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Chair, Technical Advisory Committee
Elk Valley Water Quality Plan
B.C. Ministry of Environment
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Victoria, BC V8W 9M2

Dear Lynn:

Further to the discussions that were convened during the February 4 to 6, 2014 meeting of the Technical Advisory Committee (TAC) in Vancouver, B.C., I am pleased to submit the following recommendations (advice and associated rationale) related to development of the Elk Valley Water Quality Plan (EVWQP). These recommendations apply to the following topic areas:

- Ecological Effects Assessment - Selenium;
- Ecological Effects Assessment - Cadmium;
- Ecological Effects Assessment - Sulphate/Nitrate;
- Water Quality Planning Model;
- Mitigation Measures and Incorporation into the Water Quality Planning Model;
- Management Scenarios;
- Approach to Incorporating Tributaries;
- Approach for Assessing Impacts for Calcite; and,
- Approach for Assessing Effects in Lake Koocanusa.

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1.0 Ecological Effects Assessment - Selenium

The approach for assessing the ecological effects associated with releases of selenium into the environment from coal-mining activities involves three steps, including estimating exposure of fish, birds, and amphibians to selenium, identifying toxicity thresholds (benchmarks or alternatively, dose/concentration-response relationships), and comparing exposure estimates to toxicity thresholds to estimate the magnitude and spatial extent of effects in receiving waters. Based on a review of the information that was presented at the TAC meeting, the following advice (and associated rationale) is offered:

Advice: Adopt all of the advice and recommendations offered by the Toxicology Work Group (i.e., emerging from the January, 2014 meeting).

Rationale: The advice and recommendations of the Toxicology Working Group are directly relevant for further developing the methods for assessing the effects of selenium on aquatic organisms and aquatic-dependent wildlife.

Advice: Evaluate the performance of non-linear models for estimating K_d in lotic and lentic habitats.

Rationale: The linear model that was presented does not appear to adequately describe the relationship between selenium concentrations in water and selenium concentrations in periphyton. Therefore, alternative models should be developed and evaluated to determine if they explain more of the variability in the underlying data.

Advice: Review the underlying data that were used to develop the selenium bioaccumulation model and identify the pairs of water chemistry and periphyton-tissue chemistry data that inspire the highest confidence that the concentrations of selenium in water represent the exposure concentration for the periphyton (i.e., for sampling locations that have the lowest variability in water quality conditions based on samples collected at multiple times throughout the year).

Rationale: The selenium bioaccumulation model is based on paired measurements of water chemistry and periphyton-tissue chemistry. While the periphyton-tissue chemistry data reflect integration of exposure to selenium over some extended period of time (i.e., weeks to months), the water chemistry data typically represent a point estimate of selenium concentrations (i.e., at time that the sample was collected). This disconnect between exposure concentration and tissue concentration may exp0lain some of the high variability in the K_d estimates.

Advice: Design and implement controlled-laboratory (bioaccumulation tests) and controlled-field studies (artificial stream systems) using site water to confirm or refine the water-to-periphyton model that was developed for use in bioaccumulation modelling.

Rationale: The K_d model that was developed explains only 30% of the variability in the underlying matching water chemistry and periphyton-tissue chemistry data. Hence, there is substantial uncertainty in the resultant model predictions. Conducting focussed laboratory and/or mesocosm studies would increase confidence in the K_d model and the decisions that are taken based, in part, on the selenium bioaccumulation modelling.

Advice: As part of an uncertainty analysis, describe the influence of abiotic and biotic factors (i.e., selenium speciation, influence from other contaminants, dietary preferences, temperature, habitat type, species sensitivity, life-stage, food web structure and large foraging distances) on the developed bioaccumulation model.

Rationale: Bioaccumulation is influenced by many abiotic and biotic factors that include the amount and form of selenium present, influence of other elements and compounds both natural or introduced from human activities (co-contaminants), dietary preferences, temperature, habitat type, species-specific sensitivity, life stage, and area-specific food web structure (Stewart *et al*. 2010). These factors make selenium bioaccumulation inherently difficult to understand, as well as to accurately quantify and predict site-specifically, particularly for species that forage over long distances within a watershed (e.g., WCT). Many of these factors, which could result in significant model error and misinterpretation, have not been addressed by the authors. The variability in both the periphyton and benthic invertebrate data is high. This high degree of variability is reflected in the weak model relationships (very low r^2 values and high residual variance) seen in the lentic (r^2 = 0.35) and lotic (r^2 = 0.28) periphyton models, as well as the pooled invertebrate (r^2 = 0.33), the pooled amphibian (r^2 = 0.36), and spotted sandpiper (r^2 = 0.30) models. The data variability is in part the result of the multiple factors that influence selenium exposure and accumulation characteristics in biota, which the authors suggest are not incorporated into the model. However, the authors may not have accounted for the possible error associated with the use of data from 16 different studies conducted over several decades.

