APPENDIX O

EHQ Derivation: Worked Example

Table of Contents

1.0 INTRODUCTION

This appendix serves to assist the reader in understanding how the quantitative ERA was conducted by providing example calculations using empirical baseline data. A worked example will progress from the exposure assessment (environmental concentrations that an ecological receptor is expected to encounter) through to the ecological risk characterization stage (estimation of risk from all environmental concentrations).

This example focuses on muskrat exposure to baseline environmental beryllium. The muskrat is an ideal VEC for this example because it consumes nearly all environmental media assessed in the ERA.

2.0 BERYLLIUM EXPOSURE TO THE MUSKRAT

2.1 ESTIMATION OF AVERAGE DAILY DOSES

To quantify the potential risk to the muskrat ecological receptor as a result of existing beryllium (Be) concentrations, an estimated average daily dose (ADD) from each applicable exposure pathway was first estimated as defined below:

$$ADD_j = IF_j \times AF_j \times EPC_j$$

For exposure pathway ‘j‘,

where:	ADD_j	Average Daily Dose of COPC from media j (mg COPC/kg body weight - day)
	IF_j	Intake Factor for media j (kg contaminated medium/kg body weight - day)
	AF_j	Absorption Factor of media j (default value of 1), and
	EPC_j	Exposure Point Concentration of media j (mg chemical/kg medium)

And:

$$IF_j = (IR_j \times f_{site})/BW$$

where:	IF_j	Intake Factor for media j (kg contaminated medium/kg body weight - day)
	IR_j	Ingestion Rate of media j (kg or L/day)
	f_{site}	Fraction of time spent on site (dimensionless, assumed 100% for muskrat), and
	BW	Body Weight of ecological receptor (in kg)

Intake factors (IF) for all ecological receptors for all applicable exposure pathways are presented in Appendix L. Life history traits for the muskrat are summarized in the table below:

General Parameters		
Body weight (BW)	1.17	kg
Food intake rate	1.2E-01	kg wet-wt/day
Water intake rate	1.1E-01	L/day
Ingestion of Soil		
Fraction diet that is dry solid	2.75E-01	
Fraction of food intake rate	3.01E-03	
Ingestion rate	9.93E-05	kg dry-wt/day
Intake factor (IFing-sl)	8.49E-05	kg/kg-day
Ingestion of Terrestrial Plants		
Fraction of food intake rate	1.25E-01	
Ingestion rate	1.50E-02	kg wet-wt/day
Intake factor (IFing-tp)	1.28E-02	kg/kg-day
Ingestion of Terrestrial Mammals/Birds		
Fraction of food intake rate	2.50E-02	
Ingestion rate	3.00E-03	kg wet-wt/day
Intake factor (IFing-tm)	2.56E-03	kg/kg-day
Ingestion of Surface Water		
Ingestion rate	1.10E-01	L/day
Intake factor (IFing-sw)	9.40E-02	L/kg-day
Ingestion of Freshwater Sediment		
Fraction diet that is dry solid	2.75E-01	
Fraction of food intake rate	6.22E-02	
Ingestion rate	2.05E-03	kg dry-wt/day
Intake factor (IFing-sed)	1.75E-03	kg/kg-day
Ingestion of Freshwater Aquatic Plants		
Fraction of food intake rate	8.00E-01	
Ingestion rate	9.60E-02	kg wet-wt/day
Intake factor (IFing-ap)	8.21E-02	kg/kg-day
Ingestion of Freshwater Benthic Invertebrates		
Fraction of food intake rate	2.50E-02	
Ingestion rate	3.00E-03	kg wet-wt/day
Intake factor (IFing-ai)	2.56E-03	kg/kg-day
Ingestion of Freshwater Fish		
Fraction of food intake rate	2.50E-02	
Ingestion rate	3.00E-03	kg wet-wt/day
Intake factor (IFing-fsh)	2.56E-03	kg/kg-day

Baseline EPCs used in the assessment of beryllium risk to the muskrat receptor are as follows:

Exposure Pathway	EPC
Soil	0.7 mg (Be) / kg dry weight soil
Terrestrial Plant	0.1 mg (Be) / kg wet weight terrestrial plant material
Terrestrial Mammal	0.1 mg (Be) / kg wet weight mammal
Surface Water	0.001 mg (Be) / L water
Freshwater Sediment	0.5 mg (Be) / kg dry weight sediment
Aquatic Plant	0.0457 mg (Be) / kg wet weight aquatic plant material
Aquatic Invertebrate	0.0661 mg (Be) / kg wet weight aquatic invertebrate
Freshwater Fish	0.1 mg (Be) / kg wet weight fish

Estimation of beryllium ADDs for all exposure pathways applicable to the muskrat are outlined below:

$ADD_{soil} = IF_{soil} \times AF_{soil} \times EPC_{soil}$

$ADD_{soil} = (8.49x10^{-5}) \times (1) \times (0.7)$

$ADD_{soil} = 5.94x10^{-5}$ mg/kg-bw-day

$ADD_{terrestrial\ plant} = IF_{terrestrial\ plant} \times AF_{terrestrial\ plant} \times EPC_{terrestrial\ plant}$

$ADD_{terrestrial\ plant} = (0.0128) \times (1) \times (0.1)$

$ADD_{terrestrial\ plant} = 1.28x10^{-3}$ mg/kg-bw-day

$ADD_{terrestrial\ mammal} = IF_{terrestrial\ mammal} \times AF_{terrestrial\ mammal} \times EPC_{terrestrial\ mammal}$

$ADD_{terrestrial\ mammal} = (2.56\ x10^{-3}) \times (1) \times (0.1)$

$ADD_{terrestrial\ mammal} = 2.56x10^{-4}$ mg/kg-bw-day

$ADD_{surface\ water} = IF_{surface\ water} \times AF_{surface\ water} \times EPC_{surface\ water}$

$ADD_{surface\ water} = (0.094) \times (1) \times (0.001)$

$ADD_{surface\ water} = 9.40x10^{-5}$ mg/kg-bw-day

$ADD_{freshwater\ sediment} = IF_{freshwater\ sediment} \times AF_{freshwater\ sediment} \times EPC_{freshwater\ sediment}$

$ADD_{freshwater\ sediment} = (1.75x10^{-3}) \times (1) \times (0.5)$

$ADD_{freshwater\ sediment} = 8.75x10^{-4}$ mg/kg-bw-day

$ADD_{aquatic\ plant} = IF_{aquatic\ plant} \times AF_{aquatic\ plant} \times EPC_{aquatic\ plant}$

$ADD_{aquatic\ plant} = (8.21x10^{-2}) \times (1) \times (0.0457)$

$ADD_{aquatic\ plant} = 3.75x10^{-3}$ mg/kg-bw-day

$ADD_{aquatic\ invertebrate} = IF_{aquatic\ invertebrate} \times AF_{aquatic\ invertebrate} \times EPC_{aquatic\ invertebrate}$

$ADD_{aquatic\ invertebrate} = (2.56x10^{-3}) \times (1) \times (0.0661)$

$ADD_{aquatic\ invertebrate} = 1.70x10^{-4}$ mg/kg-bw-day

$ADD_{freshwater\ fish} = IF_{freshwater\ fish} \times AF_{freshwater\ fish} \times EPC_{freshwater\ fish}$

$ADD_{freshwater\ fish} = (2.56x10^{-3}) \times (1) \times (0.1)$

$ADD_{freshwater\ fish} = 2.56x10^{-4}$ mg/kg-bw-day

To estimate the total beryllium ADD from all exposure pathways (*i.e.*, the total daily amount of beryllium the muskrat would be expected to ingest as a result of all sources (dietary items plus associated beryllium in soil, sediment, and surface water), a simple summation of each pathway ADD is performed:

$$ADD_{total} = (5.94x10^{-5}) + (1.28x10^{-3}) + (2.56x10^{-4}) + (9.40x10^{-5}) + (8.75x10^{-4}) + (3.75x10^{-3}) + (1.70x10^{-4}) + (2.56x10^{-4})$$

$$ADD_{total} = 6.74x10^{-3} \text{ mg/kg-bw-day}$$

2.2 ESTIMATION OF ECOLOGICAL HAZARD QUOTIENT

In the final step of risk characterization, the total average daily dose is compared against the Toxicity Reference Value (TRV) for beryllium exposure to mammalian receptors in order to estimate an Ecological Hazard Quotient (EHQ). In this assessment, a beryllium TRV of 0.532 mg/kg-bw/day was utilized, based on chronic toxicity studies on rats (Appendix J). After applying body scaling to account for differences between the test species (rat), and the muskrat, a revised TRV of 0.393 mg/kg-bw/day was derived. Note that this TRV is lower (*i.e.* more conservative) than the experimentally derived TRV, based on the assumption that larger animals will metabolize COPC less rapidly than smaller animals. Discussion of TRVs used in this assessment and rationale for the application of body scaling factors is provided in Appendix J.

Estimation of an EHQ for the muskrat exposed to beryllium is thus:

$$EHQ_{Beryllium} = ADD_{total} / TRV_{Beryllium}$$

$$EHQ_{Beryllium} = 6.74x10^{-3} \text{ mg/kg-bw-day} / 0.393 \text{ mg/kg-bw-day}$$

$$EHQ_{Beryllium} = 0.017$$

Alternatively, each pathway specific ADD may be compared against the TRV to derive a pathway specific EHQ. Each individual EHQ may then be summed to arrive at a final EHQ, which would be identical to that derived via the methods described above.