Fisheries and Oceans Canada | Pêches et Océans Canada
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Pacific Region

Canadian Science Advisory Secretariat
Science Response 2015/031

REVIEW OF PROPOSED INTRA-BASIN TRANSFERS AS PART OF THE ENVIRONMENTAL IMPACT STATEMENT FOR THE BLACKWATER MINE PROJECT

Context

New Gold Inc. (Proponent) is proposing a new open pit gold and silver mine (Blackwater Mine) in British Columbia, located 110 km southwest of Vanderhoof. As part of their project, the Proponent has proposed to conduct transfers of water and associated aquatic organisms within the Project Area to two other systems within the same basin. The proposed transfers are within the Nechako River Basin, and include both the diversion of the Davidson Creek headwaters to the Fawnie Creek watershed and pumping of Tatelkuz Lake water to Davidson Creek (both within the Chedakuz Creek watershed). Currently, there is little scientific information available for regulators to advise Proponents on the potential risks or impacts of intra-basin transfers or manipulations within a watershed, nor is there documented guidance for Proponents in the preparation of their proposals.

The Blackwater Mine project is currently undergoing a federal Environmental Assessment (EA) in accordance with the Canadian Environmental Assessment Act (CEAA 2012). Fisheries and Oceans Canada (DFO) Fisheries Protection Program (FPP) has requested that DFO Science assess the sufficiency of the Proponent's Environmental Impact Statement (EIS) with respect to the potential effects of proposed intra-basin transfers and provide advice regarding the data requirements, potential risks, and impacts associated with the proposed transfers to fish and fish habitat.

The purpose of this Science Response (SR) is to review information provided by the Proponent in the Environmental Impact Statement to address the specific objectives outlined below:

1. Assess whether the proposal accurately characterizes the changes to fish and fish habitat, and the potential risks, impacts and uncertainties associated with:
    a. flow augmentation from Tatelkuz Lake to Davidson Creek; and,
    b. diversion of Lake 1682 (Chedakuz Creek watershed) to Lake 1538 UEUT (Fawnie Creek watershed)
2. If not, assess the risk to fish and fish habitat, and comment on uncertainties related to potential impacts associated with the proposed intra-basin transfers, including but not limited to:
    a. change in water temperature, chemistry and flow regime in Davidson Creek;
    b. loss of gravel recruitment, instream habitat and riparian value in Davidson Creek;
    c. disruption of homing instincts and changes in habitat that may lead to loss in fisheries production in Davidson Creek;
    d. potential introduction of Rainbow Trout from Chedakuz Creek watershed to the Fawnie Creek watershed;
    e. effects on genetic diversity; and,
    f. introduction of aquatic invasive species and/or pathogens.

3. Provide advice on additional data or information that would be required to adequately assess the risks of intra-basin transfers for this project and, if possible, future projects.

The advice arising from this Canadian Science Advice Secretariat (CSAS) Science Response will assist in DFO FPP's participation in the EA and submission of advice to the CEA Agency and subsequent regulatory requirements of Section 35(2)(b) of the *Fisheries Act,* if applicable. The assessment and advice provided by DFO Science in review of the Proponent's EIS may also be used to provide guidance for similar projects in the future.

This Science Response Report results from the Science Response Process of March 27, 2015 on the Review of proposed Intra-basin Transfers as part of the Environmental Impact Statement for the Blackwater Mine project.

Background

Project Description

The Blackwater mine project proposes two intra-basin transfers primarily to mitigate or off-set the anticipated serious harm to fish and fish habitat resulting from mine infrastructure and operations associated with the new open pit gold and silver mine to be located south of the Nechako Reservoir and east of the Entiako River (Figure 1). One transfer involves the permanent diversion of a headwater lake (Davidson Creek Watershed; a subwatershed of Chedakuz Creek watershed) to an adjacent watershed (Creek 705 Watershed; a subwatershed of Fawnie Creek watershed) which drains into the Entiako River before entering the Nechako Reservoir; the other involves pumping lake water (Tatelkuz Lake) to Davidson Creek to augment flows for fish for a minimum period of 35 years (Figure 2). Tatelkuz Lake lies between Davidson Creek and Creek 661 Watersheds, and contributes to the Chedakuz Creek Watershed, which drains into the Nechako Reservoir.