Advice: As part of the documentation developed with the bioaccumulation model, provide a description of alternative selenium bioaccumulation models in the scientific literature along with the rationale for choosing the multi-step modelling approach.

Rationale: The authors do not mention the existence of other selenium accumulation models describing the relationship between selenium exposure and resulting tissue selenium in receptor organisms. There are more complex bi-phasic models that describe a hormetic response to selenium exposure (Beckon *et al*. 2008, Harding 2008). Harding (2008) suggested that bird selenium data collected in the Elk Valley best fit a hormetic model. A fuller range of possible models could be compared by the authors to determine if another approach might be more robust in describing selenium bioaccumulation in the Elk Valley.

Advice: Document how the uncertainty and variability observed in each step of the bioaccumulation model is carried forward through the linked equations and how this uncertainty and variability is described in the final equation. In addition, an evaluation of the models should be conducted by plotting the predicted versus observed concentrations, along with a line of unity.

Rationale: The authors acknowledge that the challenge in multi-step modelling is to account for uncertainty and variability across the multiple linked equations. However, it is unclear how, or if, this was accomplished. The weak r^2 values and high residual variance of these models leaves some doubt that they are "acceptable" fits of the data. The authors have not fully explained their decisions to accept these models as "reasonably representative" in light of these weaknesses. It is unclear how all the variability in these models has been accounted for. Additionally, there is no verification of the models (comparison plots of predicted versus observed concentrations).

Advice: Document the details of uncertainty in matching the samples from 16 different studies used in the bioaccumulation modelling. The documentation should include:

- Detailed description of uncertainty due to sample collection (timing, location, methods);
- Detailed description of uncertainty regarding sample analysis (composite versus individual); and,
- Describe other sources of uncertainty

Rationale: The reliability of this type of modelling is dependent on accurate, concurrently collected data from key locations and during relevant time periods for all model compartments. In this multi-step model, the data pairings were developed from 16 studies conducted over several decades. However, the authors did not provide sufficient details to fully evaluate how disparate the data pairs might be with respect to sample location, collection method used, and the date and timing of sampling relative to critical periods of selenium sequestration by target organisms. Since much of this detailed information was not provided, the studies cited were quickly reviewed to gain some appreciation of these important aspects.

Some data pairs were not collected at the same locations, but no details were provided regarding the actual distance between sample locations and the effect this might have on the accuracy of the model. As well, timing of sample collection was slightly different in each study. As mentioned above, the number of samples used to calculate a mean and/or the number of replicates in a composite value was variable. Based on examination of Table C.1.1, periphyton data collected in the fall of one year was paired with mean water quality from the year prior to or in other cases the year after periphyton sampling occurred. While synoptic water quality values may have been closer in time to periphyton sampling, at least one data pair was two years apart and did not match (lentic periphyton and lotic water). Since aqueous selenium is taken up by primary producers very quickly upon exposure, many of these pairs are unlikely to reflect water quality conditions that were relevant to periphyton selenium uptake. An additional concern is the timing of the periphyton and invertebrate samples relative to measurement of selenium in target organisms (e.g., were invertebrate samples collected in summer or fall paired with WCT tissue samples taken in spring?)

Similar problems exist with the periphyton:invertebrate model. Periphyton data reported in Minnow *et al.* (2011) were collected "throughout the year" (May, June, July and August 2009), while aquatic invertebrates samples were collected in spring, summer or both spring and summer. The time of year that periphyton or invertebrate samples were collected (spring, fall, or throughout the year) could affect the assemblage observed and, hence, the resulting selenium concentrations, since there is a high degree of variability in species-specific selenium accumulation. Golder states that amphibian selenium data were comprised of individual sample results. However, in several studies examined (e.g., Minnow 2006; Minnow *et al.* 2007, Minnow *et al.* 2011) amphibian selenium values reflect analysis of 50-150 eggs from an egg mass, not individual eggs.

The review also revealed that the historical data from the multiple studies used were generated using several different collection methods. For example, the periphyton data reported in Minnow *et al.* 2011 (15 data points) resulted from three different methods. In lentic areas, introduced substrates (plates) left for six weeks were sampled, “epipelon” was either scraped from rocks or lifted from pond sediment using a syringe, whereas in lotic areas “epilithon” was collected by scraping cobbles and boulders. In October 2001, EVS (2005) collected periphyton by scraping rocks and invertebrates were collected using a Surber sampler (mesh size not reported). In September 1996, McDonald and Strosher (1998) collected periphyton using either forceps to pull algal mats or a utility blade to scrape algae from rocks, and obtained aquatic invertebrates using a Hess sampler (mesh size not reported). Some periphyton and invertebrate data represent a single composite value while others are the geometric mean of replicate samples. It is very possible that these differing approaches could alter the representativeness of the sample, introducing variability and greater uncertainty in model predictions. Minnow *et al.* (2007 collected benthic invertebrates using either a petite ponar dredge (lentic areas) or a kick net (lentic and lotic areas). Orr *et al.* (2012) noted that combining data across multiple studies may have contributed in part to the lower r^2 values reported in three lotic trophic transfer models. Since many of the same studies in Orr *et al.* (2012) were also used here, this could be a significant source of uncertainty in these models.

