Appendix 16-B

Selection of COPCs and Water Quality Impacts to Wildlife

HARPER CREEK PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement

APPENDIX 16-B. SELECTION OF COPCS AND WATER QUALITY IMPACTS TO WILDLIFE

The introduction of Project-related contaminants to environmental media was identified as a potential effect for wildlife VCs. Wildlife exposed to contaminants of potential concern (COPCs) may be affected if COPCs are taken up into their bodies from the environment and if concentrations are greater than effects thresholds (i.e., toxicity thresholds, or the concentration that can cause adverse effects in wildlife).

The potential for toxicity to wildlife was assessed following general principles of ecological risk assessment (BC MOE 2005, 2008; Environment Canada 2012). In order to determine the potential effects of Project-related COPCs on VCs, the following three factors were considered:

1. A wildlife VC receptor has to be present.
   - The presence of wildlife VCs was based on information collected during baseline studies (Section 16.4 and Appendix 15-A).
2. A pathway must exist from the point of release of the chemical to the Wildlife VC receptor and the receptor must be able to take up the chemical (i.e., the chemical must be bioavailable).
   - The presence or absence of an exposure pathway was based on best professional judgement, taking into consideration the environmental media in which a COPC may be found (e.g., water, soil, vegetation, food chain) and whether the exposure route could result in significant COPC exposure for the wildlife VC.
3. A COPC has to be present due to Project activities at a sufficiently high concentration to have the potential to cause toxicological effects.
   - Where possible, this was determined quantitatively (e.g., through comparison of water quality model results to BC water quality guidelines [WQGs] for wildlife), otherwise qualitative assessment was used.

WILDLIFE EXPOSURE ROUTES FOR CONTAMINANTS OF POTENTIAL CONCERN

Potential Exposure Routes

During the various phases of the Project, wildlife VCs may be exposed to COPCs through three potential sources of COPCs:

- directly in water (e.g., discharge from the TMF);
- directly from ingestion of fugitive dust (deposited either in or on soil or vegetation) generated by Project activities; or
- indirectly via food chain bioaccumulation (i.e., through their diet).

The potential for exposure of wildlife to COPCs in water or through the aquatic dependent food chain will be considered in the effects assessment.

Exclusion of Ingestion of Fugitive Dust as an Exposure Pathway

Fugitive dust generated by Project-related activities will be dispersed from its place of origin to depositional areas and may accumulate in or on soil and vegetation, which may be ingested by wildlife. This has the potential to affect wildlife health, predominantly through terrestrial-based food chains (i.e., water-dependent organisms will be minimally affected by dust deposition in the terrestrial environment).

An air quality model was developed for the Project for the Construction and Operations phases; this model incorporated mitigation measures intended to protect air quality (as described in Chapter 9 and the Air Quality Management Plan, Chapter 24.2). Metal concentrations in dust were not determined as part of the air quality model. However, predictions for fugitive dust deposition from the air quality model (Section 9.5.2.3) were used to determine the areas that are predicted to be most affected by dust deposition. Dust deposition rates were used as a surrogate measure of the potential for change in the environmental quality (i.e., soil and vegetation) of affected areas.

In both the Construction and Operations phases, the air quality model predicted the dust deposition rate would be highest closest to the sources of fugitive dust (Section 9.5.2.3). However, studies show that dust levels fall rapidly with distance from the project boundaries, such that background levels are acceptable. It was shown for another open pit mining project that the monthly dustfall decreased by two thirds, from 4 $mg/dm^2/day$ at the edge of the pit to 1.3 $mg/dm^2/day$ at approximately 400 m off the pit, still within the property boundary (AMEC 2011; Stantec 2012; Rescan 2014).

While some uptake of metals via intake of dust deposited on surfaces of soil or vegetation is possible, it is unlikely that any of the wildlife VCs will be exposed to concentrations of metals high enough to cause toxicity via this exposure route (i.e., due to ingestion of fugitive dust). There are two main reasons for why this is the case.

