Appendix 12-F

Response to Information Request on Fish Health Effects Associated with Bioaccumulative Substances

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Our Reference
60590462

Karyn Lewis
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Sent by Email

Response to Information Request on Fish Health Effects Associated with Bioaccumulative Substances

Dear Ms. Lewis,

Subsequent to the submission of the Crown Mountain Environmental Assessment documents to the regulatory review panel, a specific information request relative to the Fish Health Assessment chapter of the was received. AECOM was not the originator of the Fish Health chapter of the EA, but the authors of the Fish Health chapter based their assessment in part on information presented in the Human Health and Ecological Risk Assessment (HHERA) conducted by AECOM. AECOM Canada Ltd. was subsequently contracted by NWP Coal Canada to address the information request associated with potential effects to fish health as a result of bioaccumulative substances.

The approach to address the specific information request is to identify bioaccumulative contaminants of potential concern (COPCs), establish a defensible means of predicting fish tissue residues, and establish a tissue residue guideline based on measurable toxicological effects data.

Identifying Bioaccumulative COPCs

The Surface Water Quality Assessment (EA Chapter 11) identified the following as contaminants of potential concern (COPC):

- Cobalt – selected based on guideline exceedances during the screening process;
- Cadmium – selected based on guideline exceedances during the screening process and because it is an Order constituent under the Elk Valley Water Quality Plan (EVWQP);
- Nickel – selected because it was identified as a parameter of potential concern in the Elk Valley by the Ktunaxa Nation Council;
- Nitrate – Selected because it is an Order constituent under the EVWQP;
- Selenium – Selected based on guideline exceedances during the screening process and because it is an Order constituent under the EVWQP;
- Sulphate – selected because it is an order constituent under the EVWQP.

The above list has been further examined to determine bioaccumulative potential of the identified COPCs, with cadmium being retained for further assessment. A rationale for exclusion of the other identified COPCs is provided below:

- Cobalt bioaccumulation potential was assessed by Environment Canada as part of the Federal Environmental Quality Guidelines (FEQG) for Cobalt[1]. Environment Canada determined that the bioaccumulation potential of cobalt in natural ecosystems is not high and elemental cobalt and cobalt-containing compounds do not meet the criteria for bioaccumulation as set out in the Persistence and Bioaccumulation Regulations. Cobalt is therefore excluded as a bioaccumulative substance and has not been examined with respect to the specific information request.

[1] Environment Canada. 2017. Federal Environmental Quality Guidelines – Cobalt. Available from Environment and Climate Change Canada - Federal Environmental Quality Guidelines - Cobalt

- Nickel – The British Columbian Ministry of Environment (ENV) has established through BC Contaminated Sites Regulation Protocol 1 that a bioaccumulative substance is defined as a substance with a bioaccumulation factor of greater than or equal to 2000. The literature derived water-to-fish bioaccumulation factor used in the HHERA is BAF=200 [2]. Additionally, the available toxicological data on nickel tissue residue linked to measurable effects is extremely limited. Tissue residue databases consulted identified only three references from which to draw endpoints. Nickel is therefore not considered to be a bioaccumulative substance and has not been assessed further with respect to the specific information request.
- Selenium bioaccumulation was addressed as part of the assessment conducted in the Crown Mountain HHERA using the two-phase Elk Valley selenium bioaccumulation model. Bioaccumulation of selenium as it relates to fish health has not been re-examined with respect to the specific information request.
- Nitrate and sulphate are essential nutrients in the aquatic ecosystem and involved in many biological processes. As with many other necessary chemical compounds, they can be acutely toxic to aquatic organisms at sufficiently high concentrations. Nitrate and sulphate affect aquatic organisms through osmoregulatory stress and cellular membrane dysfunction resulting from direct contact. Nitrate and sulphate are not considered to be bioaccumulative substances and have not been examined with respect to the specific information request.