Advice: Conduct a sensitivity analysis to determine the effects of pooling multiple species (i.e., in the case of the amphibians).

Rationale: Pooling data for two amphibian species is not a conservative approach given that the two species may have very different selenium bioaccumulation characteristics and toxicity thresholds. By pooling data for these species into one model, relating model predictions to potential selenium effects could be incorrect. Similarly, pooling bird and fish data seems counterintuitive and results in loss of valuable information to predict species-specific responses.

Advice: Review selenium bioaccumulation model dataset for locations where samples were taken across multiple trophic levels as an opportunity to further validate the model outputs.

Rationale: There is substantial uncertainty in the bioaccumulation models. By identifying "matching" data from the overall data set, it may be possible to reduce variability in models derived using the data that are most closely matched.

Advice: As telemetry data for Westslope Cutthroat Trout (WCT) becomes available, continue to assess whether point estimates of selenium exposure concentrations are representative of water concentrations in areas where fish are moving through.

Rationale: The migratory nature of WCT complicates development of the Se bioaccumulation model because tissue concentrations may not reflect exposure conditions where they are captured. The telemetry data will be useful for determining how water and tissue samples should be collected and evaluated to assess bioaccumulation.

Advice: Where the information is available, preference should be given to characterizing effects using the dose - response data as much as possible rather than for example relying on effects thresholds (EC x).

Rationale: In the field, exposure data is highly variable, ranging from low levels to levels that may be several multiples of the toxicity thresholds. Dose-response relationships provide a basis for evaluating the magnitude of effects associated with exceedance of toxicity thresholds, not just the frequency of exceedance.

Advice: Review the lentic periphyton database (2009 to 2010-2013) to see if there is a tighter relationship between selenium water concentration and selenium tissue concentration in periphyton based on water residence time (e.g. based on surface water connection/ distance from mainstem).

Rationale: In the field, exposure concentrations measured in water represent snapshots of conditions at the time of sampling. In contrast, periphyton tissue concentrations reflect exposure over the weeks or months prior to sampling. By focussing on exposure data that are more closely matched to the tissue data, it may be possible to reduce variability in the K_d estimates.

Advice: Where there are estimated selenium effects close to toxicity benchmarks for both juvenile growth and reproduction endpoints, assess the potential combined effects for a species.

Rationale: Effects on the growth of fish and their reproduction are not independent. As smaller fish can produce fewer and, in some cases, less viable offspring, it is important to evaluate the combined effects associated with COPC exposures on these endpoints.

2.0 Ecological Effects Assessment - Cadmium

The ecological effects assessment for cadmium will involve comparison of measured concentrations of total and/or dissolved cadmium to toxicity thresholds and/or concentration-response relationships derived from the results of laboratory toxicity tests that have been published in the literature. These data have been normalized to water hardness or BLM parameters to reduce variability in the underlying toxicity data (i.e., account for the levels of toxicity-modifying factors). Advice and associated rationale relative to the ecological effects assessment for cadmium include:

Advice: Adopt all of the advice and recommendations offered by the Toxicology Work Group (i.e., emerging from the January, 2014 meeting).

Rationale: The advice and recommendations of the Toxicology Working Group are directly relevant for further developing the methods for assessing the effects of cadmium on aquatic organisms.

Advice: Design and implement a field study to evaluate the composition (i.e., type) of dissolved organic carbon (e.g., humic substances, polysaccharides, low-molecular weight acids, and high-molecular weight acids) that occurs in the Fording River, Elk River, and tributaries during high flow and low flow conditions.

Rationale: To support the development of a BLM for cadmium, unmeasured levels of DOC in the water used in laboratory toxicity tests reflected in the cadmium toxicity data set were estimated using a variety of methods. The potential influence of the addition of food to toxicity testing chambers on DOC concentrations was not considered in these estimates of DOC concentrations however. This creates uncertainty in the BLM because DOC may have been underestimated. One argument for not considering feed-related DOC is that such carbon may not be as reactive as the DOC in waters from the Elk Valley. Thus far, no information has been presented on the composition of DOC in Elk Valley receiving waters during various times of the year. The recommended study will provide the information needed to determine the percentage of Elk Valley DOC that is likely to be reactive.

Advice: Design and implement a laboratory toxicity study to validate the application of the BLM for predicting the chronic toxicity of cadmium to fish and aquatic invertebrates.