First, noise and activity levels associated with the Project are also the highest in the same areas as where the most fugitive dust will be deposited, since they are in close proximity to Project infrastructure (i.e., Project Site and access road). Disturbance of wildlife use of habitat for many of the VCs is likely to occur in close proximity to Project infrastructure, road use, or activities. Therefore, it is likely that the elevated noise levels and increased disturbance around the Project Site and access road will decrease the likelihood of wildlife use of the areas of highest dust deposition, which will decrease the potential for exposure of wildlife to COPCs present in or on soil and vegetation in these areas.

Second, many of the wildlife VCs have large home ranges in which they forage for food. The area in which dust deposition is predicted to occur is small relative to the home range for some of the VCs (e.g., grizzly bears, ungulates, furbearers), which would decrease the overall degree of exposure to Project-related COPCs.

Additional factors that may influence or decrease the exposure of wildlife to COPCs in fugitive dust include:

- the migratory nature of some of the bird VCs (e.g., barn swallow, common nighthawk, olive-sided flycatcher) means that exposure to deposited dust is seasonal or periodic;
- some dust generation is seasonal (e.g., along the access road, minimal dust during times of snow cover or precipitation); and
- dust deposition is weather-dependent (e.g., less dust generation with precipitation such as rain or snow, wind may affect deposition areas or may blow the dust off of vegetation surfaces).

Based on the above discussion, no specific COPCs were selected in fugitive dust. Exposure to COPCs via Project-related fugitive dust is negligible for terrestrial wildlife and not applicable for water-dependent wildlife.

Potential sources of fugitive dust during the Closure phases include vehicle or equipment use associated with the decommissioning of Project infrastructure. Potential sources of fugitive dust during the Post-Closure phases include vehicle or equipment use associated with the any ongoing monitoring or maintenance requirements of remaining Project infrastructure (e.g., TMF). Although fugitive dust deposition was not modelled during these phases, it would be expected to be minimal compared to what is predicted during the Construction or Operations phases; therefore, the potential for exposure of wildlife to COPCs in dust during the Closure or Post-Closure phases is not considered any further.

Other Potential Exposure Routes Excluded from Consideration

Other exposure routes for wildlife, such as inhalation of dust or dermal absorption, were not considered in the effects assessment. While it is possible that wildlife could take up contaminants from inhalation of contaminants from the air, this pathway is considered to be a very minor source of contaminants compared to uptake through the diet (Sample et al. 1997; BC MOE 2013). Similarly, while dermal exposure in wildlife is possible, it is unlikely to be a significant exposure route since many metals (particularly in their inorganic form) do not readily cross the dermal barrier, and most wildlife VCs have an outer barrier (e.g., fur, feathers) that would minimize the amount of uptake of COPCs across the skin.

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

Since the Project is a proposed metal mine, the primary COPCs considered in the effects assessment are metals. The potential for exposure of wildlife to COPCs in water or through the aquatic dependent food chain will be considered in the effects assessment.

Changes in water quality have the potential to affect wildlife health, either directly through drinking or indirectly through dietary uptake in water-dependent food chains. Data from the water quality model (expected case and unrecovered seepage sensitivity case) were used to select COPCs during all phases in the open pit, TMF, and the waterways downstream of the Project Site. Modelling nodes are described in Chapter 13 and Appendix 13-C, and included locations on Jones Creek (J1), Baker

Creek (BK0 and BK1), P Creek (P Creek), T Creek (T Creek), and Harper Creek (HP, HM, HT, and HB). The water quality model was developed taking into account mitigation measures intended to protect water quality, described in Section 13.5.2 and in various management and monitoring plans such as the Mine Waste and ML/ARD Management Plan (Section 24.9), the Groundwater Management Plan (Section 24.8), the Sediment and Erosion Control Plan (Section 24.11), and the Site Water Management Plan (Section 24.13).

Two steps were used in the screening process for selection of COPCs for wildlife in water:

1. Predictive model results were compared against the BC WQGs for wildlife (Table 16-B1; BC MOE 2014a, 2014b) described in Chapter 13 and Appendix 13-D). This comparison was made to identify parameters that have the potential to affect wildlife health.
2. If a parameter was predicted to have a concentration greater than the applicable guideline, the predicted concentration was compared to the baseline concentration at that site. This comparison was made to identify parameters that have elevated concentration due to Project-related activities. Comparison of predicted concentrations to baseline concentrations ensures that parameters that are naturally-elevated are not selected as Project-specific COPCs, unless their concentrations are predicted to be greater than those that occur naturally.

