of mine operation (construction through closure)	years
$Years_{lifetime}$	= Lifetime of receptor	years

A worked example for the calculation of the Lifetime Average Daily Dose from Inhalation (for arsenic) under $PM_{2.5}$ is provided below.

$$LADD_{inhal} \left({}^{mg}/_{m^3} \right) = C_{PM2.5} \left({}^{kg}/_{m^3} \right) \times C_{COC\ in\ dust} \left({}^{mg}/_{kg\ dw} \right) \times \left(\frac{Years_{operation}}{Years_{lifetime}} \right)$$

$$LADD_{inhal} \left({}^{mg}/_{m^3} \right) = 1.0E - 11 \left({}^{kg}/_{m^3} \right) \times 2.93E + 01 \left({}^{mg}/_{kg\ dw} \right) \times \left(\frac{2.3E + 01\ years}{8.0E + 01\ years} \right)$$

$$LADD_{inhal} \left({}^{mg}/_{m^3} \right) = 8.44E - 11$$

(2) Calculation of the Incremental Lifetime Cancer Risk from Inhalation (for Arsenic) under $PM_{2.5}$ conditions:

$$ILCR = LADD_{inhal}\left({}^{mg}/_{m^3}\right) \times IUR_{inhal}\left({}^{mg}/_{m^3}\right)$$

Where:

Parameter	Description	Units
ILCR	= Incremental Increase in Lifetime Cancer Risk	unitless
$LADD_{inhal}$	= Lifetime averaged daily dose (inhalation)	mg/m^3
IUR_{inhal}	= Incremental Unit Risk	mg/m^3

A worked example for the Incremental Lifetime Cancer Risk from Inhalation (for arsenic) is provided below:

$$ILCR = LADD_{inhal}\left({}^{mg}/_{m^3}\right) \times IUR_{inhal}\left({}^{mg}/_{m^3}\right)$$
$$ILCR = 8.44E-11 \times 4.30E+00\left({}^{mg}/_{m^3}\right)$$
$$ILCR = 3.63E-10$$

Health Risks from Ingestion of Soil

A worked example of a toddler's total hazard quotient for metal under the Aberdeen (Future Case) is provided below.

(1) Calculation of a Toddler's Chronic Daily Intake of Metal) (for Chromium) from Ingestion of Soil under the Aberdeen (Future Case):

$$CDI_{Ingestion}\left({}^{mg}/_{kg/day}\right) = \frac{C_{soil}\left({}^{mg}/_{kg}\right) \times IR_{soil}\left({}^{kg}/_{day}\right) \times AF_{GIT} \times D_1 \times D_2}{BW(kg)}$$

Where:

Parameter	Description	Units
$CDI_{ingestion}$	= Chronic daily intake from ingestion	mg/kg/day
C_{soil}	= CoC concentration in soil	mg/kg
IR_{soil}	= Soil Ingestion Rate	kg/day
AF_{GIT}	= Absorption Factor from the Gastrointestinal Tract	unitless
D_1	= Days per week exposed/ 7 days	unitless
D_2	= Weeks per year exposed/ 52 weeks	unitless
BW	= Average body weight of receptor	kg

A worked example for a toddler's CDI of metal (for chromium) from ingestion of soil under the Aberdeen (Future Case) is provided below.

$$CDI_{Ingestion}\left({}^{mg}/_{kg/day}\right) = \frac{C_{soil}\left({}^{mg}/_{kg}\right) \times IR_{soil}\left({}^{kg}/_{day}\right) \times AF_{GIT} \times D_1 \times D_2}{BW(kg)}$$

$$CDI_{Ingestion}\left({}^{mg}/_{kg/day}\right) = \frac{4.90E+01\ \left({}^{mg}/_{kg}\right) \times\ 8.0E-05\left({}^{kg}/_{day}\right) x\ 1.0E+00\ \times\ 1.0E+00\ \times\ 1.0E+00}{1.65E+01\ (kg)}$$

$$CDI_{Ingestion}\left({}^{mg}/_{kg/day}\right) = \ 2.38E-04$$

(2) Calculation of a Toddler's Chronic Daily Intake of metal (for Chromium) from Dermal Exposure to Soil under the Aberdeen (Future Case):

$$CDI_{dermal}\left({}^{mg}/_{kg/day}\right) = \frac{C_{soil}\left({}^{mg}/_{kg}\right) \times \left(\left(SA_{hands}\,(cm^2) \times MA_{hands}\left({}^{kg}/_{cm^2}\right)\right) + \left(SA_{\,body}(cm^2) \times MA_{body}\left({}^{kg}/_{cm^2}\right)\right)\right) \times EV\left({}^{events}/_{day}\right) \times AF_{GIT} \times D_1 \times D_2}{BW(kg)}$$

Where:

Parameter	Description	Units
CDI $_{dermal}$	= Chronic daily intake from dermal contact	mg/kg/day
C $_{soil}$	= CoC concentration in soil	mg/kg
SA $_{hands}$	= Skin surface area of hands (cm^2)	cm^2
MA $_{hands}$	= Soil loading of hands	kg/cm^2-event
SA $_{body}$	= Skin surface area of arms and legs	cm^2
MA $_{body}$	= Soil loading of arms and legs	kg/cm^2-event
EV	=Event Frequency	events/day
AF_{GIT}	= Absorption Factor from the Gastrointestinal Tract	unitless
D_1	= 7 days per week exposed/ 7 days	unitless
D_2	= 52 weeks per year exposed/ 52 weeks	unitless
BW	= Average body weight of receptor	kg

A worked example of a toddler's CDI of metal (for chromium) from dermal exposure under Aberdeen (Future Case) is provided below.

Reference: Sample Calculations

$$CDI_{dermal}\left({}^{mg}/_{kg/day}\right) = \frac{C_{soil}\left({}^{mg}/_{kg}\right)\times\left(\left(SA_{hands}\,(cm^2)\times MA_{hands}\left({}^{kg}/_{cm^2}\right)\right)+\left(SA_{\,body}(cm^2)\times MA_{body}\left({}^{kg}/_{cm^2}\right)\right)\right) \times EV\left({}^{events}/_{day}\right)\times AF_{GIT}\times D_1\times D_2}{BW(kg)}$$

$$CDI_{dermal}\left({}^{mg}/_{kg/day}\right) = \frac{4.90E{+}01\left({}^{mg}/_{kg}\right)\times\left(\left(4.30E{+}02(cm^2)\times 1.0E{-}07\left(\frac{kg}{cm^2}\right)\right)+\left(2.58E{+}03(cm^2)\times 1.0E{-}08\left(\frac{kg}{cm^2}\right)\right)\right)\times 1\times 0.1\times 1\times 1}{1.65E{+}01(kg)}$$

$$CDI_{dermal}\left({}^{mg}/_{kg/day}\right) = 2.04E-05$$

(3) Calculation of a Toddler's Total Hazard Quotient of metal (for Chromium) under the Aberdeen (Future Case):

$$HQ_{Total} = \frac{CDI_{Ingestion}\left(\frac{mg}{kg/day}\right) + CDI_{dermal}\left(\frac{mg}{kg/day}\right)}{TRV\left(\frac{mg}{kg/day}\right)}$$