Rationale: The BLM that was developed for cadmium is based on laboratory toxicity and associated water chemistry data. However, much of the data on water quality conditions was estimated because major ion and/or DOC concentrations were not reported by the original investigators. Therefore, there is substantial uncertainty regarding the reliability of the BLM for predicting toxicity within the Elk River, Fording River, and associated tributaries. This uncertainty can be resolved by validating the applicability of the BLM with well-designed laboratory toxicity studies conducted using site water.

Advice: In the toxicity database for the Cadmium Biotic Ligand Model, undertake a sensitivity analysis to evaluate whether the assumption of 0.5 and 1 mg/L concentration of DOC is conservative given the DOC complexing capacity of the food provided to test organisms. Consult relevant literature to inform the range of DOC concentrations for sensitivity analysis.

Rationale: DOC is an important parameter in the BLM model as it serves as a complexing agent, binding to cadmium and therefore reducing bioavailability. A sensitivity analysis should be conducted using a range of estimated DOC concentrations to evaluate changes to the normalized effect values. The sensitivity analysis should be informed by a literature review on the contributions of DOC from feed and the complexing ability of this DOC.

Advice: The comparison of water quality conditions to normalized effect values should be conducted using both the BLM and hardness-normalized effect values.

Rationale: Studies conducted on the utility of the BLM in predicting toxicity of cadmium to aquatic organisms during chronic exposure have not shown that the BLM can accurately predict toxicity during chronic exposures. The use of the hardness-normalization procedure has been used in the development of promulgated water-quality guidelines in British Columbia and elsewhere in Canada. Therefore, the effects assessment should include an evaluation conducted using hardness-normalized effect values.

Advice: Conduct a sensitivity analysis by using the individual toxicity test results (i.e., rather than grouping the effect and endpoint values from multiple studies) in the effects assessment.

Rationale: A conservative approach would be to use methods consistent with the derivation of water quality guidelines in British Columbia (Meays 2012). In that guidance document, studies are classified as primary or secondary based on study and/or data quality. The results of individual studies are used to identify the lowest effect value from a primary study to serves as the basis for the water quality guideline.

Advice: The units used in the text, tables, and figures should be consistent within the document; both µg/L and mg/L are used when reporting cadmium toxicity data.

Rationale: The use of consistent units improves readability and minimizes interpretation errors.

Advice: Update Tables 6 and 14 in the document to state that effects are expected below the CCME water quality guideline.

Rationale: Figures 18 and 22 show that BLM and/or hardness-normalized effects data fall below the CCME water quality guideline (represented as the orange dotted line). These tables should be updated to state that effects are expected to occur below the CCME WQGs.

Advice: Where invertebrates are sensitive indicators, available bio-assessment data (e.g., field monitoring of macroinvertebrate abundance and composition) should be used to validate predictions in the effects matrix on the effects of mixtures.

Rationale: The toxicity data used to develop toxicity thresholds for cadmium are not comprehensive. Therefore, predictions of toxicity (or lack thereof) are subject to errors associated with incomplete knowledge and extrapolation from the lab to the field. Such errors can, in part, be addressed by compiling and evaluating effects data from the field (e.g., bioassessment data) to validate predictions regarding effects from exposure data.

Advice: Prepare species sensitivity distributions for BLM normalized and hardness normalized cadmium toxicity for two additional scenarios: (1) one reflective of lowest hardness conditions at the reference site, and (2) one reflective of higher hardness (e.g., 320 mg/l). The purpose of this analysis is to evaluate the difference in the slope estimate between the BLM and hardness approach.

Rationale: By providing an evaluation of the agreement between the BLM and hardness approaches by normalizing the effect values over a range of water hardness conditions, one can determine if the relative difference in toxicity estimates remains consistent across varying water quality conditions.

Advice: Evaluate data on the concentrations of cadmium in sediment cores at Elko (using toxicity data for *Hyallela azteca*, at a minimum).

Rationale: Upon release into receiving waters, cadmium can remain dissolved in water or become associated with fine sediment. Such sediments may be transported to downstream areas, where they are deposited in low energy zones (depositional areas). In these areas, sediment-associated cadmium can reach concentrations of concern relative to benthic invertebrates. As Elko Reservoir is one despositional area in the Elk Valley, it is appropriate to evaluate the potential effects of cadmium on this area (and others).

3.0 Ecological Effects Assessment - Sulphate/Nitrate

The ecological effects assessment for sulphate and nitrate will involve comparison of measured concentrations of these substances to toxicity thresholds and/or concentration-response relationships derived from the results of laboratory toxicity tests that have been published in the literature and/or conducted using site water. These data have been normalized to account for toxicity modifying factors to reduce variability in the underlying toxicity data (i.e., account for the levels of toxicity-modifying factors). Advice and associated rationale relative to the ecological effects assessment for sulphate and nitrate include:

Advice: Adopt all of the advice and recommendations offered by the Toxicology Work Group (i.e., emerging from the January, 2014 meeting).

Rationale: The advice and recommendations of the Toxicology Working Group are directly relevant for further developing the methods for assessing the effects of sulphate and nitrate on aquatic organisms.