Table 16-B1. BC Water Quality Guidelines for Wildlife

Parameter	Wildlife Water Quality Guideline (mg/L)	Type of Guideline
Aluminum	5	Maximum
Arsenic	0.025	Maximum
Boron	5	Maximum
Chloride	600	maximum
Copper	0.3	Maximum
Fluoride	1.5	Maximum
Fluoride	1.0	30-day Mean
Lead	0.1	Maximum
Mercury	0.00002	30-day Mean
Molybdenum	0.00005	Maximum
Nitrate	100 (combined nitrate and nitrite)	Maximum
Nitrite	10	Maximum
Selenium	0.002	30-day Mean

BC WQGs for wildlife were compiled from (BC MOE 2014a, 2014b)

A parameter was considered to be a COPC if the predicted concentration at a water quality modelling node was greater than both the guideline for wildlife and the baseline concentration measured at the site. If a parameter does not have a guideline for wildlife it was excluded from further consideration. Results of the screening process are found in Appendix 13-D, and will be summarized in subsequent sections for each phase of the Project.

If specific COPCs were identified in water, the potential for the COPC to bioaccumulate in the food chain was also considered. Metals that are known to bioaccumulate or biomagnify in the food chain include selenium, mercury, and molybdenum; identification of these metals as COPCs would indicate that exposure via the food chain would be an important consideration in the assessment of the potential for toxicity to wildlife VCs.

Potential Contaminants Excluded from Consideration

Chemicals associated with mining activities include those used by the mine during the Construction and Operation phases. Examples of chemicals used or stored on-site will include materials such as fuel, oil and waste oil, hydraulic fluid, flocculants, chemical reagents and solvents, lead acid batteries, and explosives. These chemicals will be stored and handled according to safe handling and storage procedures (Chapter 5, Project Description; Section 24.18, Waste Management Plan; Section 24.7, Fuel and Hazardous Materials Management Plan; Section 24.5, Explosives Handling Plan) and are not anticipated to be released into the environment at concentrations where wildlife would be affected. Any accidental spills will be addressed under the Spill Prevention and Response Plan (Section 24.15). Therefore, these materials have been excluded from consideration, and the effects assessment for the potential for toxicity in wildlife has been focused on metals.

Modelling Nodes Excluded from Consideration

The wildlife VCs that could be affected by water quality in the open pit or TMF are Migratory Birds, Raptors, Amphibians, and Large Mammals, since the ponds may appear as attractive habitat if not properly managed. A number of COPCs for wildlife were identified in the open pit (fluoride, molybdenum, mercury, and selenium) and the TMF (selenium). With mitigation (Section 16.5.2), wildlife exposure to water in the open pit or TMF is expected to be minimal and, therefore, residual effects to wildlife VCs due to COPCs in the open pit or TMF are not predicted. Therefore, COPCs identified in the open pit and TMF were not considered any further in the assessment.

Contaminants of Potential Concern for Wildlife

Selection of COPCs was based on the water quality modelling results from the expected case and the unrecovered seepage sensitivity case. The only COPC identified for wildlife, outside of the TMF and open pit, was selenium at the P Creek, T Creek, and Harper Creek (HP, HM, HT, and HB) modelling nodes. As shown in Table 16-B2, COPCs for wildlife were not identified at any of the other modelling nodes.

Exposure Assessment

Predicted Selenium Concentrations in P, T, and Harper Creeks

Selenium at P Creek Modelling Node

The P Creek modelling node is located in the lower end of P Creek, just upstream from the confluence with Harper Creek. Based on the unrecovered seepage sensitivity case, selenium concentrations in water are predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) in August of Years 3 to 28 (Operations 1 and Operations 2 phases), peaking in August of Year 28 at 6.2 µg/L. The concentration of selenium is predicted to be below BC WQGs during all other months and phases.