Where:

Parameter	Description	Units
HQ $_{total}$	= Absorption Factor from the Gastrointestinal Tract	unitless
CDI $_{ingestion}$	= Chronic daily intake from ingestion	mg/kg/day
CDI $_{dermal}$	= CoC concentration in soil	mg/kg/day
TRV	= Soil Ingestion Rate	mg/kg/day

A worked example for a toddler's HQ $_{total}$ is provided below.

$$HQ_{Total} = \frac{CDI_{Ingestion}\left({}^{mg}/_{kg/day}\right) + CDI_{dermal}\left({}^{mg}/_{kg/day}\right)}{TRV\left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{Total} = \frac{2.38E-04\left({}^{mg}/_{kg/day}\right) + 2.04E-05\left({}^{mg}/_{kg/day}\right)}{1.5E+00\left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{Total} = 1.72E-04$$

Health Risks from Ingestion of Food

Three worked examples of the health risk associated with the ingestion of food are provided below.

(1) Calculation of the Non-Carcinogenic Human Health Risk for Toddlers from the Ingesting of metal in Deer (for Chromium) (one component of total wild meat ingestion) for Aberdeen (Future Case):

$$HQ_{meat} = \frac{C_{meat}\left({}^{mg}/_{kg}\right) \times\ IR_{meat}\left({}^{mg}/_{kg/day}\right) \times\ AF_{GIT} \times\ D_1 \times D_2 \times\ F_{site}}{BW\ (kg)\ \times TRV\left({}^{mg}/_{kg/day}\right)}$$

Where:

Parameter	Description	Units
HQ_{meat}	Hazard Quotient for Ingestion of Wild Meat	dimensionless
C_{meat}	= CoC concentration in Meat	mg/kg
IR_{meat}	= Deer Meat Ingestion Rate	kg/day
AF_{GIT}	= Absorption Factor from the Gastrointestinal Tract	unitless
D_1	= Days per week exposed/ 7 days	unitless
D_2	= Weeks per year exposed/ 52 weeks	unitless
F_{site}	= Fraction of total meat ingestion from Site	unitless
BW	= Average body weight of receptor	kg
TRV	= Toxicity Reference Value (oral)	mg/kg-bw-day

A worked example for the partial HQ_{meat} derived from the ingestion of metal in deer is provided below.

$$HQ_{meat} = \frac{C_{meat}\left({}^{mg}/_{kg}\right) \times\ IR_{meat}\left({}^{mg}/_{kg/day}\right) \times\ AF_{GIT} \times\ D_1 \times D_2 \times\ F_{site}}{BW\ (kg)\ \times TRV\left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{meat} = \frac{1.74E-02\left({}^{mg}/_{kg}\right) \times\ 6.88E-03\left({}^{mg}/_{kg/day}\right) \times\ 1\ \times\ 1\ \times\ 1 \times\ 1}{1.65E+01\ (kg)\ \times\ 1.50E+00\ \left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{meat} = \ 4.84E-06$$

Reference: Sample Calculations

(2) Calculation of the Non-Carcinogenic Human Health Risk (Hazard Quotient) for Toddlers Exposed to Metals (for Chromium) associated with the ingestion of fish:

$$HQ_{fish} = \frac{C_{fish}\left({}^{mg}/_{kg}\right) \times IR_{fish}\left({}^{mg}/_{kg/day}\right) \times AF_{GIT} \times D_1 \times D_2 \times F_{site}}{BW\ (kg) \times TRV\left({}^{mg}/_{kg/day}\right)}$$

Where:

Parameter	Description	Units
HQ_{fish}	Hazard Quotient for Ingestion of Fish	dimensionless
C_{fish}	= CoC concentration in fish	mg/kg
IR_{fish}	= Fish Ingestion Rate	kg/day
AF_{GIT}	= Absorption Factor from the Gastrointestinal Tract	unitless
D_1	= Days per week exposed/ 7 days	unitless
D_2	= Weeks per year exposed/ 52 weeks	unitless
F_{site}	= Fraction of total fish ingestion from Site	unitless
BW	= Average body weight of receptor	kg
TRV	= Toxicity Reference Value (oral)	mg/kg-bw-day

A worked example for HQ_{fish} is provided below.

$$HQ_{fish} = \frac{C_{fish}\left({}^{mg}/_{kg}\right) \times IR_{fish}\left({}^{mg}/_{kg/day}\right) \times AF_{GIT} \times D_1 \times D_2 \times F_{site}}{BW\ (kg) \times TRV\left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{fish} = \frac{1.92E-01\left({}^{mg}/_{kg}\right) \times 5.60E-03\left({}^{mg}/_{kg/day}\right) \times 1 \times 1 \times 1 \times 1}{1.65E+01\ (kg) \times 1.50E+00\ \left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{fish} = 4.33E-05$$

(3) Calculation of the Non-Carcinogenic Human Health Risk for Toddlers from the Ingesting of Metals (for Chromium) in Fruit for Aberdeen (Future Case):

A worked example of the hazard quotient from the ingestion of metal (for Chromium) in Fruit (garden fruit only) is provided below.

$$HQ_{fruit} = \frac{C_{fruit}\left({}^{mg}/_{kg}\right) \times IR_{fruit}\left({}^{mg}/_{kg/day}\right) \times AF_{GIT} \times D_1 \times D_2 \times F_{site}}{BW\ (kg) \times TRV\left({}^{mg}/_{kg/day}\right)}$$

Where:

Parameter	Description	Units
HQ_{fruit}	Hazard Quotient for Ingestion of fruit	dimensionless
C_{fruit}	= CoC concentration in fruit	mg/kg
IR_{soil}	= Soil Ingestion Rate	kg/day
AF_{GIT}	= Absorption Factor from the Gastrointestinal Tract	unitless
D_1	= Days per week exposed/ 7 days	unitless
D_2	= Weeks per year exposed/ 52 weeks	unitless
F_{site}	= Fraction of total fruit ingestion from Site	unitless
BW	= Average body weight of receptor	kg
TRV	= Toxicity Reference Value (oral)	mg/kg-bw-day

A worked example for HQ_{fruit} is provided below.

$$HQ_{fruit} = \frac{C_{fruit}\left({}^{mg}/_{kg}\right) \times IR_{fruit}\left({}^{mg}/_{kg/day}\right) \times AF_{GIT} \times D_1 \times D_2 \times F_{site}}{BW\ (kg) \times TRV\left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{fruit} = \frac{1.55E-02\left({}^{mg}/_{kg}\right) \times 1.05E-02\left({}^{mg}/_{kg/day}\right) \times 1 \times 1 \times 1 \times 1}{1.65E+01\ (kg) \times 1.50E+00\ \left({}^{mg}/_{kg/day}\right)}$$

$$HQ_{fruit} = 6.60E-06$$

ECOLOGICAL HEALTH RISK

Health Risks to the American Mink exposed to antimony (Peterson Creek-Future Case):

A worked example of the health risk to the American Mink from metals in water (for antimony) under the Peterson Creek Future Case is provided below.

