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5.3.9 Fish Habitat

5.3.9.1 Introduction

This section addresses potential effects of the Project on the Fish Habitat Valued Component (VC). The five indicators of the fish habitat VC are surface water flow, surface water quality (including water temperature), sediment quality, ecological health, and riparian habitat.

This Introduction describes the information sources of the assessment (**Section 5.3.9.1.1**), the applicable regulatory framework for the assessment of the VC (**Section 5.3.9.1.2**), the spatial, temporal, administrative and technical boundaries of the assessment (**Section 5.3.9.1.3**), the assessment approach (**Section 5.3.9.1.4**), the five fish habitat indicators (**Section 5.3.9.1.5**), and the measureable factors used for the assessment (**Section 5.3.9.1.6**).

The remainder of this section includes sub-sections dealing with the following: a brief summary of baseline data on the Fish Habitat VC (**Section 5.3.9.2**), potential effects and mitigation measures (**Section 5.3.9.3**), residual effects and their significance (**Section 5.3.9.4**), cumulative effects (**Section 5.3.9.5**), limitations of the assessment (**Section 5.3.9.6**), conclusions (**Section 5.3.9.7**), and follow-up monitoring (**Section 5.3.9.8**).

This section is similar in outline to **Section 5.3.8** – the assessment of Project effects on the fish VC. There is, however, overlap because fish live in, and depend on, fish habitat. Also, fish habitat has long been used as a surrogate for fish because fish habitat can be measured more accurately than fish numbers and does not involve sampling mortality. For many environmental issues, predicting the future condition of fish habitat is more practical, reliable and accurate than predicting the future condition of fish populations.

This section describes features of fish habitat and focuses on Project effects on fish habitat (e.g., water flow). In contrast, **Section 5.3.8** describes fish species and populations and focuses on the response of fish to environmental conditions (e.g., migration success and temperature optima). Hence, the lists of potential effects differ for each VC for each potential stressor. However, there is unavoidable overlap between the two sections.

Effects assessment was conducted on six major components of the Project: the mine site, mine access road, airstrip and airstrip access road, Freshwater Supply System (FSS), transmission line, and the Kluskus and Kluskus-Ootsa Forest Service Roads (FSR).

Fish habitat, as defined by the federal *Fisheries Act*, is “spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes” (Government of Canada, 2013). For the Project, this includes fish habitat in lakes and streams within the aquatic Local Study Area (LSA) and Regional Study Area (RSA) (both defined in **Section 4.3.1** and **Section 5.1.2.6**). In this section, most references to the LSA and RSA refer to the mine site LSA and RSA. There is also an LSA for each of the transmission line and access road corridors.

Fish habitat in streams and lakes is a dynamic interaction between physical, chemical, and biological parameters. In streams, physical characteristics include channel geometry and gradient, substrate and cover types, bank shape and composition, habitat type (i.e., pools, riffles, and glides), water temperature, riparian vegetation, as well as the quantity of flow. In lakes, physical characteristics include shoreline length and surface area, bathymetry, water temperature, light penetration, and the relative abundance and distribution of shallower, near-shore littoral habitats compared to deeper, offshore profundal habitats.

Chemical parameters of fish habitat in streams and lakes include water temperature, concentration of dissolved oxygen (DO), concentration of total suspended solids (TSS), and concentrations of total and dissolved nutrients (e.g., phosphorus, nitrogen, carbon).

Together, these physical and chemical parameters directly influence the productivity of primary (i.e., periphyton, phytoplankton) and secondary (i.e., zooplankton and benthic macroinvertebrates or BMI) producers that form the basis of the food-webs upon which fish in both habitats depend.

The rationale for selection of fish habitat as a VC is provided in **Section 5.3.1**. In brief, the rationale was based on:

- The ecological importance of fish habitat for maintaining fish populations that have social, cultural, and recreational value within Project areas;
- The likelihood that, prior to mitigation, fish habitat would be adversely affected by the Project including potential key interactions between the various Project components and stream flows, lake levels, physical habitat, water quality, and temperature (**Table 4.3-2** in **Section 4.3**);
- The social, economic and scientific value of fish habitat as expressed during consultations with the public (**Section 3.4**), federal and provincial regulators (**Section 3.4**) and Aboriginal groups (**Section 3.3**);
- The ability to monitor fish habitat over time and space to detect potential changes and trends resulting from the Project;
- The necessity to identify effective mitigation measures to reduce or eliminate potential Project and cumulative effects to fish habitat; and
- The regulatory requirements to identify any and all potential “serious harm to fish”, including any permanent alteration or destruction of fish habitat, which may require offsetting under Section 35(2) of the federal *Fisheries Act* (Government of Canada, 2013), and of Section 27.1 of Environment Canada’s (EC) *Metal Mining Effluent Regulations* (MMER) (EC, 2011) before the Project can proceed. (Section **5.3.8.1.2** summarizes relevant legislation and policies for both the fish and fish habitat VCs).