Table 16-B2. Contaminants of Potential Concern for Wildlife

COPCs Based on the Expected Case Water Quality Model Results					
Model Node	**Construction**	**Operations 1**	**Operations 2**	**Closure**	**Post-Closure**
BK0	-	-	-	-	-
BK1	-	-	-	-	-
J1	-	-	-	-	-
P Creek	-	-	-	-	-
HP	-	-	-	-	-
HM	-	**Se***	**Se***	-	-
T Creek	-	-	-	**Se**	**Se**
HT	-	**Se**	**Se**	**Se**	**Se**
HB	-	-	-	**Se**	**Se**
COPCs Based on the Unrecovered Seepage Sensitivity Case Water Quality Model Results					
Model Node	**Construction**	**Operations 1**	**Operations 2**	**Closure**	**Post-Closure**
P Creek	**Se**	**Se**	**Se**		
HP	-	**Se**	**Se**		
HM		**Se***	**Se***		

(*) means that although the parameter was identified as a COPC based on the screening procedure it was not carried into the residual characterization section (see rationale provided in text for each modelling node).

Selenium at HP Modelling Node

The HP modelling node is located in upper Harper Creek, just downstream of the confluence with P Creek.

Based on the expected case water quality model results, no COPCs were identified at the HP modelling node. Based on the unrecovered seepage sensitivity case, selenium concentrations in water are predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) by up to 3.0 fold in:

- February and March of Years 3 and 4 (Operations 1 phase);
- January to March of Years 5 to 7 (Operations 1 phase);
- January to March and December of Years 8 and 9 (Operations 1 phase);
- January to March, September, and December of Years 10 to 12 (Operations 1 phase);
- January to March, September, November, and December in Year 13 (Operations 1 phase);
- January to March and September to December in Years 14 to 17 (Operations 1 phase);
- January to March and August to December in Years 18 to 23 (Operations phase 1);
- January to March and September to December in Years 24 and 25 (Operations 2 phase); and
- January to March and August to December in Years 26 to 28 (Operations phase 2).

Selenium is predicted to be below BC WQGs in all months and years after January of Year 29. The concentration of selenium is predicted to increase throughout Operations 1 phase to a maximum of 6.0 µg/L in March of Year 27 of Operations 2 phase.

Selenium at HM Modelling Node

The HP modelling node is located in upper Harper Creek, approximately midway between P and T creeks.

Based on the expected case water quality modelling results, selenium is predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) with a maximum concentration of 2.8 µg/L during:

- March of Years 19 to 21 and Year 25 of the Operations 1 and 2 phases; and
- February and March in Years 22 to 24, 26, and 27 of the Operations 1 and 2 phases.

Based on the unrecovered seepage sensitivity case, selenium is predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) with a maximum concentration of 2.1 µg/L during March of Years 15, 16, 20, 21, 23, 27, and 28 of the Operations 1 and 2 phases.

In both models, selenium is predicted to be below the BC WQGs in all other months and in all other phases. Based on the timing of the elevated selenium concentrations (winter, low flow), it is unlikely that the selenium will be taken up into the aquatic food chain since there is limited productivity in the lower trophic levels during the winter. The concentration of selenium is only marginally greater than the BC WQG and, based on a literature search conducted to support the Selenium Management Plan (see Section 24.12), it is unlikely that a concentration of 2.8 µg/L occurring during the non-growing season in a lotic (fast flowing) aquatic environment would have adverse effects on wildlife. Therefore, the predicted elevation of selenium concentrations at the HM modelling node is not considered further.

Selenium at T Creek Modelling Node

The T Creek modelling node is located in the lower end of T Creek, just upstream from the confluence with Harper Creek.

Starting in June of Year 31, selenium concentrations in water are predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) during all months throughout the Closure and Post-Closure phases. The concentration of selenium is predicted to be highest in the third and fourth years of the Closure phase (October to December of Year 31 and January to March of year 32, 12.1 µg/L), with concentrations decreasing annually thereafter. The minimum predicted concentration throughout the Closure and Post-Closure phases is 4.5 µg/L in May of Years 94 to 99. Concentrations of selenium are generally predicted to be higher during periods of lower flow (September through April), and lower during higher flow periods (May to August).