Reference: Sample Calculations

(1) Calculation of the American Mink's Intake Factor of metal from water (for antimony) under the Peterson Creek Future Case:

$$IF\ \left({}^{L}/_{kg\ bw/day}\right) = \frac{IR\ \left({}^{L}/_{day}\right) \times fsite}{BW\ (kg)}$$

Where:

Parameter	Description	Units
IF	= Intake Factor	L/kg body weight/ day
IR	= Water Ingestion Rate	L/day
f_{site}	= Fraction of time American mink spends at the site	unitless
BW	= Average body weight of American mink	kg

A worked example for American Mink's IF (for antimony) is provided below.

$$IF\ \left({}^{L}/_{kg\ bw/day}\right) = \frac{IR\ \left({}^{L}/_{day}\right)\ \times\ fsite}{BW\ (kg)}$$

$$IF\left({}^{L}/_{kg\ bw/day}\right)\ =\ \frac{9.0E-02\ \left({}^{L}/_{day}\right)\ \times 100\%}{8.5E-01\ (kg)}$$

$$IF\left({}^{L}/_{kg\ bw/day}\right)\ =\ 1.10E-01$$

(2) Calculation of the American Mink's Average Daily Dose of metals from water (for antimony) under the Peterson Creek Future Case:

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right)\ =\ IF\ \left({}^{L}/_{kg\ bw/day}\right) \times AF \times\ EPC_{antimony}\left({}^{mg}/_{L_{antimony}}\right)$$

Where:

Parameter	Description	Units
$ADD_{antimony}$	=Average daily dose of antimony from water ingestion	mg/kg body weight/ day
IF	= Intake Factor	L/kg body weight/ day
AF	=Absorption Factor for antimony from the gastrointestinal tract	unitless
$EPC_{antimony}$	=Exposure point concentration for antimony in water	mg/L water

A worked example for American Mink's ADD $_{antimony}$ is provided below.

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = IF\left({}^{L}/_{kg\ bw/day}\right) \times AF \times EPC_{antimony}\left({}^{mg}/_{L_{antimony}}\right)$$

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = 1.10E-01\left({}^{L}/_{kg\ bw/day}\right) \times 1 \times 4.60\ E-04\left({}^{mg}/_{L_{antimony}}\right)$$

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = 4.90E-05$$

(3) Calculation of American Mink's risk from Metals in Water (for antimony):

$$RQ_{water} = \frac{ADD_{antimony}\left({}^{mg}/_{kg/day}\right)}{TRV\left({}^{mg}/_{kg/day}\right)}$$

Where:

Parameter	Description	Units
RQ $_{water}$	= Risk Quotient for water ingestion	unitless
ADD $_{antimony}$	= Average daily dose of antimony from water ingestion	mg/kg/day
TRV	= Oral Toxicity Reference Value	mg/kg/day

A worked example for the American Mink's RQ $_{water}$ (for antimony) is provided below.

$$RQ_{water} = \frac{ADD_{antimony}\left({}^{mg}/_{kg/day}\right)}{TRV\left({}^{mg}/_{kg/day}\right)}$$

$$RQ_{water} = \frac{4.90E-05\left({}^{mg}/_{kg/day}\right)}{4.70E-01\left({}^{mg}/_{kg/day}\right)}$$

$$RQ_{water} = 1.0E-04$$

CALCULATION OF HEALTH RISKS FROM INGESTION OF FISH

A worked example of the health risk to the American Mink (for antimony) from fish under the Peterson Creek Future Case is provided below.

(1) Calculation of the American Mink's Metal Intake Factor (for antimony) from Fish under the Peterson Creek Future Case:

$$IF\ \left({}^{L}/_{kg\ bw/day}\right) = \frac{IR\ \left({}^{L}/_{day}\right) \times fsite}{BW\ (kg)}$$

Where:

Parameter	Description	Units
IF	= Intake Factor	L/kg body weight/ day
IR	= Ingestion Rate	L/day
f_{site}	= Fraction of time American mink spends at the site	unitless
BW	= Average body weight of American mink	kg

A worked example for American Mink's *IF (for antimony) is provided below.*

$$IF\left({}^{L}/_{kg\ bw/day}\right) = \frac{IR\ \left({}^{L}/_{day}\right) \times fsite}{BW\ (kg)}$$

$$IF\ \left({}^{L}/_{kg\ bw/day}\right) = \frac{2.20E-01\ \left({}^{L}/_{day}\right) \times 100\%}{8.5E-01\ (kg)}$$

$$IF\left({}^{L}/_{kg\ bw/day}\right) = 2.60E-01$$

(2) Calculation of the American Mink's Average Daily Dose of metal from fish (for antimony) under the Peterson Creek Future Case:

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = IF \times AF \times EPC_{antimony}\left({}^{mg}/_{L_{antimony}}\right)$$

Where:

Parameter	Description	Units
ADD $_{antimony}$	= Average daily dose of antimony from fish ingestion	dimensionless
IF	= Intake Factor	kg fish/kg body weight/day
AF	= Absorption Factor for antimony from the gastrointestinal tract	unitless
EPC $_{antimony}$	= Exposure point concentration for antimony in fish	mg/L water

Reference: Sample Calculations

A worked example for ADD antimony is provided below.

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = IF \times AF \times EPC_{antimony}\left({}^{mg}/_{L_{antimony}}\right)$$

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = 2.60E-01 \times 1\ x\ 7.20E-03\ _{antimony}\left({}^{mg}/_{L_{antimony}}\right)$$

$$ADD_{antimony}\left({}^{mg}/_{kg\ bw/day}\right) = 1.90E-03$$

(3) Calculation of the Health Risk (Risk Quotient) to the American Mink under the Peterson Creek Future Case:

$$RQ_{fish} = \frac{ADD_{antimony}\left({}^{mg}/_{kg/day}\right)}{TRV\left({}^{mg}/_{kg/day}\right)}$$

Where:

Parameter	Description	Units
RQ water	= Risk Quotient for water ingestion	unitless
ADD antimony	= Average daily dose of antimony from fish ingestion	mg/kg/day
TRV	= Oral Toxicity Reference Value	mg/kg/day

A worked example of RQ fish under the Peterson Creek Future Case.

$$RQ_{fish} = \frac{ADD_{antimony}\left({}^{mg}/_{kg/day}\right)}{TRV\left({}^{mg}/_{kg/day}\right)}$$

$$RQ_{fish} = \frac{1.90E-03\left({}^{mg}/_{kg/day}\right)}{4.70E-01\left({}^{mg}/_{kg/day}\right)}$$

$$RQ_{fish} = 4.0\mathrm{E}-03$$

Reference: Sample Calculations

Conclusion

The sample calculations outlined in this technical memo, in conjunction with the dust deposition calculations provided in the Community-Specific Dustfall Calculations Technical Memo and the Calculation of the Weighted Running Average Concentration for Surface Water under Baseline Conditions Technical Memo provide the information necessary to follow the exposure and risk calculations presented in the Human Health and Ecological Risk Assessment Technical Data Report (Appendix 10.4-A).