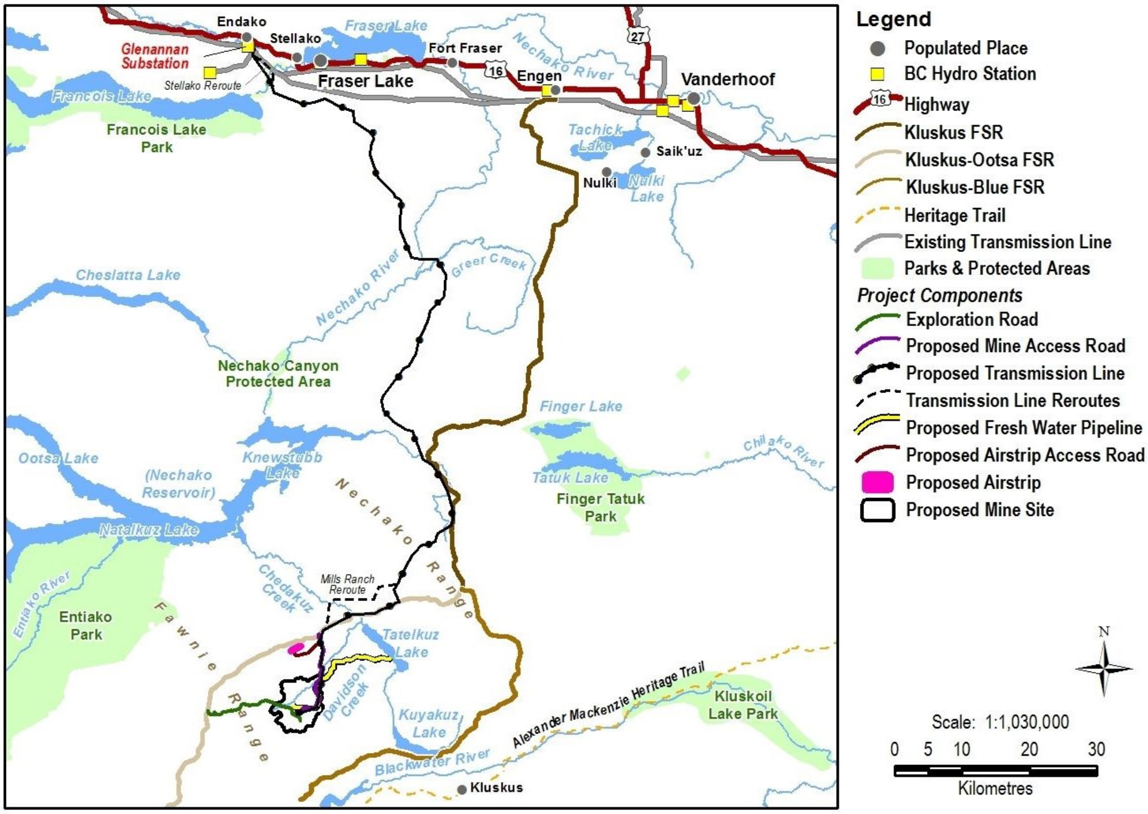

Figure 1. Proposed mine site, and associated water systems. (from New Gold, 2014. Application for an Environmental Assessment Certificate/Environmental Impact Statement – Executive Summary. Figure ES 1: Project Location).

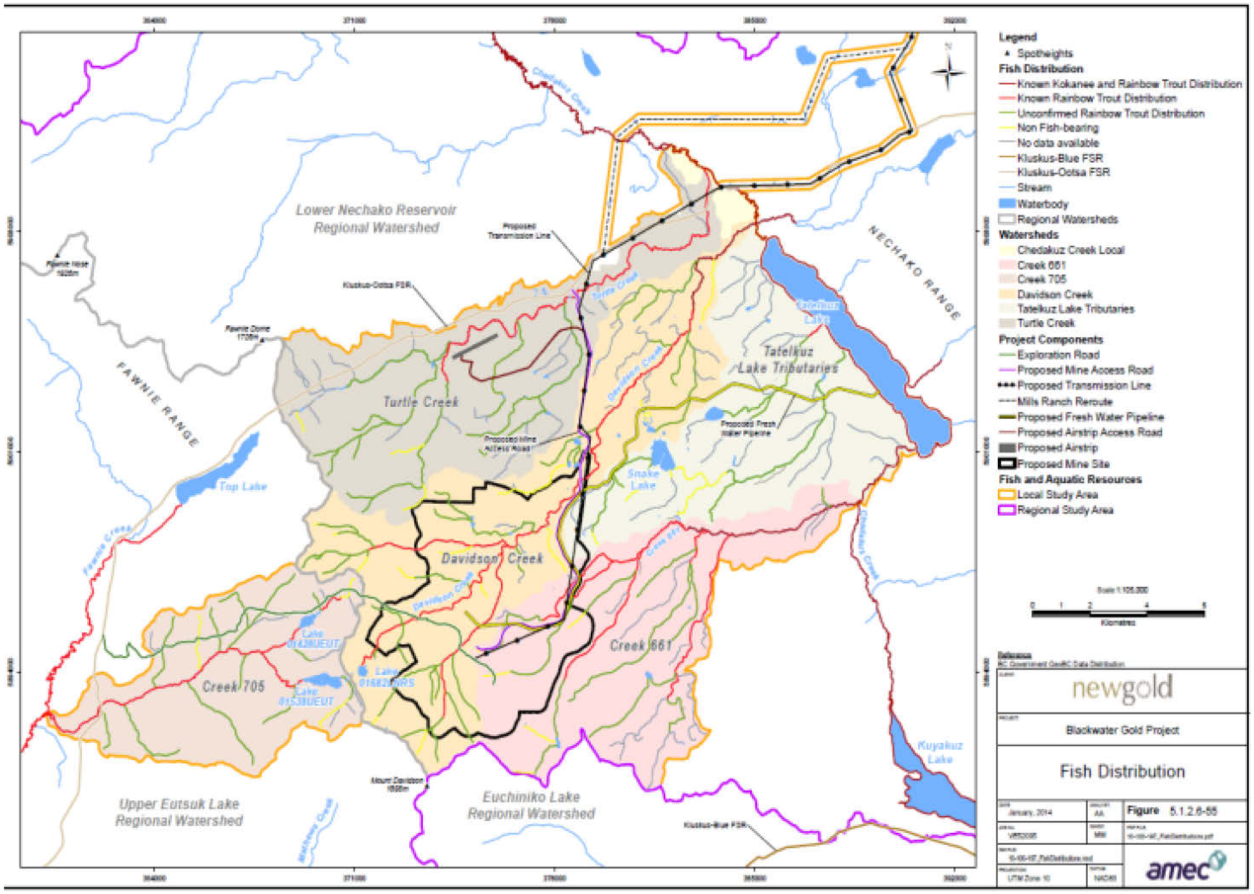

Figure 2. Watershed map of proposed mine site and proposed areas of intra-basin transfer. (from New Gold, 2014. Application for an Environmental Assessment Certificate/Environmental Impact Statement – Assessment of Potential Environmental Effects. Volume 2, Section 5.1.2.: Environmental Baseline – Aquatic Environment, Subsection Fish and Fish Habitat. Figure 5.1.2.6-55: Fish Distribution).

Most mining activity is located in the upper half of Davidson Creek Watershed, which has an approximate surface area of 86 km^2 (Figure 2). Davidson Creek originates from a small headwater lake (Lake 01682 LNRS) located near the drainage divide between Chedakuz and Fawnie Creek watersheds, and flows north-east from Mount Davidson to lower Chedakuz Creek. Elevations range from 1,700 masl (metres above sea level) at the summit of Mount Davidson to 950 masl at the confluence with Chedakuz Creek. Approximately 58% of water by volume and 249 ha of riparian habitat will be lost or removed within the Davidson Creek Watershed due to mine development.