Selenium at HT Modelling Node

The HT modelling node is located in upper Harper Creek, just downstream of the confluence with T Creek. Selenium concentrations in water are predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) by up to 3.0 fold in:

- March of Years 19 to 21 (Operations 1 phase);
- February and March of Years 22 to 28 (Operations 1 and 2 phases);
- June, July and September to December of Year 31 (Closure phase);
- all months except August of Years 32 to 42 (Closure and Post-Closure phases);
- all months except August and November of Years 43 to 46 (Post-Closure phase);
- six to nine months per year in Years 47 to 65 (Post-Closure phase); and
- February to April, June, and October during in Years 66 to 99 (Post-Closure phase).

The concentration of selenium is predicted to be peak in March of Year 36 (5.9 µg/L), with concentrations decreasing annually thereafter. Concentrations of selenium are generally predicted to be higher during periods of lower flow (September through April), and lower during higher flow periods (May to August).

Selenium at HB Modelling Node

The HB modelling node is located in lower Harper Creek, just upstream of North Barrière Lake. Selenium concentrations in water are predicted to be greater than the BC WQG (0.002 mg/L or 2 µg/L) in:

- March of Year 32 (Closure phase, 2.03 µg/L)
- February and March of Years 36 to 41 (Post-Closure phase); and
- March of Years 42 to 72 (Post-Closure phase).

The concentration of selenium is predicted to be highest in the first year of the Post-Closure phase (March of Year 36, 3.2 µg/L), with concentrations decreasing annually with time. Concentrations of selenium in water are predicted to be below the 30-day average BC WQG (2 µg/L) in all months after March of Year 72. Concentrations of selenium are predicted to be higher during periods of lower flow (September through April), and lower during higher flow periods (May to August).

Wildlife Valued Components that could be Affected by Selenium

To determine which wildlife VCs may have the potential for residual effects due to exposure to COPCs, the spatial extent of potential changes to the aquatic or terrestrial environment (e.g., due to changes in water quality) was compared to the spatial distribution of the wildlife VC (e.g., based on habitat suitability mapping, or where VCs may be expected to be present). This identified the VCs that might have an operable exposure pathway to COPCs. If wildlife VCs and their habitat are not present in the areas predicted to have elevated COPC concentrations, these wildlife VCs were not considered any further in the effects assessment of the potential for toxicity. In addition, the sensitivity of the wildlife VC was considered; species with low sensitivity were excluded from further consideration.

Potential exposure routes from dust deposition or changes in water quality and wildlife VCs are shown in Table 16-B3. Exposure pathways that were determined to be "negligible" are not considered further in the assessment of residual effects because it is unlikely that the exposure pathway will result in exposure of the VC to concentrations of COPCs that are high enough to lead to adverse effects.

Table 16-B3. Exposure Routes for Selenium for the Wildlife VCs

Valued Component	COPC in Water	COPC in Fugitive Dust
Western Toad	Negligible	Negligible
Barn Swallow	Negligible	Negligible
Common Nighthawk	Negligible	Negligible
Olive-sided Flycatcher	Negligible	Negligible
Harlequin Duck	**Yes**	Negligible
Northern Goshawk	Negligible	Negligible
Bald Eagle	Negligible	Negligible
Fringed myotis	Negligible	Negligible
Little brown myotis	Negligible	Negligible
Northern myotis	Negligible	Negligible
Fisher	Negligible	Negligible
Mule deer	Negligible	Negligible
Wolverine	Negligible	Negligible
Grizzly bear	Negligible	Negligible
Mountain caribou	Negligible	Negligible
Moose	Negligible	Negligible

Amphibians

Western toad is the representative species for amphibians. Western toad are typically found in wetlands or other locations with still (lentic) water during the breeding season, and in forested areas away from the water during the winter season. Western toad would not be expected to be found in the lotic environment of P, T, or Harper creeks; therefore, with limited potential for exposure to selenium, Western toad was excluded from further assessment.