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ATTACHMENT A- RECEPTOR CHARACTERISTICS, EXPOSURE FACTORS AND UPTAKE FACTORS FOR THE HHERA.

INTRODUCTION

This attachment includes the human health receptor parameters, human exposure factors and chemical uptake factors adopted in the HHERA. The receptor parameters and exposure factors were used to estimate human health risks associated with ingestion of soil, dermal contact with soil and ingestion of country foods. The uptake factors were used to calculate concentrations in media, which served as inputs to the risk calculations for both human and ecological receptors. The receptor characteristics and exposure factors for ecological receptors are provided in Section 5.1 of Appendix 10.4 and are not reproduced in this attachment.

HUMAN HEALTH RECEPTOR CHARACTERISTICS

The majority of receptor parameters applied in the HHRA for the Residential receptor, the Aboriginal receptor, the Farmer/Rancher receptor and the Recreational receptor are provided in Section 4.1.1 of the Technical Data Report (Appendix 10.4). These parameters have been included and summarized below in Table 1 to Table 5. Table 5 also contains an explanation of the proportioning approach that was used to estimate food ingestion rates for the Aboriginal receptor based on information provided in the First Nations Food and Nutrition and Environment Study by Chan et al. (2011) and in Health Canada (2010).

ATTACHMENT A

Table 1: General Receptor Parameters

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference/Explanation
General Receptor Characteristics							
Age Range	-	0-6 m	7 m - 4 yrs	5 - 11 yrs	12-19 yrs	>20yrs	Health Canada, 2010
Years within an Age Group	years	0.5	4.5	7	8	60	Health Canada, 2010
Body Weight	kg	8.2	16.5	32.9	59.7	70.7	Health Canada, 2010
Soil Ingestion Rate	g/day	0.02	0.08	0.02	0.02	0.02	Health Canada, 2010
Daily Inhalation Rates	m^3/day	2.1	9.3	14.5	15.8	15.8	Health Canada, 2010
Drinking Water Consumption	L/day	0.3	0.6	0.8	1	1.5	Health Canada, 2010
Time Spent Outdoors	hr/day	1.5	1.5	1.5	1.5	1.5	Health Canada, 2010
Skin Surface Area							
Hands	cm^2	320	430	590	800	890	Health Canada, 2010
Upper & Lower Arms	cm^2	550	890	1480	2230	2500	Health Canada, 2010
Upper & Lower Legs	cm^2	910	1690	3070	4970	5720	Health Canada, 2010
Totals	cm^2	1780	3010	5140	8000	9110	Health Canada, 2010
Soil Loading to Skin							
Hands	g/cm^2	1.0E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	Health Canada, 2010
Other Surfaces	g/cm^2	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	Health Canada, 2010
Averaged Loading	g/cm^2	2.6E-05	2.3E-05	2.0E-05	1.9E-05	1.9E-05	Calculated

Table 2: General Food Ingestion Parameters (All Receptors)

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference/Explanation
Fruits and Vegetables							
Root Vegetables	g/day	0	105	161	227	188	Heath Canada (2010)
Local Root Vegetables	g/day	0	10.5	16.1	22.7	18.8	Calculated as 10 % of the intake of root vegetables recommended by Health Canada (2010)
Other Vegetables	g/day	0	67	98	120	137	Health Canada (2010). Based on the full intake for men and women combined
Local Other Vegetables	g/day	0	6.7	9.8	12	13.7	Calculated as 10 % of the intake of other vegetables recommended by Health Canada (2010)
Fruits	g/day	0	234	268	258	247	Richardson (1997)
Local Fruits	g/day	0	23.4	26.8	25.8	24.7	Calculated as 10 % of the intake of fruit recommended by Richardson (1997)

Table-3: Food Ingestion Characteristics for the Residential Receptor

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference/Explanation
Local Cattle							
Meat Ingestion Rate	g/day	0[a]	86	123	170	182	Richardson 1997
Ingestion Rate for Cattle	g/day	0[a]	8.6	12.3	17	18.2	Calculated as 10 % of the total meat ingestion rate recommended by Richardson (1997)
Local Wild Meat							
Ingestion Rate of Wild Meat	g/day	0[a]	8.6	12.3	17	18.2	Calculated as 10 % of the total meat ingestion rate recommended by Richardson (1997)
Wild Meat includes deer, snowshoe hare and grouse. It was assumed that ingestion rates of deer, snowshoe hare and grouse account for 80%, 10% and 10% of the ingestion rate of wild meat, respectively.							
Ingestion Rate of Deer	g/day	0[a]	6.88	9.84	13.6	14.56	Calculated as 80% of the ingestion rate of wild meat.
Ingestion Rate of Snowshoe Hare	g/day	0[a]	0.86	1.23	1.7	1.82	Calculated as 10% of the ingestion rate of wild meat.
Ingestion Rate of Grouse	g/day	0[a]	0.86	1.23	1.7	1.82	Calculated as 10% of the ingestion rate of wild meat.
Local Fish							
Total Fish Intake Rate	g/day	0[a]	56	90	104	111	Health Canada, 2004
Intake Rate of Fish from LSA	g/day	0[a]	5.6	9	10.4	11.1	Calculated as 10% of the total fish intake rate.

Notes:

[a] Humans are only expected to consume milk during the infant life stage

Table 4: Food Ingestion Characteristics for the Farmer/Rancher Receptor

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference/Explanation
Local Cattle							
Meat Ingestion Rate	g/day	0[a]	86	123	170	182	Richardson 1997
Ingestion Rate for Cattle	g/day	0[a]	43	61.5	85	91	Calculated as 50 % of the total meat ingestion rate recommended by Richardson (1997)
Local Wild Meat							
Ingestion Rate of Wild Meat	g/day	0[a]	8.6	12.3	17	18.2	Calculated as 10 % of the total meat ingestion rate recommended by Richardson (1997)
Wild Meat includes deer, snowshoe hare and grouse. It was assumed that ingestion rates of deer, snowshoe hare and grouse account for 80%, 10% and 10% of the ingestion rate of wild meat, respectively.							
Ingestion Rate of Deer	g/day	0[a]	6.88	9.84	13.6	14.56	Calculated as 80% of the ingestion rate of wild meat.
Ingestion Rate of Snowshoe Hare	g/day	0[a]	0.86	1.23	1.7	1.82	Calculated as 10% of the ingestion rate of wild meat.
Ingestion Rate of Grouse	g/day	0[a]	0.86	1.23	1.7	1.82	Calculated as 10% of the ingestion rate of wild meat.
Local Fish							
Total Fish Intake Rate	g/day	0[a]	56	90	104	111	Health Canada, 2004
Intake Rate of Fish from LSA	g/day	0[a]	5.6	9	10.4	11.1	Calculated as 10% of the total fish intake rate.