The headwaters of Davidson Creek will be captured by the tailings pond and associated works, resulting in a loss of flow to the lower reaches of the creek during the operation and closure phases of the mine; estimated to be a period of 35 years. To mitigate this loss, the Proponent proposes to pump water from Tatelkuz Lake into a small impoundment, and release water under a seasonal flow schedule to Davidson Creek. It is estimated that up to 6 million m^3/yr of lake water will be pumped through an 8 km buried pipeline to augment instream flow needs in lower Davidson Creek for fish and mining operations. To avoid entrainment of fish and other larger organisms, fish screens will be installed at the intakes.

Creek 705 Watershed (45 km^2) drains south-west of Mount Davidson into Fawnie Creek. Elevations range from approximately 1,500 masl to 1,000 masl near the confluence of Creek

705 and Fawnie Creek. Creek 705 has two headwater lakes; Lake 01538 UEUT (into which Lake 01682 LNRS will be diverted) and Lake 01428 UEUT. The proposed diversion of Lake 01682 LNRS to Creek 705 Watershed will increase its current size from 9.2 ha to a proposed 21.7 ha.

Aquatic Species of Interest

The primary aquatic species of interest in the study area are Kokanee (*Oncorhynchus nerka*), the landlocked life history variant of Sockeye salmon, and Rainbow Trout (*Oncorhynchus mykiss*). Kokanee and Rainbow Trout are the two most numerous fish species in the study area, are both components of recreational and Aboriginal fisheries, and have been assessed to be directly affected by the development of this mine site. Rainbow Trout populations exist in Davidson Creek and Lake 01682 LNRS, and are considered genetically distinct from each other. However, only the lake population is considered resident, as the Rainbow Trout adults in the lower and middle Davidson Creek migrate to Tatelkuz Lake or Chedakuz Creek after spawning to forage and overwinter. Trout fry and juveniles remain one to two years in Davidson Creek before migrating downstream. Kokanee adults also spawn in lower Davidson Creek; the average abundance during the baseline period was about 4,000 fish (EIS Section 5.1.2.6.3.2.4.7). This is considered a distinct population as genetic markers and life history (spawn timing) suggests this group-differs from other spawning aggregations in the basin (Taylor, 2013[1]).

In accordance with the *Federal Fisheries Act*, DFO is responsible for the sustainability and protection of fish that are part of, or contribute to, “commercial, recreational, or Aboriginal fisheries”. Both fish species are considered part of a fishery and thus are protected under the Federal *Fisheries Act.* No federally listed species-at-risk were identified in the EIS.

Risks Assessed

In addition to assessing the potential impacts associated with changes in hydrodynamics, water chemistry and temperature, and habitat structure, this assessment also considers the potential risk from aquatic invasive species and/or pathogens that may result from the proposed mitigation strategies.

“A Canadian Action Plan to Address the Threat of Aquatic Invasive Species" (2004) provides clear direction on activities that involve inter-basin transfers (movement of water from one drainage basin to another) by stating they should not occur, but the guidance for intra-basin transfers (movement of water within the same basin) is less clear, stating only that caution should be exercised due to the risk of spreading invasive species or disease causing organisms. Water diversions have been recognized as a major pathway for aquatic invasive species (AIS), including high risk species such as dreissenid mussels. Although in a majority of cases these diversions have been at the inter-basin scale, the movement of species also can occur at the intra-basin level when species (or populations/genetic entities) and/or their diseases/pathogens are not homogenously distributed across the landscape.

[1] Taylor E.B. 2013. Microsatellite DNA analysis of populations of kokanee (Oncorhynchus nerka) in the Tatelkuz Lake/Chedakuz Creek Watershed, Interior British Columbia. Prepared for New Gold Inc. by the Department of Zoology, University of British Columbia, Vancouver, BC. February 2013

Analysis and Response

To prepare this response, the following sections of the EIS were reviewed:

Section/Document	Title
Section 5.1.2	Aquatic Environment
Section 5.3.2	Surface Water Flow
Section 5.3.3	Surface Water Quality
Section 5.3.8	Fish
Section 5.3.9	Fish Habitat
Section 12	Summary of Proposed Environmental and Operational Management Plan
Section 13	Follow-up Monitoring and Compliance Reporting
Section 19	Summary of Residual Effects
Section 20	Summary of Mitigation Measures
Appendix 5.1.2.6C	Fisheries Mitigation and Offsetting Plan
Appendix 5.1.2.6D	Instream Flow Study
Appendix 5.1.2.6E	Homing Assessment
Appendix 5.2-4	Periphyton Taxonomic Composition and Density in Streams, 2011-2012
Appendix 5.3-1	Benthic Macroinvertebrate Taxonomic Composition and Density in Streams, 2011-2012
Appendix 5.4-3	Lake Phytoplankton Taxonomic Composition and Density, 2012
Annex 5.5-1	Lake Zooplankton Taxonomic Composition and Density, 2012
Annex 5.6-1	Lake Benthic Macroinvertebrate Taxonomic Composition, 2012

DFO Science Branch responses to the three objectives requested by DFO FPP (above; see Context) are detailed below.

Change in temperature in Davidson Creek

Adequacy of Proposal

New Gold predicts the pumping of deep water from Tatelkuz Lake using the proposed Freshwater Supply System (FSS) to Davidson Creek will alter the thermal regime of the creek. Similar to the situation that often occurs for rivers below storage reservoirs (Olden and Naiman 2010), temperatures in the creek are predicted to be cooler in the summer, and warmer in the fall and winter post-construction. Predictions of temperatures in Davidson Creek (e.g. Table 5.3.3-21) appear to be based on limited field data and a simplistic mixing model. It seems likely that the proposed headpond for the FSS will result in heat exchange with the air, especially during winter months. Some cooling might be expected in the pipeline as well, as the ground will freeze from the surface during winter. No attempt has been made to model the effects of heat exchange between water and air in the headpond and the changes in water temperature that may occur down the length of the stream. There is a correction that has been applied based on observed temperatures, but a more explicit approach that accounts for the actual inflows and predicted heat exchange would be required to predict temperatures more accurately. These shortcomings likely result in warmer predicted winter temperatures than will be observed in the lower creek. The magnitude of the bias is uncertain, but it may be important for the development of Kokanee eggs and alevins (see below).