Model Selection

A variety of options were considered for predicting fish tissue concentration based on predicted changes to aqueous concentrations of cadmium. A description and rationale for the inclusion or exclusion of each is as follows:

- Use of the US EPA Bioaccumulation and Aquatic System Simulator (BASS), an off-the shelf model that simulates population and bioaccumulation dynamics of age-structured fish communities. This is a complex model which considers both biological attributes of fishes and physico-chemical properties of the chemicals that determine diffusive exchange across gill membranes and intestinal mucosa. Relevant physico-chemical properties include aqueous diffusivity, n-octanol / water partition coefficient (K_{ow}), and, for metals, binding coefficients to proteins and other organic matter. Th BASS model was initially developed for the assessment of hydrophobic organic chemicals such as PCBs, and although it is suitable for use with metals that form organometallics such as cadmium, the model was considered too complex with too many unknowns to implement for the current scope.
- Statistically Derived Site-Specific Model – Site specific data relating water concentration to biota in an effort to establish site-specific statistically derived bioaccumulation models (either as a one-, two-, or three- phase models) was assessed. The site-specific dataset was considered lacking for the development of a defensible model. The number of sampling stations along stream reaches where project activities are predicted to influence water chemistry (primarily Alexander Creek) was too low (n=4) to have confidence in statistically derived models. Additionally, water quality data was not collected at the time of tissue sampling, so average concentrations of constituents of interest in water samples collected from monitoring locations would need to be used. The resulting dataset available for establishing relationships between water and biotic tissues would be too small to allow for meaningful analysis.
- Regional Water-to-Fish Bioaccumulation Factors – The EA submission documents for the 2015 Teck Coal Limited Elkview Operations Baldy Ridge Extension Project includes an Appendix (Appendix B6.2-4) which details the calculated bioaccumulation factors relating total concentration of cadmium in water, to the measured concentration in fish tissue (both muscle and whole body). The regional bioaccumulation factors for cadmium were calculated based on co-occurring fish and water quality measurements from 20 locations over 9 water/year combinations. The calculated BAFs were plotted relative to water concentration on a log-log basis and linear regressions were calculated to determine whether a statistically significant relationship exists between the calculated BAF and the total water concentration. If a statistically significant relationship was observed, then the linear model describing that relationship was used to calculate the representative BAF, otherwise the median BAF for all water/tissue pairings. Cadmium indicates a statistically significant negative relationship between the calculated BAF and the concentration in water. In order to avoid underestimating fish tissue concentrations in the project assessment, the calculated BAF was not extrapolated past the highest water concentration included in the assessment.

[2] Source Wildlife Transfer Database (version 1.3) available at https://www.wildlifetransferdatabase.org/

- Site-Specific Bioaccumulation Factors – Appendix C of the Crown Mountain HHERA presents freshwater to whole organism bioaccumulation factors calculated for the prediction of fish tissue in the multimedia food web. Concentration ratios for COPCs in fish tissue were calculated based on site specific surface water data for total COPC concentration in waters of Alexander Creek and Grave Creek. The arithmetic mean of the calculated BAFs for these two stream reaches was used as the BAF for the multimedia exposure model. In consideration of the limited data and uncertainties associated with calculating water-to-whole organism tissue concentrations, the calculated site-specific BAFs were validated by comparing them to an upper bound of the literature derived values sourced from the Wildlife Transfer Database. The calculated BAF for cadmium met the validation criteria and was therefore carried forward in the multimedia exposure assessment. The calculated water-to-whole organism BAF for cadmium is 3207 (L/kg).

In consideration of the following, it was determined that the site-specific BAFs presented in Appendix C of the Crown Mountain HHERA would be carried forward to assess potential effects to fish health as a result of bioaccumulation:

1. Site-specific BAFs were derived for the watercourses of interest and are in general agreement with literature derived values.

2. Regional BAFs based on a negative linear relationship with the concentration of water appear to break down as the concentration increases. The asymptotic nature of the relationship is not captured in the analysis presented in Teck (2015).

3. The site-specific data is insufficient to support a more complex statistically derived two- or three-phase bioaccumulation model.

Predicted Tissue Concentrations

Whole-body fish tissue residues were calculated for surface water quality model node presented in the HHERA which is outside of the project exclusion zine, and which receives surface water runoff potentially affected by project activities. Predicted fish tissue was calculated in the HHERA multimedia exposure model using the maximum value of the 30-day rolling average for the water quality time series and the site-specific BAF.