Notes:
[a] Humans are only expected to consume milk during the infant life stage

Table 5: Food Ingestion Characteristics for the Aboriginal Receptor

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference/Explanation
Local Cattle							
Meat Ingestion Rate	g/day	0[a]	86	123	170	182	Richardson, 1997
Ingestion Rate for Cattle	g/day	0[a]	8.6	12.3	17	18.2	Calculated as 10 % of the total meat ingestion rate recommended by Richardson (1997)
Local Wild Meat							
Ingestion Rate of Wild Meat	g/day	0[a]	85	125	175	270	Health Canada, 2004
Wild Meat includes deer, snowshoe hare and grouse. It was assumed that ingestion rates of deer, snowshoe hare and grouse account for 80%, 10% and 10% of the ingestion rate of wild meat, respectively.							
Ingestion Rate of Deer	g/day	0[a]	68	100	140	216	Calculated as 80% of the ingestion rate of wild meat.
Ingestion Rate of Snowshoe Hare	g/day	0[a]	8.5	12.5	17.5	27	Calculated as 10% of the ingestion rate of wild meat.
Ingestion Rate of Grouse	g/day	0[a]	8.5	12.5	17.5	27	Calculated as 10% of the ingestion rate of wild meat.
Local Fish							
Total Fish Intake Rate	g/day	0[a]	95	170	200	220	Health Canada, 2004
Intake Rate of Fish from LSA	g/day	0[a]	9.5	17	20.0	22.0	Calculated as 10% of the total fish intake rate.
Traditional Plants							
							The intake rate for the adult was based on the mean grams of traditional plants consumed per day by an Aboriginal in

Parameter	Units	Infant	Toddler	Child	Teen	Adult	Reference/Explanation
							Ecozone 3 as presented in Chan (2011). The intake rates for the remaining age groups were calculated by combining the intake rate for an adult from Chan et al. (2011) with the intake rates for other vegetables provided by Health (Canada). The intake rate for a given a group was calculated by adjusting the intake rate for the adult by the ratio of the intake rate of other vegetables for the age group and the intake rate of other vegetables for the adult. The information in Chan et al (2011) was also used to determine that intake of traditional plants is comprised of 80% berries and 20% leafy plants (forage).

EXPOSURE FACTORS

The exposure factors for the Residential receptor, the Farmer/Rancher receptor and the Aboriginal receptor are summarized in Table 6. The exposure factors for the Recreational receptor are provided in Table 7. This Recreational receptor was only evaluated for inhalation exposure.

Table 6: Exposure Averaging Factors for the Residential Receptor, the Aboriginal Receptor and the Farmer/Rancher Receptor.

Time Driven Exposure Factors								
Age Group	**Hours per day on-site**	**Days per Week**	**Weeks per year**	**Total Hours per day**	**Days Per Year Exposed**	**Years Exposed (Out of a total of 80 Years)**	**AF (for non-carcinogenic exposure)**	**AF (for carcinogenic exposure)**
Inhalation								
Infant	24	7	52	24	365	23	1	0.29 (Based on 23 years exposure out of a 80 year lifetime)
Toddler	24	7	52	24	365			
Child	24	7	52	24	365			
Teen	24	7	52	24	365			
Adult	24	7	52	24	365			
Event Driven Exposure Factors								
Age Group	**Hours per day on-site**	**Days per week**	**Weeks per year**	**Total Hours per day**	**Days per year**	**Years**	**AF (for non-carcinogenic exposure)**	**AF (for carcinogenic exposure)**
Soil Ingestion, Dermal Contact with Soil, Drinking Water, Food Ingestion								
Infant	NA	7	52	NA	365	80	1	1
Toddler	NA	7	52	NA	365			
Child	NA	7	52	NA	365			
Teen	NA	7	52	NA	365			
Adult	NA	7	52	NA	365			

Notes:
NA- Not Applicable

Table 7: Exposure Averaging Factors for the Recreational Receptor.

Time Driven Exposure Factors								
Age Group	**Hours per day on-site**	**Days per Week**	**Weeks per year**	**Total Hours per day**	**Days Per Year Exposed**	**Years Exposed (Out of a total of 80 Years)**	**AF (for non-carcinogenic exposure)**	**AF (for carcinogenic exposure)**
Inhalation								
Infant	5	7	52	24	365	80	0.21	NA
Toddler	5	7	52	24	365			
Child	5	7	52	24	365			
Teen	5	7	52	24	365			
Adult	5	7	52	24	365			

Notes:
NA- Not Applicable

UPTAKE FACTORS

The uptake factors used to predict COPC concentrations in the HHERA are provided below. The uptake factors for a given media (e.g., soil to plant uptake factor) are provided in a table followed by an example calculation of the predicted media concentration using the uptake factor. Uptake factors provided below are based on Baseline Case media concentrations. Some uptake factors are based on non-linear uptake equations and are concentration dependent. As a result, the values of these uptake factors may be slightly different under Future Case conditions.

SOIL TO PLANT UPTAKE FACTORS

Table 8: Soil to Plant Uptake Factors (Baseline Case)

COPC	Baseline Soil Conc. (mg/kg)	Uptake Factor: Soil to Plant (mg/kg-dry plant/ mg/kg-dry soil)	Reference	Soil to Plant Bioavailability Factor (Unitless)	Plant Metabolic Factor (Unitless)	Terrestrial Plant Dry Weight to Wet Weight Conversion Factor	UF: Soil to Plant Uptake Factor (mg/kg-wet plant/ mg/kg-dry soil)
Aluminum	1.9E+04	1.6E-03	Geometric mean, various sources	1.0E+00[b]	1.0E+00[b]	0.15	2.4E-04
Antimony	4.7E-01	3.9E-02[a]	US EPA (2007)	1.0E+00[b]	1.0E+00[b]	0.15	5.9E-03
Arsenic	5.9E+00	3.8E-02	Bechtel Jacobs (1998), in US EPA (2007)	1.0E+00[b]	1.0E+00[b]	0.15	5.6E-03
Chromium	6.7E+01	4.1E-02	Bechtel Jacobs (1998), in US EPA Eco-SSL (2007)	1.0E+00[b]	1.0E+00[b]	0.15	6.2E-03
Cobalt	1.6E+01	7.5E-03	Bechtel Jacobs (1998), in US EPA Eco-SSL (2005a)	1.0E+00[b]	1.0E+00[b]	0.15	1.1E-03
Copper	9.2E+01	1.3E-01[a]	Bechtel Jacobs (1998)	1.0E+00[b]	1.0E+00[b]	0.15	1.9E-02
Lead	5.2E+00	1.3E-01[a]	Bechtel Jacobs (1998), in US EPA (2007)	1.0E+00[b]	1.0E+00[b]	0.15	1.9E-02
Manganese	8.0E+02	7.9E-02	US EPA Eco-SSL (2007)	1.0E+00[b]	1.0E+00[b]	0.15	1.2E-02