Davidson Creek is also used for spawning by adult Rainbow Trout and as a nursery area for juvenile trout before they migrate to Tatelkuz Lake as sub-adults. The FSS releases are expected to lower summer temperatures and increase fall and winter temperatures over the baseline, as noted above. Lower summer temperatures will extend the period of egg and larval incubation, and has the potential to reduce growth of age-0 trout; this may effect survival, but the effects may be countered by the presence of warmer water in the fall months. The EIS concluded that the impact was considered to be “not significant” (Table 5.3.8-60). This statement cannot be adequately evaluated by DFO, due to the limitations of the temperature modelling.

Potential risks to productivity

As impacts to fish species are dependent on their life histories, the following analysis considers Kokanee and Rainbow Trout separately.

Kokanee

Kokanee spawn in Davidson Creek in mid-summer and fry emerge from spawning gravels in the spring (likely May or June) and migrate to Tatelkuz Lake. The Proponent notes that warmer fall and winter temperatures are predicted to accelerate the development of eggs and alevins in the spawning beds, but the effects were considered to be “not significant” with moderate confidence (Table 5.3.8-60). However, detailed studies on the ontogeny of sockeye salmon from small streams in the Stuart-Takla region, 200 km to the north, suggest that relatively small changes in water temperature can have impacts on development and potentially the survival of sockeye eggs and larvae (Macdonald et al. 1998).

Water temperatures in small streams in central BC are near 0°C from November to May (Figure 5.1-1; Macdonald et al. 1998). The temperature-dependent development of eggs and alevins in the spawning beds for fall spawning species depends largely on heat during the summer and fall period, as little development will occur over the winter months. After spawning in mid-August, Sockeye salmon eggs hatch in the fall, and larval development is nearly complete by November when temperatures fall to 0°C. Emergence from spawning gravels occurs in late April and May as water temperature rises to 5°C. Fry migrations from spawning streams are presumed to co-occur with the onset of biological production in the nursery lakes. Macdonald et al. (1998) hypothesize that relatively small changes in water temperature, in their case resulting from clear-cut logging, could have impacts on development rates and survival of sockeye eggs, alevins and fry.

Accumulated thermal units (ATU, or degree-days) are often used to assess thermal habitats for incubating salmonids. ATU estimates for Davidson Creek were computed as the product of the number of days in the month and the monthly estimated water temperature; summed from August 1 through to April 30. Currently for Kokanee, if it is assumed that spawning occurs on August 1, and fry migration on May 1, 543 ATU accumulate at the lower site (WQ7), based on the monthly average temperature data (Table 5.3.3-21). Macdonald et al. (1998) observed an average of 660 ATU between spawning and fry emergence for Takla Sockeye salmon. ATU estimates for the project operations phase, using the “regression-derived” predictions, are 1932 and 1138 ATU for releases from 8 m and 12 m intakes in Tatelkuz Lake, respectively. The large increase is due to the predicted increase in fall and winter temperature over the baseline as a result of FSS releases.

Doubling or tripling the thermal units for incubation is a risk factor for successful recruitment for this population, as there is far more heat than required to complete development. Productivity could be reduced if Kokanee alevins deplete their yolk resources during the winter months, or migrate early to Tatelkuz Lake. Early development might result in early migration (which could be mid-winter) or a prolonged period of holding in spawning gravels. Winter temperatures are predicted to be in the 2-4°C range and will result in more energy consumption than would occur at 0°C. The energy source for alevins in spawning gravels is yolk, and once yolk is depleted, alevins will starve unless exogenous feeding commences (Macdonald et al. 1998). Some compensation in development rate does occur (compensation results in the development rate slowing at higher temperatures) and that tends to mitigate the effects of warmer water temperatures. However, Macdonald et al. (1998) find an inverse relationship between mean temperatures during the incubation period and date of fry emergence across years suggesting developmental compensation is not sufficient to completely offset variation in temperature regimes.

Rainbow Trout

The productivity of the Rainbow Trout population may be affected by elevated winter temperatures resulting from the FSS releases, but this risk is not analyzed in the EIS. Warm water releases will reduce ice cover on the creek, and in the presence of very cold air temperatures, increase the risk of frazil and anchor ice formation. Further, altered temperature regimes can disrupt the life histories of aquatic invertebrates, lowering potential food sources for fish (Brown et al. 2011). Study of juvenile salmonids rearing in ice-free areas below hydro facilities has shown evidence of reduced survival and energy storage as a result of increased activity and predation risk relative to ice-covered reaches (Hedger et al. 2013).

As noted above, it is difficult to evaluate the risks of the winter temperature regime with the information presented. As trout parr production likely limits the size of the Rainbow Trout population, losses of parr during the overwintering phase will directly impact adult abundance. A more thorough analysis of the temperatures is needed to characterize risks associated with an altered thermal regime. The biological response will be difficult to predict and will likely remain a risk factor if the thermal regime is significantly different than what occurs naturally.

Changes in Water Chemistry in Davidson Creek

Adequacy of Proposal

Fish production is often related to the potential for food production in streams; as is evidenced by the correlations between fish production or biomass and dissolved ions (as alkalinity), direct measurements of nutrients (N and P) or primary productivity (e.g., Kwak and Waters 1997). Diversion of water from a lake or impoundment can change productivity of a stream if there are significant differences in water chemistry between the source and receiving water bodies. Such effects are listed in 4.3.7 of the mitigation and offsetting plan, but the Proponent does not include any analysis in the project documentation. For example, an analysis of the potential change in water chemistry parameters that could affect primary productivity in Davidson creek, as a result of the FSS water releases, is needed to assess the risk of a change in the trophic status of the creek. Averages (over depths, seasons) are presented in Tables 5.1.2.2-1 and -5; however, these summary statistics are not detailed enough for that analysis. The analysis should focus on the water entrained from Tatelkuz Lake (from the appropriate depth) for the open water (growing season) months, and consider, if possible, the chemistry of the residual flow in Davidson Creek will receive, and mix with the FSS flows.