Advice: Explain the potential uncertainties in the exposure concentrations that were developed from water chemistry measurements conducted at the beginning and end of each toxicity test.

Rationale: Measurements of concentrations of COPCs in water at the beginning and end of toxicity tests provide reasonable estimates of exposure conditions during static toxicity tests. However, such measurements may be inadequate for estimating exposure concentrations for static-renewal or flow-through toxicity tests (i.e., because stock solutions may be remade at various times during the test and there is potential for errors during stock solution preparation). Therefore, some discussion of the potential errors and the procedures that were applied to ensure that exposure concentrations remained consistent during the toxicity tests would be helpful.

Advice: Conduct an evaluation of the effects on aquatic organisms associated with exposure to major anions and cations (i.e., total dissolved solids; TDS).

Rationale: The Terms of Reference of the EVWQP indicate that the plan will address the cumulative effects of point and non-point sources of waste on water, aquatic biota, and human consumers, using best available science. Before cumulative effects can be evaluated, the effects of individual stressors need to be determined. To date, little or no information has been compiled on the effects on aquatic organisms associated with exposure to elevated levels of major ions (relative to pre-mining levels; with the exception of sulphate and nitrate). Yet, exposure to elevated levels of major ions (as measured by total dissolved solids, hardness, alkalinity, specific conductance, concentrations of individual ions) has the potential to influence the abundance of individual taxa and/or the diversity/species composition of aquatic communities. Therefore, the effects of major ions on aquatic organisms needs to be evaluated.

Advice: The effects matrix that was developed to interpret water chemistry data for nitrate and sulphate requires additional support from the primary literature. More specifically, a comprehensive review of the literature that links the magnitude of effects observed in laboratory toxicity tests to responses of aquatic organisms in the field needs to be conducted. The results of such a literature review needs to be compiled and used to support the interpretations of toxicity test results presented in the effects matrix (i.e., $>IC_{50}$ - greater potential for population level effects, etc.). Similarly, the matrix that combines the evaluations conducted with literature-based toxicity thresholds and site-specific toxicity thresholds requires further information to support the interpretation of the results and the associated conclusions (see slides 28 and 30 in presentation). This comment also applies to the assessments of selenium and cadmium.

Rationale: Our experience is not consistent with the interpretation of toxicity test results presented in the effects matrix. In contrast to the interpretation presented therein, we have observed adverse effects in the field when COPC concentrations exceed an IC_{20} level. Above an IC_{50}, adverse effects on populations of sensitive species are expected to occur. Therefore, the interpretive framework presented in the effects matrix needs to be supported by empirical data before it can be applied.

Advice: The potential effects of nitrate enrichment on the trophic status of Elk Valley tributaries, the Fording River, the Elk River, and Lake Koocanusa need to be evaluated. This evaluation needs to consider current conditions of both nitrogen and phosphorus and the potential for additional releases of phosphorus into receiving waters from various municipal, agricultural, and industrial sources.

Rationale: The evaluation of the effects of nitrate have, thus far, consisted of a toxicological evaluation for aquatic organisms. However, releases of nitrate into surface waters can also result in eutrophication, if nitrogen is a limiting nutrient for aquatic plant growth. It is essential that both the toxicological and eutrophication-related effects of nitrate are assessed in the EVWQP.

Advice: Where invertebrates are sensitive indicators, available bio-assessment data (e.g., field monitoring of macroinvertebrate abundance and composition) should be used to validate predictions in the effects matrix on the effects of mixtures.

Rationale: The toxicity data used to develop toxicity thresholds for sulphate and nitrate are not comprehensive. Therefore, predictions of toxicity (or lack thereof) are subject to errors associated with incomplete knowledge and extrapolation from the lab to the field. Such errors can, in part, be addressed by compiling and evaluating effects data from the field (e.g., bioassessment data) to validate predictions regarding effects from exposure data.

Advice: The effect sizes used to determine if responses are measurable in the field should be informed by the AEMP design (i.e., based on detectable effect sizes, necessary sample size and sampling frequency) rather than implying that a less than 20% effect is not measurable in the field.

Rationale: While a less than 20% effect size has been used as a threshold for estimating a significant response in other studies, the AEMP should be relied upon as the basis for the effect sizes for each of the identified valued components.

4.0 Water Quality Planning Model

No additional comments are provided at this time on the water quality planning model that will be used to guide management decisions in the Elk Valley.

5.0 Mitigation Measures and Incorporation into the Water Quality Planning Model

Additional information on mitigation measures and management scenarios was presented at the fourth TAC meeting. Advice and associated rationale relative to the evaluation of mitigation measures and subsequent incorporation into the water quality planning model include:

Advice: The planning horizon for the EVWQP (i.e., 20 years) is too short to support the identification of the most appropriate long-term solutions to the water quality issues that are evident in the Elk Valley. While 12 to 20 years is an appropriate timeframe for meeting the long-term targets that need to be developed under the EVWQP, planning activities must also consider a longer timeframe (i.e., 140 years and beyond) to ensure that appropriate decisions are made.