COPC	Baseline Soil Conc. (mg/kg)	Uptake Factor: Soil to Plant (mg/kg-dry plant/ mg/kg-dry soil)	Reference	Soil to Plant Bioavailability Factor (Unitless)	Plant Metabolic Factor (Unitless)	Terrestrial Plant Dry Weight to Wet Weight Conversion Factor	UF: Soil to Plant Uptake Factor (mg/kg-wet plant/ mg/kg-dry soil)
Mercury	4.5E-02	1.5E+00[a]	Bechtel Jacobs (1998)	1.0E+00[b]	1.0E+00[b]	0.15	2.3E-01
Molybdenum	1.1E+00	2.4E-01	Geometric mean, various sources	1.0E+00[b]	1.0E+00[b]	0.15	3.6E-02
Nickel	5.8E+01	3.9E-02[a]	Bechtel Jacobs (1998)	1.0E+00[b]	1.0E+00[b]	0.15	5.8E-03
Selenium	4.1E-01	4.6E-01[a]	Bechtel Jacobs (1998)	1.0E+00[b]	1.0E+00[b]	0.15	6.9E-02
Thallium	8.7E-02	2.5E-03	Geometric mean, various sources	1.0E+00[b]	1.0E+00[b]	0.15	3.7E-04
Uranium	5.3E-01	1.8E-02[a]	Sheppard and Evenden (1988)	1.0E+00[b]	1.0E+00[b]	0.15	2.7E-03

Notes:

a Dependent on soil concentration (mg/kg) and a non-linear relationship.

b Conservative default.

SAMPLE CALCULATION FOR SOIL TO PLANT UPTAKE FACTOR FOR ANTIMONY

$$UF = UP_{SP} \times BA_{SP} \times MF_P \times CF$$

Where:

UP_{SP} = Soil to plant uptake factor dry weight (mg/kg-dry plant/ mg/kg-dry soil)

BA_{SP} = Soil to plant bioavailability factor (set at 1.0; unitless)

MF_P = Plant metabolic factor (set at 1.0; unitless)

CF = Terrestrial plant dry weight to wet weight conversion factor

UF = Soil to plant uptake factor wet weight (mg/kg-wet plant/ mg/kg-dry soil)

Values:

UP_{SP} = 3.9E-02 mg/kg-dry plant/ mg/kg-dry soil

BA_{SP} = 1 (unitless)

MF_P = 1 (unitless)

CF = 0.15

UF = 5.9E-03mg/kg-wet plant/ mg/kg-dry soil for Antimony

SOIL TO INVERTEBRATE UPTAKE FACTORS

Table 9: Soil to Invertebrate Uptake Factors (Baseline Case)

COPC	Baseline Soil Conc. (mg/kg)	Uptake Factor: Soil to Plant (mg/kg-dry plant/ mg/kg-dry soil)	Reference	Soil to Invertebrate Bioavailability Factor (Unitless)	Soil Invertebrate Metabolic Factor (Unitless)	Earthworm Dry Weight to Wet Weight Conversion Factor	UF: Soil to Invertebrate Uptake Factor (mg/kg-wet tissue/ mg/kg-dry soil)
Aluminum	1.9E+04	4.3E-02	Sample et al. (1998a), App A, Table C1	1.0E+00[b]	1.0E+00[b]	0.16	6.9E-03
Antimony	4.7E-01	1.0E+00	Conservative Default - US EPA (2005b)	1.0E+00[b]	1.0E+00[b]	0.16	1.6E-01
Arsenic	5.9E+00	1.4E-01[a]	Sample et al. (1998a) - Table 12	1.0E+00[b]	1.0E+00[b]	0.16	2.3E-02
Chromium	6.7E+01	3.1E-01	Sample et al. (1998a) - Table 11	1.0E+00[b]	1.0E+00[b]	0.16	4.9E-02
Cobalt	1.6E+01	1.2E-01	Sample et al. (1998a), App A, Table C1	1.0E+00[b]	1.0E+00[b]	0.16	2.0E-02
Copper	9.2E+01	1.9E-01[a]	Sample et al. (1998a) - Table 12	1.0E+00[b]	1.0E+00[b]	0.16	3.1E-02
Lead	5.2E+00	5.8E-01[a]	Sample et al. (1998a) - Table 12	1.0E+00[b]	1.0E+00[b]	0.16	9.4E-02
Manganese	8.0E+02	5.3E-02[a]	Sample et al. (1998a) - Table 12	1.0E+00[b]	1.0E+00[b]	0.16	8.5E-03
Mercury	4.5E-02	1.7E+00	Sample et al. (1998a) - Table 11	1.0E+00[b]	1.0E+00[b]	0.16	2.7E-01
Molybdenum	1.1E+00	9.5E-01	Sample et al. (1998a), App A, Table C1	1.0E+00[b]	1.0E+00[b]	0.16	1.5E-01
Nickel	5.8E+01	1.1E+00	Sample et al. (1998a) - Table 11	1.0E+00[b]	1.0E+00[b]	0.16	1.7E-01
Selenium	4.1E-01	9.9E-01	Sample et al. (1998a) - Table 11	1.0E+00[b]	1.0E+00[b]	0.16	1.6E-01

COPC	Baseline Soil Conc. (mg/kg)	Uptake Factor: Soil to Plant (mg/kg-dry plant/ mg/kg-dry soil)	Reference	Soil to Invertebrate Bioavailability Factor (Unitless)	Soil Invertebrate Metabolic Factor (Unitless)	Earthworm Dry Weight to Wet Weight Conversion Factor	UF: Soil to Invertebrate Uptake Factor (mg/kg-wet tissue/ mg/kg-dry soil)
Thallium	8.7E-02	4.7E-02	Jacques Whitford Limited (2008)	1.0E+00[b]	1.0E+00[b]	0.16	7.5E-03
Uranium	5.3E-01	3.3E-02	Sample et al. (1998a), App A, Table C1	1.0E+00[b]	1.0E+00[b]	0.16	5.3E-03

Notes:

[a] Dependent on soil concentration (mg/kg), non-linear relationship.

[b] Conservative default.