Potential risks to productivity

As noted in the section above, inferences regarding trophic status can be made based on alkalinity/water chemistry as well as direct measurements of nutrients or primary productivity. Based on the averages presented in Tables 5.1.2.2-1 and -5, Tatelkuz Lake appears to have a slightly lower trophic status than Davidson Creek but the differences are small, thus the potential loss of fish productivity may also be small. A more detailed analysis of the chemistry of water being pumped into Davidson creek is required to fully review the potential impacts on the productivity of Davidson Creek.

Changes to the Flow Regime of Davidson Creek

Adequacy of proposal

New Gold uses standard physical habitat simulation methods to develop their flow release schedule and calculate the potential changes to physical habitat (defined as water velocity, depth and stream bed composition) for trout and Kokanee resulting from the flow releases. The procedures follow the standardized protocols developed in British Columbia for small-scale water diversions. The resulting schedule of water releases has a seasonal pattern that resembles the natural regime and includes a spike flow designed to mobilize fine particulate material in the stream bed. The flow regime is designed to retain ~90% of the naturally occurring physical habitat under 30 day low flow conditions for the various life stages of trout and Kokanee present in the creek.

New Gold has conducted its analysis on monthly mean discharge data, as few daily discharge data are available. The shape of hydrographs, based on monthly data, is often quite different than daily data; the main difference is the freshet peak is shorter in duration and of greater maximum flows than implied by the monthly schedule. Thus the hydrographs presented do not portray the magnitude of the peak flows that are most influential in channel forming and affecting instream habitat features.

The proposed flow release schedule provides flows that are similar to, or are slightly lower than the 30 day average low flow for the 4 “stanzas” (Table 15, App 5.2.1.6D). Thus flows to the creek during the operations phase are within the natural range and have thus been experienced by the existing fish populations. In addition, the physical habitat modelling suggests the release schedule will result in a less than 10% reduction in available habitat over the naturally occurring low flows. These observations do not imply there will be no impact to the fish populations; if productivity and flow are positively related the population may benefit from “wet” years where flows are above average. Those benefits will be eliminated by the regulated regime that replicates average or dry years.

A more thorough analysis of the risks of lower flows on Kokanee spawning habitat is warranted. The effects of winter flows on habitat are not addressed, and reducing flow in winter (and maintaining a low overall flow across years) may pose risks that have not been assessed. The Proponent provides a brief analysis of water depths during the incubation periods on Page 62 of the instream flow study but it is difficult to evaluate the risks that those flows will pose to spawning areas. As the instream flow study used a stratified scheme to select transects, it should be possible to make explicit predictions about water depths and velocities for riffle habitats where spawning is likely to occur.

It is also important to note that physical habitat modelling is only a part of instream flow analysis, as the latter reflects the integration of physical habitat with other aspects of the environment affected by the project. The flow releases from the FSS should include provisions to address some of the other factors (i.e. temperature, water chemistry, fish homing) identified in this review where appropriate, as some of these factors may be more important than hydraulic habitat in determining fisheries productivity.

Potential risks to productivity

Simple relations between features of the hydrograph (flow levels) and fish production are not common in research and monitoring studies. As noted above, many factors interact to determine overall success of populations. Thus, although the flow regime has been developed using standard approaches, and is designed to provide adequate physical habitats for fish, the fisheries productivity that will result will depend on the interaction of the flow regime with other factors that have been modified by the project. Those factors should be incorporated into the design of the FSS and the flow release schedule. A well-designed monitoring program, coupled with responsive management that makes adjustments to operations as needed to address unanticipated changes, will reduce the uncertainty and risk associated with potential impacts of flow regime changes on productivity.

Changes to Instream Habitat Conditions in Davidson Creek

Adequacy of proposal

In unregulated rivers, gravel, sediment and woody debris is moved into the channel and downstream by peak flows (and in some cases by ice). Streams reach a dynamic equilibrium between inputs and losses, although there can be considerable variation in conditions due to interannual variation in flows and climate conditions.

Peak flows also shape the riparian habitat; by disturbance of the stream margins, and through the provision of flow, sediment and nutrients during high flows. Life histories of riparian species are adapted to these features of the flow regime. These channel forming processes can be altered by the presence of a dam that reduces or eliminates peak flows (Church 1995).

As noted by the Proponent, it is difficult to predict the magnitude of habitat changes associated with flow regulation during the operations and closure phases of the mine. The Proponent presents only monthly average flows in Table 5.3.2-11, so the true magnitude of peak flows cannot be assessed. As noted by the Proponent, the supply of sediment, gravel and organic debris from the headwaters of Davidson Creek will be eliminated as the FSS will supply only lake water. The proposed flushing flows will be critical for maintaining the quality of the stream bed, and they are deliberately designed to prevent the mobilization and loss of gravel or woody debris that cannot be replaced by recruitment from the headwaters. The magnitude of flushing flows is consistent with recommendations for other flow diversion projects in BC. New Gold has proposed a monitoring program with potential for remedial measures, if needed (5.1.2.6D), although there are few details.

Potential risks to productivity

The absence of a true freshet can also lead to riparian encroachment of the stream channel. In alluvial (gravel) channels this can cause significant change to habitat conditions, but in the case of Davidson creek the potential for these effects to be significant is unknown. These effects can take decades to occur, and it is noted that after mine closure, predicted peak flows will increase beyond baseline, which will mitigate some of these changes. As noted, the Proponent presents monthly averages only, so the potential impacts of the true magnitude of peak flows are unknown.

Risks to fisheries productivity associated with changes to stream habitat are difficult to predict, but can be managed with monitoring and flexibility in facility operations. For example, the timing and magnitude of the flushing flows can be varied, and it may prove useful to take advantage of natural inflow events to maximize the power of the flushing releases. Over the life of the mine the risks are likely low, if an adaptive approach is taken. The restoration of peak flows post-closure should help to restore natural processes.

Changes to Fish Migration and Imprinting in Davidson Creek.