Rationale: One limitation of the approach that is being taken for evaluating the applicability of various management options in the EVWQP is the overall planning horizon. Utilization of a short-term planning horizon during development of the EVWQP creates a bias against mitigation measures that may be appropriate for implementation over a longer time period and those that may result in water quality improvements beyond the 20-year planning horizon. This bias is likely to result in selection of active water treatment in perpetuity to address ongoing water quality issues. Because the potential value of bituminous geomembrane (BGM) covers cannot be demonstrated within a 20-year planning horizon, progressive reclamation activities are likely to proceed with the placement of vegetated covers that may not provide substantial improvements in water quality conditions. A longer planning horizon is required to recognize the potential value of BGM covers and other technologies that required longer timeframes to achieve benefits.

Advice: Model the effectiveness of BGM covers over a period of at least 200 years. This modelling effort should include a range of assumptions regarding the effectiveness of BGM covers in reducing loadings of COPCs to receiving waters from wasterock storage facilities (e.g., 35%, 50%, 65%, and 80% load reductions).

Rationale: Modelling water quality conditions over a 20-year period necessarily results in a bias against the use of BGM covers to mitigate water quality effects. While active wastewater treatment represents a necessary short-term solution for addressing key water quality issues (i.e., selenium and nitrate) in the Elk Valley, active wastewater treatment in perpetuity is not a preferred long-term solution. Therefore, it is essential to evaluate the potential efficacy of alternative mitigation measures that may provide substantial benefits over the long term. It is likely the BGM covers will provide such long-term benefits, but long-term modelling will be required to evaluate those benefits.

6.0 Management Scenarios - Approach and Emerging Patterns

The overall patterns that are emerging from the preliminary water quality modelling activities were described at the fourth TAC meeting. The representative scenarios that were considered included active water treatment (AWT), AWT plus clean water diversion (CWD), and AWT plus CWD plus BGM covers. Based on the modelling results, CWDs were expected to have a small influence on in-stream concentrations of COPCs. In addition, these results indicated that BGM covers would not reduce treatment volumes and would not reduce in-stream concentrations of COPCs. Advice on the emerging patterns and implications for further analysis of management scenarios includes:

Advice: Adopt placement of BGM covers as best management practice for progressive reclamation at coal-mining operations in the Elk Valley. Doing so will require adoption of the reasonable assumption that BGM covers will reduce infiltration into wasterock storage facilities and that reduced infiltration into these facilities will reduce loadings of selenium and other COPCs to receiving waters. Subsequent research should be focussed on evaluating the efficacy of BGM covers over the longer term.

Rationale: In the absence of data demonstrating that the BGM covers provide an effective basis for reducing the loadings of selenium and other COPCs into receiving waters, progressive reclamation activities will proceed with the placement of vegetated covers over wasterock storage facilities. Once such covers have been placed, it is virtually certain that the wasterock management facilities will not be retrofitted with BGM covers. Hence, the opportunity to control releases of COPCs at the source will be largely lost. As a result, long-term water quality issues will likely need to rely upon active wastewater treatment in perpetuity. This option is unlikely to be favored by KNC members. Adopting BGM covers as a best management practice would ensure that opportunities for placement of BGM covers are not lost and that this technology can be fully evaluated within the next 20 to 40 years.

Advice: Identify opportunities for large-scale trials to evaluate the effectiveness of BGM covers in the Elk Valley.

Rationale: There are a number of wasterock storage facilities that are currently available for covering and that can be resloped to 3:1 (e.g., Brownie Dump). These facilities should be evaluated to identify at least two that are sufficiently similar to support evaluation of the effectiveness of vegetated vs. BGM covers. Such trials should be initiated in the near term (within the next 10 years) to provide the information necessary to confirm or reject the use of BGM covers as a best management practice for progressive and final reclamation.

Advice: Evaluate the potential applications and effectiveness of *in situ* bioreactors (i.e., located within or immediately down gradient of wasterock storage facilities) in the Elk Valley.

Rationale: Fluidized-bed reactors have been demonstrated to facilitate removal of selenium from wastewaters in the Elk Valley. While large-scale wastewater treatment systems utilizing this technology are likely to provide near-term solutions to the water quality issues that are evident in the Elk Valley, there may be opportunities to control releases of selenium at or near the source through the application of *in-situ* bioreactors (such as those that have been designed by Microbial Technologies Inc. and/or Envirogen Technologies).