SAMPLE CALCULATION FOR SOIL TO INVERTEBRATE UPTAKE FACTOR FOR ANTIMONY

$$UF = UP_{SI} \times BA_{SI} \times MF_I \times CF_I$$

Where:

UP_{SI} = Soil to Invertebrate uptake factor of dry tissue in dry soil (mg/kg-dry tissue/ mg/kg-dry soil)

BA_{SI} = Soil to invertebrate bioavailability factor (Set at 1; unitless)

MF_I = Soil invertebrate metabolic factor (set at 1; unitless)

CF_I = Earthworm dry weight to wet weight conversion factor

UF = Soil to invertebrate uptake factor of wet tissue in dry soil (mg/kg-wet tissue/ mg/kg-dry soil)

Values:

UP_{SI} = 1.0E+00 mg/kg-dry tissue/ mg/kg-dry soil)

BA_{SI} = 1.0E+00 (Unitless)

MF_I = 1.0E+00 (Unitless)

CF_I = 0.16

UF = 1.6E-01(mg/kg-wet tissue/ mg/kg-dry soil)

SOIL TO ANIMAL UPTAKE FACTORS

Table 10: Soil to Animal Uptake Factors (Baseline Case)

COPC	Baseline Soil Conc. (mg/kg)	Uptake Factor: Soil to Animal (mg/kg-dry animal/ mg/kg-dry soil)	Uptake Factor Reference	Dry Animal Weight to Wet Animal Weight Conversion Factor	Soil to Animal Uptake Factor (mg/kg-wet tissue/ mg/kg-dry soil)
Aluminum	1.9E+04	2.6E-02	Sample et al. (1998b) - Table C1	0.32	8.4E-03
Antimony	4.7E-01	2.0E-03[a]	US EPA Eco SSL 2005b: assumes diet of 100% plants	0.32	6.3E-04
Arsenic	5.9E+00	5.7E-03[b]	Sample et al. (1998b) - Table 8	0.32	1.8E-03
Chromium	6.7E+01	7.6E-02[b]	Sample et al. (1998b) - Table 8	0.32	2.4E-02
Cobalt	1.6E+01	2.7E-02[b]	Sample et al. (1998b) - Table 8	0.32	8.6E-03
Copper	9.2E+01	1.6E-01[b]	Sample et al. (1998b) - Table 8	0.32	5.2E-02
Lead	5.2E+00	3.4E-01[b]	Sample et al. (1998b) - Table 8	0.32	1.1E-01
Manganese	8.0E+02	2.1E-02	US EPA Eco-SSL (2007)	0.32	6.6E-03
Mercury	4.5E-02	1.2E-01	Sample et al. (1998b) - Table 7	0.32	4.0E-02
Molybdenum	1.1E+00	2.2E-01	Jacques Whitford Limited (2008)	0.32	7.0E-02
Nickel	5.8E+01[b]	8.9E-02	Sample et al. (1998b) - Table 8	0.32	2.9E-02

COPC	Baseline Soil Conc. (mg/kg)	Uptake Factor: Soil to Animal (mg/kg-dry animal/ mg/kg-dry soil)	Uptake Factor Reference	Dry Animal Weight to Wet Animal Weight Conversion Factor	Soil to Animal Uptake Factor (mg/kg-wet tissue/ mg/kg-dry soil)
Selenium	4.1E-01[b]	1.1E+00	Sample et al. (1998b) - Table 8	0.32	3.7E-01
Thallium	8.7E-02	1.1E-01	Sample et al. (1998b) - Table 7	0.32	3.6E-02
Uranium	5.3E-01	2.3E-03	Jacques Whitford Limited (2008)	0.32	7.4E-04

Notes:

[a] Calculated as 0.05 multiplied by the soil to plant bioavailability factor.

[b] Dependent on soil concentration (mg/kg), non-linear relationship.

SAMPLE CALCULATION FOR SOIL TO ANIMAL UPTAKE VALUE FOR ANTIMONY

$$UF = UP_{SA} \times CF_A$$

Where:

UP_{SA} = Uptake factor for soil to dry animal (mg/kg-dry animal/ mg/kg-dry soil)

CF_A = Conversion factor dry animal weight to wet animal weight

UF = Uptake factor for soil to wet animal tissue (mg/kg-wet tissue/ mg/kg-dry soil)

Values:

UP_{SA} = 2.0E-03 mg/kg-dry animal/ mg/kg-dry soil

CF_A = 0.32

UF = 6.3E-04 mg/kg-wet tissue/ mg/kg-dry soil

FRESHWATER SEDIMENT TO AQUATIC PLANT UPTAKE FACTOR

Table 11: Freshwater Sediment to Aquatic Plant Uptake Factor (Baseline Case-Petersen Creek)

COPC	Sediment Conc. (mg/kg)	Aquatic Plant Dry Weight to Wet Weight Conversion Factor	Uptake factor Soil to Plant[a]	Freshwater Sediment to Aquatic Plant Uptake Factor (mg/kg-wet tissue/ mg/kg-dry sed)	Uptake Factor Reference
Aluminum	1.3E+04	0.13	1.6E-03	2.1E-04	See reference for soil to plant uptake factors (Table 8)
Antimony	3.4E-01	0.13	3.9E-02	5.1E-03	See reference for soil to plant uptake factors (Table 8)
Arsenic	4.5E+00	0.13	3.8E-02	4.9E-03	Bechtel Jacobs (1998), in US EPA EcoSSL (2005c)
Chromium	1.2E+02	0.13	4.1E-02	5.3E-03	Bechtel Jacobs (1998), in US EPA Eco-SSL (2005c)
Cobalt	1.4E+01	0.13	7.5E-03	9.8E-04	See reference for soil to plant uptake factors (Table 8)
Copper	5.7E+01	0.13	NA	2.2E-02[a]	Bechtel Jacobs (1998)
Lead	4.9E+00	0.13	NA	1.7E-02[a]	Bechtel Jacobs (1998)
Manganese	9.6E+02	0.13	7.9E-02	1.0E-02	US EPA Eco-SSL (2007)
Mercury	6.3E-02	0.13	NA	1.7E-01[a]	Bechtel Jacobs (1998)
Molybdenum	1.7E+00	0.13	2.4E-01	3.1E-02	See reference for soil to plant uptake factors (Table 8)
Nickel	7.4E+01	0.13	NA	4.8E-03[a]	Bechtel Jacobs (1998)

COPC	Sediment Conc. (mg/kg)	Aquatic Plant Dry Weight to Wet Weight Conversion Factor	Uptake factor Soil to Plant[a]	Freshwater Sediment to Aquatic Plant Uptake Factor (mg/kg-wet tissue/ mg/kg-dry sed)	Uptake Factor Reference
Selenium	7.3E-01	0.13	NA	6.4E-02[a]	Bechtel Jacobs (1998)
Thallium[a]	6.3E-02	0.13	2.5E-03	3.2E-04	See reference for soil to plant uptake factors (Table 8)
Uranium[a]	1.1E+00	0.13	1.8E-02	2.4E-03	See reference for soil to plant uptake factors (Table 8)

Notes:

a Non-linear relationship dependent on sediment concentration

NA Not Applicable. Uptake factor from soil to plant was not used to calculate the freshwater sediment to aquatic plants uptake factor. Sediment to aquatic plant uptake factor was calculated using an equation from literature.