Adequacy of proposal

The augmentation of flow to Davidson Creek has the potential to affect the migratory patterns of Rainbow Trout and Kokanee, as a consequence of changes in the chemical composition of water discharged by the freshwater supply system, but the impacts may be difficult to predict. For example, in the case of the Bridge River, BC, the re-introduction of flow (after 50 years of diversion) seemed to have little effect on the upstream migration of adult salmon and steelhead trout (Decker et al 2008), however, salmon of the nearby Seton River have been found to be very sensitive to mixing of waters of different origins (Fretwell 1989).

In addition to the homing of adults to spawning areas, juvenile trout and Kokanee have evolved to return to Tatelkuz Lake from spawning areas through a combination of downstream migration in Davidson Creek and then upstream migration in Chedakuz Creek to Tatelkuz Lake. Such migrations are thought to result from a combination of genetic and environmental controls (Kelso et al. 1981). Juvenile migration success is less likely to be affected by changes in water chemistry from the flow augmentation because no change in the water chemistry of Tatelkuz Lake and Chedakuz Creek will occur.

The Proponent's suggestion that flow augmentation is "unlikely" to disrupt migration of spawners into Davidson Creek (5.1.2.6E) is not supported. There are many unknowns, and the water diversion should still be considered a risk factor.

Potential risks to productivity

As noted by New Gold, genetic and environmental influences likely interact in determining migration routes, and the relative importance of proximal (chemical) migratory cues is difficult to predict. The Proponent notes that genetic and environmental influences likely interact in determining migration routes and the relative importance of proximal (chemical) migratory cues is unknown.

With current knowledge, it is very difficult to predict the effects of altered water chemistry and flow on the migration success of adult spawners in Davidson Creek during the construction and operations phase. Appropriate monitoring and consideration of a response plan are suggested to reduce the risk to Rainbow Trout and Kokanee populations. Further details are provided in the "Recommended Additional Data/Information Requirements" section of this assessment.

Introductions of Aquatic Invasive Species

Adequacy of proposal:

Intra-basin water transfers are identified as a potential offsetting measure, but the EIS does not specifically address the potential risk related to the introduction of AIS, or the potential redistribution of species due to these transfers. Although Table 20.1-1 does identify an Invasive Species Management Plan (ISMP) as part of the Proponent's Environmental Management System, it is unclear if this plan is intended to include the proposed intra-basin water transfers in the aquatic environment that could result in the redistribution of species. It is probable that this plan is focused more on the terrestrial environment and plant introductions related to planned activities.

There is considerable information available in the supplementary material (see list of Appendices above), but the format in which the data is recorded precludes an evaluation of the degree of similarity in species composition between the source and destination locations, and no analysis was completed specifically for AIS.

Further, the level of taxonomic resolution for some taxa is not sufficient to be able to identify if a potential AIS issue exists or not. Specifically, some organisms were not identified to species such that genera (or even higher taxonomic level classifications) could represent specific species common among locations or different species (populations/genetic units) that are geographically different. Taxonomic resolution increased as the size of the organism increased, such that the most complete taxonomic information provided was for fish species, all of which are native. However, even for this group of organisms, there were some differences between source and destination waters, suggesting that species are not equally distributed across the landscape and there is the potential to introduce organisms from source to destination locations. For example, Tatelkuz Lake water (containing 10 fish species; Table 5.3.8-5) entering Davidson Creek (only 3 fish species; Table 5.3.8-5), where only Rainbow Trout, Kokanee, and Mountain Whitefish are common between these water bodies, has the potential to allow at least some of the other fish species inhabiting Tatelkuz Lake to enter Davidson Creek where they are currently absent.

The proposal does not consider the potential redistribution of species via intra-basin water transfers. Little attention is paid to the potential implications of the proposed offsetting measures. While an analysis of potential redistribution of species via intra-basin water transfers, some information in the Proponent's submission is available and could be used to characterize the potential risk of intra-basin water transfers.

Potential risks to productivity

The detailed species lists provided in the background material were not assessed against known AIS in British Columbia. Because a spatially-explicit, searchable database or reference catalogue of known AIS in British Columbia does not presently exist, distributional information for each potential AIS would have to be identified through engagement with researchers (federal, provincial, academic) and/or managers on a case-by-case basis. No AIS were identified by the Proponent, and there is insufficient information to identify potential changes in productivity due to species redistributions, as a result of the proposed intra-basin water diversions. As noted above, fish species are not equally distributed across the landscape such that the proposed water transfers could result in new species introductions. Based on the current distribution of other fish species in other creeks surveyed in the watershed, it appears environmental conditions may be similar between source and destination waters, which may allow some species to become established (self-sustaining populations) in the receiving waters. Further, the proposed transfer of Lake 01682 LNRS water (with only Rainbow Trout; Table 5.3:8-5) to Fawnie Creek (with Rainbow Trout and Kokanee) could result in the introduction of new genetic material between these watersheds (see section Genetic Changes) but the lack of other fish species in the source water suggests the risk to receiving environments would be low (i.e., there are no additional fish species in Lake 01682 LNRS). However, for other taxonomic groups additional analyses would be required to fully assess the potential risk.

Effects on Genetic Diversity

Adequacy of proposal

The proposed diversion of Lake 01682 LNRS in the upper Davidson Creek drainage to Creek 705 in the Fawnie Creek watershed will likely lead to the introduction of Rainbow Trout from the Chedakuz Watershed to the Fawnie Creek watershed. The Proponent has conducted adequate genetic studies that indicated the Rainbow Trout from the two watersheds are closely related, but genetically and demographically distinct. The genetic analyses support the suggestion that the watersheds may have in the recent past (10-100's of years), or in exceptionally high water years, been connected, allowing fish to move between the two catchments.

The transfer of water from Tatelkuz Lake to Davidson Creek, is likely to alter spawning habitat for Kokanee and Rainbow Trout in the lower Davidson Creek watershed, as identified in previous sections of this assessment. The EIS does not explicitly address effects that reduced spawning success would have on Kokanee and Rainbow Trout population abundance and, therefore, genetic diversity within the Chedakuz drainage. Smaller populations are generally less diverse and less resilient to perturbations than larger ones.