Table 1: Predicted whole body fish tissue residue at water quality model prediction nodes.

Water Quality Prediction Node	Predicted Whole Body Tissue Concentration (mg/kg)	Water Quality Prediction Node
AC-1	0.142	Alexander Creek upstream of Highway 3.
AC-2	0.158	Alexander Creek mid-reach between Highway 3 and West Alexander Creek
AC-3	0.261	Alexander Creek downstream of confluence with West Alexander Creek
AC-4	0.038	Alexander Creek upstream of confluence with West Alexander Creek
AC-5	1.29	West Alexander Upstream of Confluence with Alexander Creek.
ER1	0.014	Elk River downstream of confluence with Michel Creek
GC-1	0.058	Grave Creek upstream of confluence with Elk River
GC-2	0.063	Grave Creek downstream of confluence with Harmer Creek
GC-3	0.038	Grave Creek upstream of confluence with Harmer Creek
GC-4	0.079	Harmer Creek upstream of confluence with Grave Greek
GC-7	0.039	Grave Creek downstream of Clean Coal Transfer Area
GC-8	0.038	Grave Creek downstream of CHPP

Tissue Residue Benchmarks

Tissue residue benchmarks related to observable effects endpoints of growth, and survival were sourced from the US EPA Toxicity Residue Database[3]. The database contains more than 3,000 effect and no-effect endpoints for survival, growth and reproductive parameters for invertebrates, fish and aquatic life-stage of amphibians. Data were abstracted from approximately 500 literature references on approximately 200 chemicals and 190 freshwater and marine test species. Survival endpoints account for about 74% of the total amount of data, with growth and reproduction accounting for 19 and 7% respectively.

The database was filtered to include whole body tissue residue data from a variety of life stages. The dataset was limited to the following species Rainbow Trout (*Oncorhynchus mykiss*), Brook Trout (*Salvelinus fontinalis*), Bluegill (*Lepomis macrochirus*), Dace (*Triborodon hakonensis*), Atlantic Salmon (*Salmo salar*), Stickleback (*Gasterosteus aculeatus*), and European Perch (*Perca fluviatilis*).

A screening benchmark for tissue residue was derived from the non-effect and effects data for the reported endpoints. The screening benchmark is established as the median of the 50th percentile of the no-effects dataset and the lower 15th percentile of the effects dataset. The resulting benchmark (whole body tissue residue = 0.285 mg/kg) acknowledges the uncertainty in the tissue residue and effects dataset but includes the majority of non-effects data.