SAMPLE CALCULATION FOR FRESHWATER SEDIMENT TO AQUATIC PLANT UPTAKE FACTOR FOR ANTIMONY

$$UF = UP_{SP} \times BA_{SP} \times MF_P \times CF$$

Where:

UP_{SP} = Dry soil to plant uptake factor dry weight (mg/kg-dry plant/ mg/kg-dry soil)

BA_{SP} = Soil to plant bioavailability factor (set at 1.0; unitless)

MF_P = Plant metabolic factor (set at 1.0; unitless)

CF = Aquatic plant dry weight to wet weight conversion factor

UF = Dry sediment to aquatic plant uptake factor wet weight (mg/kg-wet plant/ mg/kg-dry sediment)

Values:

UP_{SP} = 3.9E-02 mg/kg-dry plant/ mg/kg-dry soil

BA_{SP} = 1 (unitless)

MF_P = 1 (unitless)

CF = 0.13

UF = 5.1E-03mg/kg-wet plant/ mg/kg-dry sediment for Antimony

FRESHWATER SEDIMENT TO BENTHIC INVERTEBRATE UPTAKE FACTOR

Table 12: Freshwater Sediment to Benthic Invertebrate Uptake Factor (Baseline Case-Petersen Creek)

COPC	Sediment Conc. (mg/kg)	Freshwater Sediment to Benthic Invertebrate Uptake Factor (mg/kg-dry tissue/ mg/kg-dry sed)	Invertebrate Dry Weight to Wet Weight Conversion Factor	Freshwater Sediment to Benthic Invertebrate Uptake Factor (mg/kg-wet tissue/ mg/kg-dry sed)	Uptake Factor Reference
Aluminum	1.3E+04	1.9E-01	0.24	4.6E-02	Modified from Hamilton et al. 2002
Antimony[a]	3.4E-01	3.0E-02	0.24	7.2E-03	Modified from Haus et al. 2007
Arsenic	4.5E+00	NA	0.24	3.5E-01[a]	ORNL 1998 (all data)
Chromium[b]	1.2E+02	NA	0.24	7.7E-02[a]	ORNL 1998 (all data)
Cobalt[a]	1.4E+01	1E-02	0.24	2.4E-03	Garn et al. 2001
Copper	5.7E+01	NA	0.24	8.2E-01[a]	ORNL 1998 (Non-depurated data)
Lead	4.9E+00	NA	0.24	1.1E-01[a]	ORNL 1998 (all data)
Manganese[b]	9.6E+02	6.3E-01	0.24	1.5E-01	Modified from Hamilton et al. 2002 and Garn et al. 2001
Mercury	6.3E-02	5.1E-01	0.24	1.2E-01	Modified from multiple sources
Molybdenum	1.7E+00	2.2E+00	0.24	5.2E-01	Modified from Hamilton et al. 2002 and Garn et al. 2001
Nickel	7.4E+01	NA	0.24	9.8E-02[a]	ORNL 1998 (Depurated data)
Selenium	7.3E-01	NA	0.24	1.7E+00[a]	Compiled from Orr et al. 2006 and Saiki et al. 1993

COPC	Sediment Conc. (mg/kg)	Freshwater Sediment to Benthic Invertebrate Uptake Factor (mg/kg-dry tissue/ mg/kg-dry sed)	Invertebrate Dry Weight to Wet Weight Conversion Factor	Freshwater Sediment to Benthic Invertebrate Uptake Factor (mg/kg-wet tissue/ mg/kg-dry sed)	Uptake Factor Reference
Thallium[a]	6.3E-02	NA	0.24	1.1E-01	'No data available - Uptake assumed similar to Lead
Uranium[a]	1.1E+00	7.0E-02	0.24	2.0E-02	Garn et al. 2001

Notes:

[a] Non-linear relationship dependent on sediment concentration

NA Not Applicable. Uptake factor from sediment (wet weight) is based on an equation rather than a simple dry weight uptake factor adjusted by the moisture content of invertebrates.

SAMPLE CALCULATION FOR FRESHWATER SEDIMENT TO BENTHIC INVERTEBRATE UPTAKE FACTOR FOR ANTIMONY

$$UF = UP_{SI} \times CF_I$$

Where:

UP_{SI} = Sediment to Invertebrate Uptake Factor of dry tissue in dry sediment (mg/kg-dry tissue/ mg/kg-dry soil)

CF_I = Benthic Invert dry weight to wet weight conversion factor

UF = Sediment to benthic invertebrate uptake factor of wet tissue in dry sed (mg/kg-wet tissue/ mg/kg-dry soil)

Values:

UP_{SI} = 3.0E-02 mg/kg-dry tissue/ mg/kg-dry sediment)

CF_I = 0.24

UF = 7.2E-03(mg/kg-wet tissue/ mg/kg-dry sediment)

SURFACE WATER TO FRESHWATER FISH UPTAKE FACTOR

Table 13: Surface Water to Freshwater Fish Uptake Factor (Baseline Case-Petersen Creek)

COPC	Surface Water Conc. Dissolved (mg/L)	Surface Water to Freshwater Fish Uptake Factor (mg/kg-wet tissue/ mg/L-water)	Uptake Factor Reference
Aluminum	6.7E-03	2.8E+01	Empirical measurements of Fish Tissue[b]
Antimony[a]	3.8E-04	2.0E+02	Canadian Standards Association 1987
Arsenic	2.8E-03	5.0E+01	Based on Trophic Level 3 fish (upper end of range of 19 to 96) from: US EPA. 2003. Technical summary of information available on the bioaccumulation of arsenic in aquatic organisms. Report No. EPA-822-R-03-032 and Lijzen et al. 2001.
Chromium	5.0E-04	2.0E+02	Canadian Standards Association 1987 and Lijzen et al. 2001
Cobalt	3.6E-04	1.0E+02	Canadian Standards Association 1987
Copper	3.7E-03	5.1E+02[a]	McGeer et al. 2003 (Salmonids)
Lead	7.4E-05	4.7E+02[a]	McGeer et al. 2003
Manganese[b]	2.0E-01	3.4E+01	Based on upper end of range of 18 to 34.3 from Nussey et al. 1999
Mercury	1.0E-05	7.2E+02[a]	McGeer et al. 2003
Molybdenum	2.0E-02	1.0E+02	Canadian Standards Association 1987
Nickel	4.4E-03	1.8E+02[a]	McGeer et al. 2003
Selenium	1.2E-03	1.7E+02	Davis et al. 1993

COPC	Surface Water Conc. Dissolved (mg/L)	Surface Water to Freshwater Fish Uptake Factor (mg/kg-wet tissue/ mg/L-water)	Uptake Factor Reference
Thallium[a]	1.1E-05	2.9E+03	Sheppard et al. 2010
Uranium[a]	3.8E-03	5.0E+01	Davis et al. 1993

Notes:

[a] Non-linear relationship dependent on sediment concentration

[b] Empirical values are based on measured data from North Pond, Muggah Creek (JDAC 2002)

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