Potential risks to productivity

An evaluation of the EIS suggestion that loss of a distinct Rainbow Trout population in Lake 016682 would represent a minor reduction in biodiversity resulting from the expected hybridization of the currently distinct but closely related Rainbow Trout populations of Lakes 01682LNRS and 01538UEUT into a single population within the Entiako River drainage is reasonable. For both Rainbow Trout and Kokanee, the altered habitat and flow regime of lower Davidson Creek may lead to lower adult abundances and reduced genetic diversity within the Davidson Creek components of the Tatelkuz Lake populations. Smaller or extirpated spawning aggregations in lower Davidson Creek would represent a minor loss of biodiversity for both species. However, connectivity with closely related spawning aggregates in Tatelkuz Lake and Chedakuz Creek tributaries could enable recolonization of the Davidson Creek Rainbow Trout and Kokanee spawning grounds, if habitat conditions supporting fish reproduction are maintained or re-established during mine operation and closure.

Introductions of Pathogens/Parasites

Adequacy of proposal

No parasite or pathogen profile was provided in the EIS for the lake or rivers in question, even though a very extensive survey of other biological factors was performed. This lack of health information precludes an assessment of the potential impact from pathogens or parasites once the systems are joined. The EIS concludes that disease would not be a significant risk in the diversion of water between systems, specifically: "Although the pathogen communities of Kokanee and Rainbow Trout were not studied as part of baseline work, it is reasonable to assume from the lack of barriers to migration and the Kokanee genetic analysis that the fish pathogen communities of the two watersheds are similar" AMEC Report Page 5.3.8-79. These conclusions are based on the genetic assessments respecting the homogeneity of the populations that are to become integrated by the diversions, which given the scale and proximity of the proposed transfers is a valid approach.

Potential risks to productivity

There was no pathogen list or screen completed for this EIS. In the absence of this information, it remains difficult to predict if significant harm to the recipient system is a possibility. The genetic data included in the Proponent's EIS indicates that there is already some mixing of stocks within this watershed, so it is likely that the pathogen/parasite profile between the systems is also similar. This reduces the likelihood of significant impact from pathogens or parasites in the diversion of water between the systems.

Additional Data or Information Requirements

The third objective for this assessment was to provide advice on additional data or information that would be required to adequately assess the risks of intra-basin transfers for this project and, if possible, future projects. The following includes both specific recommendations for the EIS reviewed, which may be generalized for this type of project, as well as suggestions for monitoring. However, a case by case assessment would be required for new projects to be assessed, as scope, scale, species affected and potential risks may vary by project.

Change in temperature in Davidson Creek

Additional work to clarify temperature effects on Kokanee egg and alevins development rates and fry emergence and potential mitigations could include:

- Explicit modelling of daily air and water temperatures during baseline and project periods to reduce errors associated with monthly means.
- Continuous depth-based temperature monitoring of Tatelkuz Lake to fully understand the thermal dynamics and availability of waters of differing temperatures.
- Modelling the thermal dynamics of the headpond.
- Explicit modelling of downstream effects of winter heat exchange on the water temperature. The presence of groundwater is inferred by observation of open leads in the winter and should be considered in the modelling.
- Consideration of a multiport intake in Tatelkuz Lake that includes a shallow intake to access colder surface waters after fall turnover.
- Consideration of measures to manage water temperature in the headpond, including circulation or variable depth outlets, as appropriate.

Additional data / information required to improve the analysis of the risks of the winter temperature on Rainbow Trout populations:

- Presentation of detailed air temperature data for the site that allows consideration of the occurrence of sub 0°C and more extreme (<-20°C) temperature events.
- Modelling the thermal dynamics of the freshwater reservoir. The capacity reservoir is variously listed as 400,000 m^3 (page 102 of FMOP) and 700,000 m^3 (page 14), with a surface area of 11ha (110,000m^2) implying the mean depth is in the 3-6m range. The winter instream flow release is 10,800 m^3/d suggesting the residence time of water in the reservoir could extend to multiple weeks depending on the use of water by the mine. There does not appear to have been an explicit consideration of the potential for cooling of this reservoir, but it could have a significant impact on the temperature of release water. The reservoir may also contribute to warming water in the summer which may mitigate some of the anticipated changes.
- Modelling the change in water temperature as the flow releases from the reservoir move downstream. Although there is likely considerable uncertainty in the modelling it should indicate the potential for freezing, and the extent of the open and ice covered areas, and the potential for frazil and anchor ice formation. The presence of groundwater inputs should be included in those considerations

Changes to the Flow Regime / Fish Migration and Imprinting in Davidson Creek

Uncertainty about the effects of the flow diversion on the migration of fish in Davidson Creek suggests an implementation program based on monitoring and management measures is needed to ensure success. Initially, a systematic monitoring program should be established that can estimate the relative proportions of spawners in different river reaches, preferably by non-invasive methods, and include the collection of baseline data for 2-3 years prior to structure start up or commissioning.

To decrease the risk of a disruption of migration patterns, as a result of flow augmentation the Proponent could include a strategy to bring the new flow augmentation structures online at an appropriate time during the summer months when spawners, juveniles and eggs are present in the creek. This would maximize the number of cohorts exposed to the new flow mixture (as eggs, juveniles, or repeat spawners).

Consideration could also be given to manipulating the flow release regimes if issues arise in attracting spawners to the creek. While the instream flow releases are designed to optimize habitat values, in the first 3-5 years the emphasis should be on establishing spawning populations in the appropriate locations. Most likely this would entail decreased releases at key times to maximize the proportion of Davidson Creek water in the lower reaches if homing to the creek is identified as an issue. Stream biota and fish are generally resilient to short-term decreases, as long as water quality parameters are maintained. Conversely, higher flows may be needed to attract Rainbow Trout spawners to the upper reaches of Davidson Creek if the regulated flows are insufficient. Short term changes in flow at key times may be required to enable migration.