Birds

The exposure route for harlequin duck was considered to be operable, meaning that harlequin duck could be exposed to Se via the aquatic food chain. Although not observed during baseline studies, suitable habitat for this species was found to be present in Harper Creek but not tributaries (Section 16.4.3.4 and Appendix 15-A). By assessing the potential for effects to the representative species at highest risk, the risk to other bird VCs is conservatively over-estimated (i.e., risk to other bird VCs would be lower).

Raptors (e.g., the bald eagle VC) occupy a position at the top of the food chain and can bioaccumulate some COPCs, such as Se, through the food chain. However, raptors are likely to avoid areas in close proximity to the Project footprint (due to sensory disturbance or habitat alteration), have large home ranges for hunting food (much of which would be uninfluenced by the Project), and consume diverse prey species. Some raptors may consume fish, which could also bioaccumulate Se in the aquatic environment (Chapter 14), but there are no fish in most of P or T creeks (Section 14.4.2.3) and relatively limited populations of fish present in Harper Creek in the areas where Se is predicted to be elevated. Raptors would be at lower risk of toxicity due to selenium than waterbirds (i.e., birds dependent on the aquatic food chain that reside on or near P, T, or Harper creeks would have a greater degree of exposure to Se in water or via the diet), so assessing the risk to migratory birds would provide a conservative estimate of the risk to raptors. Given these factors, raptors were not considered further in the effects assessment.

Small and Large Mammals

Other wildlife VCs were excluded from further consideration since Se was the only COPC identified in the receiving environment. Selenium may be bioaccumulated by most wildlife but none of the documented incidences of elevated selenium concentrations in tissues of most mammals (except ungulates) indicated any negative impacts to these organisms (Puls 1988; Janz et al. 2009)

While bioaccumulation of selenium is possible for ungulates (e.g., mule deer, mountain caribou, and moose VCs), these mammals are herbivores. Thus, effects of uptake of bioaccumulative COPCs in these animals would predominantly be through direct exposure to soil and vegetation, and the effects of bioaccumulation in these mammals would be more heavily dependent on soil quality. No specific COPCs were identified in soil (see section "Exclusion of Ingestion of Fugitive Dust as an Exposure Pathway"), and it is unlikely that ungulates (or other wildlife VCs) will forage exclusively in areas where Project-related dust deposition may occur. Therefore, ungulates were not considered any further.

TOXICITY ASSESSMENT AND RISK CHARACTERIZATION

Harlequin duck are the only wildlife VC that were identified to have an operable pathway for exposure to selenium. The toxicity assessment included conducting a literature search to determine the toxicity thresholds for harlequin ducks (or birds in general). Risk characterization was done by comparing toxicity thresholds to the predicted concentration of the COPC to determine whether toxicity was likely to occur.

Potential Adverse Effects to Birds due to Selenium in Water

Although Se is an essential element for vertebrates and is required for good health, like most chemicals, it becomes toxic at high doses. Egg-laying vertebrates, such as amphibians and water-dependent birds, are among the more sensitive ecological receptors to toxicity caused by Se. At the primary producer trophic level, uptake of Se is directly from the water. However, the major pathway of Se bioaccumulation in organisms at higher trophic levels is via uptake through diet, not through the water column (Orr, Guigutr, and Russel 2006; Chapman et al. 2009; Orr et al. 2012).

Selenium that is taken up via the diet can be transferred from the female to egg (known as maternal transfer), where it can have effects on the developing embryo. High levels of Se can cause mortality or deformities in developing embryos, reduced hatchability of fertilized eggs, and reduced fledging success of nestlings (Janz et al. 2009; Harry M. Ohlendorf et al. 2011). Relatively little is known about the toxicity of Se in amphibians, but it is suspected that amphibians have similar sensitivity to Se as other egg-laying vertebrates (H. M. Ohlendorf 2003; Janz et al. 2009).