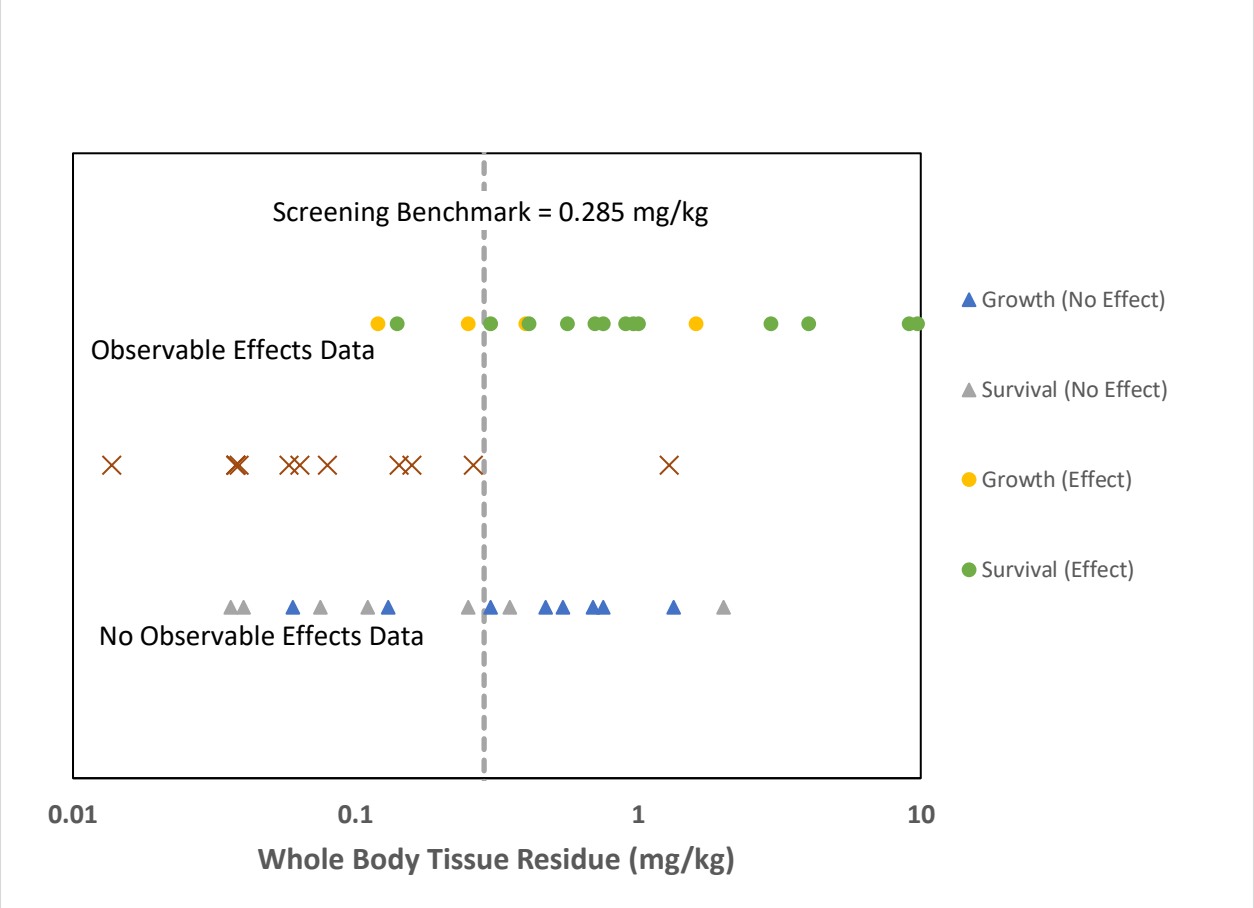

Figure 1: Predicted fish tissue concentration relative to tissue residues associated with effects and no-effects data for growth, reproduction, and survival endpoints.

[3] Jarvinen, A.W., and G.T. Ankley. 1999. Linkage of effects to tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. SETAC Press, pp. 1-358. Available from Toxicity Residue | Research | US EPA

Assessment of Potential Effects Associated with Cadmium Bioaccumulation

Project activities are predicted to have an impact on the concentration of total cadmium in some water courses within the local study area. This is particularly true in West Alexander Creek, which will convey site effluent towards Alexander Creek, however it is important to acknowledge that much of West Alexander Creek will no longer exist as a waterbody, and that concentrations of cadmium are quickly ameliorated after the confluence with Alexander Creek.

The predicted concentration of cadmium in whole body fish tissue for most water quality prediction nodes is below the derived screening benchmark, and for many sites is also below the lowest observed effect level (LOEC). Only predicted fish tissue residues at prediction node AC-5, which carries mine effluent is predicted to have a tissue residue which exceeds the derived screening benchmark. During project operation West Alexander Creek will be re-engineered to accommodate the main sedimentation ponds. West Alexander Creek will cease to provide suitable fish habitat as a result of changes to water quantity, as described in EA Chapter 12 – Fish and Fish Habitat. As such, the predicted fish tissue result from water quality node AC-5 is not directly relevant to the assessment of potential bioaccumulative effects.

Fish tissue from AC-3, located in Alexander Creek at the confluence with West Alexander Creek provides a reasonable worst-case scenario for predicted fish tissue concentrations as a result of project activities. Predicted concentrations of cadmium at AC-3 (0.261 mg/kg) are elevated relative to the upstream reaches of Alexander Creek (0.038 mg/kg), but concentrations remain below the derived screening benchmark.

Overall, the likelihood of deleterious effects as a result of cadmium bioaccumulation is considered to be low. Predicted tissue concentrations for fish located in waterbodies outside the project exclusion zone suggest an acceptable risk based on the current assessment.

Yours sincerely,

<Original signed by>

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