Transplantation of trout spawners from the lower creek to the middle reaches is a reasonable action to stimulate imprinting to the new flow regime. However, the transplantation of fish from other streams should be avoided unless the Davidson Creek population is extirpated. The potential for genetic control of migration reduces the likelihood that transplantation of individuals from other basins would be successful unless the migration routes and other biological traits were similar. Microsatellite DNA assesses genetic divergence of neutral alleles, but not variation in adaptive traits, so the success of transplants cannot be estimated from the neutral allele analysis. Behavioural studies such as Kelso et al. (1981) suggest there is adaptive genetic variation in migration at small spatial scales and outbreeding (mixing differentiated populations) runs the risk of lowering overall fitness through the production of mal-adapted hybrids.

Introductions of AIS

To evaluate the potential risk associated with the introduction of potential AIS (i.e., species not currently present in receiving waters) an analysis that compares the species composition in the source waters to that in the destination waters for both proposed intra-basin transfers is recommended. It is probable that some species might not have been sampled, due to potential biases in sampling methodology. These potential biases are likely greater for smaller taxa than for larger ones.

For future consideration, a systematic monitoring program to identify potential species transfers between source and destination waters would be beneficial to confirm the number and type of species that can be transferred with intra-basin transfers such as the one proposed. In the case of this proposal, an analysis of similarity between source and destination waters could be conducted based on the data collected to date to determine if there were significant differences between the systems.

A current challenge with the assessment of AIS introduction potential, is that a spatially-explicit, searchable list of AIS in the province is not currently available. Such a list would allow this and future projects to cross check survey inventories with an AIS inventory. Identification of Aquatic Invasive Species or species redistributions at smaller spatial scales would be improved by development of a spatially-explicit database. Such a tool would allow for an assessment of similarities between source and destination waters for this and future projects. The utility of such a database increases with high resolution taxonomy (i.e., organisms identified to the species level).

Effects on Genetic Diversity

Follow up microsatellite surveys of Kokanee and Rainbow Trout to confirm there is low impact on abundance and genetic structure/diversity of rainbow and Kokanee populations is recommended. Surveys for Rainbow Trout and Kokanee on the same geographic scale as those in the pre-development proposal. conducted in a time frame of five to ten years after flow changes have been instituted and stabilized, is recommended.

Introduction of Pathogens

To assess the potential risks to productivity from a project like this, an inventory of the parasite and pathogen fauna from the source and receiving systems would be required to better understand the potential impacts in joining two watersheds as proposed. Conducting this as a risk profile, in advance of the water transfer, would ensure that there would not be a specific parasite or pathogen present in one system that would have the ability to negatively impact the recipient system.

Conclusions

The Proponent has identified most aspects of the changes to fish and fish habitat that are likely to occur in Davidson Creek, as a result of the use of the freshwater supply system to augment flows during the operation and closure phases of the mine. These include changes to water temperature, chemistry, flow regime and habitat conditions. In addition, an assessment of the risks from the introduction of pathogens and parasites, and changes in genetic diversity has been conducted. However, there is no assessment of the potential risks associated with the introduction of Aquatic Invasive Species or species redistributions due to intra-basin water movements.

This review has identified inadequacies in the modelling procedures, input data, and assumptions, as well as in the assessment of uncertainties. Therefore, some results and conclusions presented in the Proponent's analysis, as well as the associated uncertainties are not fully substantiated. The following are the main observations and conclusions of this review:

- No attempt has been made to model the effects of heat exchanged between water and air in the headpond and the changes in water temperature that may occur down the length of Davidson Creek. The approach taken using a correction factor is likely biased high for the winter months, and while the magnitude of the bias is unknown, this may be important for the development of Kokanee eggs and alevins. With respect to Rainbow Trout, the conclusion that the impact of temperature changes is "not significant" cannot be adequately evaluated, due to limitation of the temperature modelling.
- While the potential differences in water chemistry between the source and receiving water bodies, and potential associated effects to productivity are identified, no analysis is provided. A more detailed analysis of the chemistry of the water being pumped into Davidson creek is required to fully review the potential impact on productivity due to water chemistry changes.
- Augmentation of the flow to Davidson Creek has the potential to affect migratory patterns of Rainbow Trout and Kokanee. The Proponent's conclusion that flow augmentation is unlikely to disrupt migration of spawners into Davidson Creek is not supported; however, the effects of water chemistry on homing are difficult to predict. An integrated analysis of the risks of lower flows on trout and Kokanee populations is needed that considers all factors (e.g.,

physical habitat, temperature, water chemistry, homing and migration) that can affect productivity of these populations. An appropriate monitoring and adaptive management plan is recommended as biological responses to these changes are difficult to predict.

- There is no specific assessment of the potential risk related to the introduction of Aquatic Invasive Species, or the potential redistribution of species that may result from the proposed water transfer. While information is provided on species present in each of the source and receiving systems, the format of the data precludes an evaluation of the degree of similarity in species composition. No analysis was completed specifically for Aquatic Invasive Species.
- The Proponent has conducted adequate genetic studies that indicated the Rainbow Trout from the two watersheds are closely related, but genetically and demographically distinct. However, the EIS does not explicitly address effects that reduced spawning success would have on Kokanee and Rainbow Trout population abundance and, therefore, genetic diversity within the Chedakuz drainage if habitat loss leads to smaller or extirpated spawning aggregations in lower Davidson Creek. At the species level this would represent a minor loss of biodiversity for both species. Recolonization of the Davidson Creek Rainbow Trout and Kokanee spawning grounds is feasible, if habitat conditions supporting fish reproduction are maintained or re-established during mine operation and closure.
- No parasite or pathogen profile was provided in the EIS for the lake or rivers in question, even though a very extensive survey of other biological factors was performed. This lack of health information precludes an assessment of the potential impact from pathogens or parasites once the systems are joined. However, given the scale and proximity of the proposed transfers the likelihood of significant impact from pathogens or parasites in the diversion of water between the systems is low.

There are a number of uncertainties that cannot be resolved with pre-project assessment. Recommendations are provided to improve the EIA. In addition, a monitoring program and the commitment to adaptively manage the freshwater supply system, and related activities are needed to ensure mitigation measures perform as expected.

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