Toxicity Assessment

Adverse effects to birds from Se occur due to the transfer of Se from the maternal body burden or diet into the eggs, with effects observed in developing embryos or in early-life developmental stages (Section 16.5.1.4). The predicted changes in water quality during Operations (P Creek, HP, and HT modelling nodes), Closure phase (at T Creek, HT, and HB modelling nodes) and Post-Closure phase (T Creek, HT, and HB modelling nodes) have the potential to affect Harlequin ducks) health due to bioaccumulation of Se in the aquatic food chain.

No studies of the effects of selenium on harlequin duck could be located. Toxicity thresholds for various other species of birds range from approximately 7 to greater than 20 µg/g dw, based on the concentration of Se in the egg (Janz et al. 2009; H. M. Ohlendorf and Heinz 2011; Beatty and Russo 2014).

Harding, Graham, and Paton (2005) related aqueous Se concentrations to effects on Spotted Sandpiper and found a slightly reduced hatchability at the highest measured mean egg Se concentration of 7.3 µg/g dw. However, subsequent studies and data analysis suggested that Spotted Sandpiper may be able to regulate their body burdens of Se, such that the rate of bioaccumulation decreases as the concentration of Se in water increases (i.e., the relationship is polynomial rather than linear) and plateaus at concentrations at or near the toxicity threshold (Rescan 2013). This is similar to the findings of studies on Red-winged Blackbirds, where the rate of bioaccumulation decreases and the regression relationship between Se in water and Se in egg plateaus near the toxicity threshold (Golder Associates Ltd. 2007; SciWrite Environmental Services Ltd. 2007; Harding 2008). Additional data will be required to confirm this for Spotted Sandpiper, since there is limited data available for Se concentrations in bird eggs at higher water concentrations.

Using the bioaccumulation model developed for the Quintette Mine (Selenium Management Plan, Section 24.12; Golder Associates Ltd. 2012), toxicity thresholds for Se in water can be back-calculated based on toxicity thresholds that would be expected to be protective of bird species reliant on aquatic environments. To be conservative, the toxicity threshold (rounded down to 7.0 µg/g dw) reported by Harding, Graham, and Paton (2005) was used to back-calculate an environmental target for Se that would be protective of birds. Back-calculation yields a water concentration of Se of 11.5 µg/L; this concentration of Se in water would be expected to be protective of sensitive bird species dependent on the aquatic food chain and was used as the toxicity threshold for harlequin ducks.

Risk Characterization

Potential habitat for harlequin ducks was only observed in Harper Creek, and not in the tributaries such as P and T creeks. Residual effects to harlequin duck were only considered possible at the modelling nodes in Harper Creek (i.e., HP, HT, and HB modelling nodes).

In addition, harlequin duck would be present in Harper Creek during the breeding season only (i.e., May through August) and would not be present in the winter months. Sites where selenium is predicted to be greater than the guidelines only in the winter months were also excluded from consideration (i.e., HB modelling node).

Therefore, residual effects to harlequin duck were assessed based on water quality predictions at the HP and HT modelling nodes, where there is the potential for both spatial and temporal overlap of harlequin duck habitat with the timing of elevated selenium concentrations.

Based on the expected case water quality model results (Appendix 13-C), the maximum predicted concentration is 5.9 µg/L during the first year of the Post-Closure phase at the HT modelling node. Based on the unrecovered seepage sensitivity case (Appendix 13-C), the maximum predicted concentration of selenium in Harper Creek is 6.0 µg/L at the HP modelling node during the Operations 2 phase. The predicted concentrations are lower than the toxicity threshold for birds of 11.5 µg/L, and below the environmental target concentration proposed for Harper Creek (i.e., 10 µg/L; Selenium Management Plan, Section 24.12).

The likelihood that toxicity will occur in harlequin duck due to Project-related elevation in Se concentration in the aquatic environment is low. This is because the concentration of Se is predicted to increase in the lotic environments of Harper Creek but is expected to remain below toxicity thresholds for birds. In other words, although the concentration of Se in water is predicted to be greater than guidelines for wildlife, it is unlikely that birds will experience toxicity due to Se exposure. Monitoring will be carried out under the Fish and Aquatic Effects Monitoring and Management Plan (Section 24.6) and the Selenium Management Plan (Section 24.12) to ensure that potential effects in the aquatic environment are identified and adaptively managed as needed.

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