7.0 Approach to Incorporating Tributaries

The approach for incorporating the tributaries into the planning process for the EVWQP involves mapping the extent of the tributaries and the influence of mining activities therein, comparison of COPC concentrations to benchmarks, and evaluating effects utilizing available bioassessment data. Advice on the approach for inclusion of the tributaries into the EVWQP includes:

Advice: Develop a conceptual site model for the tributaries that describes the linkages between all of the potential stressors within the tributaries and all of the ecological receptors that utilize habitats within the tributaries. A similar conceptual site model needs to be developed for the mainstream areas that explicitly recognizes the role that tributaries play in the maintenance of healthy and productive fish communities (i.e., providing spawning habitat, rearing habitat, exporting invertebrates to the mainstem, etc.).

Rationale: A conceptual site model provides a basis for describing the scope of the study area, identifying physical and chemical stressors, evaluating the transport and fate of COPCs, evaluating the effects of the various COPCs, COPC mixtures, and other stressors identifying potentially complete exposure pathways, identifying ecological receptors, and developing effects hypotheses that link the stressors and receptors. In turn, the CSM supports identification of the measurement endpoints that are most appropriate for evaluating effects on each ecological receptor group. This information will provide a basis for evaluating the adequacy of the data and information that are assembled to evaluate effects in the tributaries, both now and in the future. The CSM must consider such stressors as flow reductions, calcite formation, COPC concentrations, suspended sediments, deposited sediment, and others (e.g., blasting proximal for waterbodies, diversions, etc.).

Advice: Provide additional information on the methods that will be used to predict the concentrations of COPCs and the magnitude of other stressors in the future.

Rationale: Information on future water quality conditions and the presence of other stressors is required to evaluate the potential effectiveness of the EVWQP for mitigating effects in the mining-affected tributaries within the Elk Valley. However, little information was provided on the methods that will be used to predict future conditions within each of the tributaries that could be affected by the proposed mitigation measures. Therefore, more information is required on the procedures that will be used for predicting future conditions.

Advice: In addition to evaluating the effects of individual stressors present within the tributaries, the cumulative effects of multiple stressors (including long-term climate change) need to be assessed. Such an evaluation needs to be directed by the development of effects hypotheses (i.e., that emerge from the CSM development process).

Rationale: Ecological receptors utilizing habitats within the tributaries have the potential to be adversely affected by a number of stressors, including changes in streamflows, changes in water quality conditions, formation of calcite, climate change, and others. While stressor-by-stressor evaluations of effects can provide useful insights into the factors that are causing effects in the tributaries, the effects assessment will be incomplete and underpredictive of effects if a cumulative effects assessment is not conducted. Therefore, the approach to incorporating tributaries into the EVWQP needs to include a multiple stressor analysis within a cumulative effects framework.

Advice: Clearly describe the nature (type), magnitude, and spatial extent of effects in each mining-affected tributary under current conditions and under future management scenarios.

Rationale: Information on the effects within the tributaries under current conditions and under the proposed future management scenarios is required to understand the trade-offs that may need to be considered to balance economic, social, and environmental interests. By clearly documenting effects in each tributary under current conditions and describing how the proposed management scenarios will alter those conditions, the implications of the various management scenarios can be better understood.

8.0 Approach for Assessing Impacts for Calcite

An approach for assessing impacts on fish and aquatic life associated with calcite formation in receiving waters is required to support development of the EVWQP. This requirement was addressed by presenting information on the processes that lead to calcite formation, on the monitoring program that was developed to evaluate calcite issues, on the results of monitoring conducted to date, and on the options that have been explored to manage calcite formation in the watershed. Advice on the assessment of calcite impacts and associated rationale for these recommendations includes:

Advice: The narrative objective that was proposed for addressing calcite formation needs to be revised to focus on managing the problem, rather than understanding the problem. The following narrative objective is recommended for inclusion in the EVWQP: "***Manage mine related calcite formation such that stream-bed substrates within the Elk River, the Fording River, and associated tributaries support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish (i.e., comparable to those present in appropriately selected reference areas)***."

Rationale: The Terms of Reference for the EVWQP indicate that narrative objectives need to be articulated to guide calcite management. The narrative objective proposed at the fourth TAC meeting does not meet this requirement.

Advice: Develop medium-term and long-term targets for calcite. As no targets have been proposed to date, the following targets are recommended for inclusion in the EVWQP:

1. *Short-term goals:* Within three years, survey all streams in the Elk Valley that are affected by coal mining-related activities; map the spatial extent and magnitude (i.e., low, moderate, and high) of calcite formation in all streams; evaluate the effects of calcite formation through the implementation of well-designed field studies that include appropriate effects metrics; complete and document laboratory and field investigations conducted to identify and evaluate candidate calcite management approaches and systems; identify the most effective approaches to managing calcite formation for each type of source area and receiving water stream; and, complete a preliminary calcite management plan.
2. *Medium-term target:* Within 10 years, reduce the spatial extent of moderate and high levels of calcite by 50% relative to 2013/2014 levels.
3. *Long-term target:* Within 20 years, reduce the spatial extent of moderate and high levels of calcite by 80% relative to 2013/2014 levels.

Rationale: The Terms of Reference for the EVWQP indicate that medium-term and long-term targets and timeframes need to be established to reduce the rate and control the formation of calcite and manage impacted streams. Therefore, such targets need to be included in the EVWQP.

Advice: Conduct a comprehensive review of the scientific literature to identify candidate approaches to evaluating stream-bed substrate quality. The results of this literature search should be used to identify assessment endpoints (e.g., survival and growth of aquatic plants; survival, growth, and reproduction of benthic invertebrates; survival, growth, and reproduction of fish) for evaluating the effects of calcite formation. In addition, these results should be used to identify the measurement endpoints (e.g., abundance of benthic invertebrates and individual taxa; diversity of the benthic invertebrate community, intragravel dissolved oxygen levels, etc.) for evaluating the effects of calcite formation on fish and other aquatic organisms.

Rationale: The Terms of Reference of the EVWQP indicate that the plan will address the impact of calcite formation. However, methods for evaluating the effects of calcite formation on fish and other aquatic organisms have not been described. Therefore, a literature search should be conducted to support identification and evaluation of candidate impact assessment methods for calcite.

Advice: Revise the calcite monitoring program to include metrics that facilitate evaluation of effects on fish and other aquatic organisms associated with calcite formation in receiving waters. A before-after-control-impact approach should be used to evaluate the effects of calcite formation and associated management strategies to control calcite formation. The steps involved in the design of such a monitoring program should include:

1. Develop a conceptual model for calcite formation in receiving waters;
2. Identify all receiving waters in the Elk Valley with water quality conditions and/or mining activities potentially sufficient to promote calcite formation;
3. Classify receiving waters prone to calcite formation based on physical-chemical characteristics and habitat types;
4. Identify appropriate reference areas for type of receiving water that was identified within the mining-affected areas;
5. Identify the assessment endpoints and measurement endpoints that will be incorporated into the monitoring program;
6. Identify a number of representative reaches of each type of receiving water within mining-influenced and reference areas that will be used to support intensive effects monitoring;
7. Describe the type and frequency of sampling and analysis that will be conducted within each reach;
8. Describe the type and frequency of monitoring that will be conducted on other stream reaches to further evaluate the nature, extent, and magnitude of calcite formation; and,
9. Describe the procedures that will be used to evaluate the resultant data and determine the effects of calcite formation on aquatic organisms.

Rationale: The Terms of Reference of the EVWQP indicate that the plan will address the impact of calcite formation. However, methods for evaluating the effects of calcite formation on fish and other aquatic organisms have not been described. Therefore, a literature search should be conducted to support identification and evaluation of candidate impact assessment methods for calcite.

9.0 Approach for Assessing Impacts in Lake Koocanusa

Assessment of effects on Lake Koocanusa associated with releases of COPCs from coal-mining operations, releases of COPCs from other sources, and with other stressors needs to be evaluated under the EVWQP. Advice on the assessment of impacts in Lake Koocanusa include:

Advice: A Working Group should be established immediately to define the scope of the assessment that needs to be conducted on Lake Koocanusa.

Rationale: The TAC has recommended that impacts in Lake Koocanusa be evaluated, under current conditions and under future conditions, under the EVWQP. However, a work package describing the approach that will be used to assess impacts in Lake Koocanusa will not be presented to the TAC until April, 2014. This timing will not provide the members of the TAC sufficient time to provide meaningful input on the approach. Therefore, a Working Group should be established immediately to guide the development of an approach for assessing impacts in Lake Koocanusa.

Advice: At minimum the scope of the assessment of effects in Lake Koocanusa needs to include the following:

1. Evaluation of ambient water quality conditions throughout the lake (including evaluation of existing water-chemistry data, surface-water toxicity data, periphyton, zooplankton, and trophic status information, and other related data and information);
2. Evaluation of ambient sediment quality conditions throughout the lake (including evaluation of existing sediment-chemistry data, sediment-toxicity data, and benthic invertebrate community structure data);
3. Evaluation of existing invertebrate-tissue chemistry, fish-tissue chemistry, and bird-egg chemistry data;
4. Evaluation of current loadings of COPCs to the lake from all sources;
5. Evaluation of the factors that are currently limiting primary productivity within the lake; and,
6. Identification of long-term monitoring and assessment needs for confirming that loadings of COPCs to the lake are being reduced, that a water quality objective of 2 μg/L for selenium is protective of aquatic organisms and aquatic-dependent wildlife, and that inputs of nutrients are not adversely affecting the trophic status of the lake.

Rationale: An assessment of current conditions in Lake Koocanusa is required to establish baseline conditions in the lake and to support the evaluation of future permit applications for development projects (i.e., coal mine expansion and other developments). The results of such an assessment and future monitoring are also needed to ensure that international waters, species at risk, and First Nations interests are adequately protected.

Here's hoping that this supplemental advice is useful to you and the rest of the Technical Advisory Committee.

Sincerely,

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