The Project has the potential to affect fish habitat directly (e.g., loss due to reduction in flows) or indirectly (e.g., loss due to changes in water quality or temperature or abundance and composition of primary and secondary producer communities). Therefore, an assessment of potential effects on fish habitat is necessary to:

- Develop mitigation measures to reduce, eliminate, or offset any potential effects;
- Identify and assess any residual effects that may remain after mitigation;
- Develop offsetting measures for potential effects that cannot be entirely mitigated; and
- Identify and assess any potential cumulative effects to fish habitat from other past, present or reasonably foreseeable projects in the Regional Study Area (RSA).

5.3.9.1.1 Information Sources

Section 5.1.2.6 provides a detailed summary of the information used to assess potential Project effects on fish habitat. There were two main sources of information: baseline surveys of fish conducted from 1977 to 2013, and Traditional Knowledge (TK) gathered from consultation with First Nations. This section summarizes the sources of baseline information. **Section 5.3.9.2.1** describes TK relevant to fish habitat.**Section 5.1.2.6.2** describes the methods used to collect baseline information. The first step was a detailed review of historical information contained in government databases, reports, and management plans, as well as in environmental baseline reports prepared for forestry companies and mining companies that have operated in the RSA (**Section 5.1.2.6.2.1**).

The second step was a data gap analysis accompanied by reconnaissance overflights of the Local Study Area (LSA) and RSA. A baseline study plan was developed to fill those data gaps in 2011 and 2012 (**Section 5.1.2.6.2.2**). A study plan for 2013 was based on the results of the first 2 years of baseline study.

Government guidelines and scientific standards and protocols were used to design the field studies (**Section 5.1.2.6.2.3**). These study plans were discussed with representatives of regulatory agencies such as the BC Ministry of Environment (BC MOE), the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO), and Fisheries and Oceans Canada (DFO).

The objectives of the field studies on fish habitat were to:

- Characterize fish habitat in streams and lakes that may be affected by the Project;
- Identify potential interactions between the Project and fish habitat;
- Identify opportunities for mitigation and offsetting;
- Provide baseline data that would support future Environmental Effects Monitoring programs; and
- Quantify fish habitat potentially affected by the Project in support of developing an offsetting plan for any unavoidable loss of fish habitat.

Field studies of fish habitat in 2011, 2012 and 2013 included 15 separate components (**Table 5.3.9-1**; **Section 5.1.2.6.2.4**).

Table 5.3.9-1: Summary of Fish Habitat Baseline Studies for the Project, 2011-2013

Study	2011	2012	2013
Reach break analysis and reconnaissance level survey of fish habitat	✓	✓	✓
Stream temperature monitoring	✓	✓	✓
Stream periphyton and BMI community survey	✓	✓	
Stream BMI tissue metals concentrations		✓	
Characterization of fish habitat at stream sites	✓	✓	✓
Headwater lakes phytoplankton and zooplankton community survey		✓	
Headwater lakes BMI community survey		✓	
Headwater lakes BMI tissue metals concentrations		✓	
Tatelkuz Lake phytoplankton and zooplankton community survey			✓
Tatelkuz Lake BMI community survey			✓
Characterization of fish habitat in headwater lakes (bathymetric survey, physical and biological limnology, and littoral habitat survey)	✓	✓	
Characterization of fish habitat in Tatelkuz Lake (bathymetric survey, physical and biological limnology, littoral habitat survey)		✓	✓
Fish habitat surveys at stream crossings along the transmission line and Kluskus and Kluskus-Ootsa FSRs		✓	✓
Fish habitat surveys at stream crossings along the mine access road, airstrip and the Freshwater Supply Pipeline			✓
Overwintering habitat quality survey		✓	✓

Note: BMI = benthic macroinvertebrate; FSR = Forest Service Road

Field-collected data on fish habitat were analyzed and interpreted using guidance documents from the scientific literature and from the provincial and federal governments (**Section 5.1.2.6.2.5**). They were in addition to those documents listed in **Section 5.1.2.6.2.3**.

Detailed results of the 2011-2013 field studies were presented in two baseline reports: one for 2011 and 2012 (**Appendix 5.1.2.6A**) and one for 2013 (**Appendix 5.1.2.6B**). **Section 5.1.2.6.3** summarized those results.

In addition, three studies on fish and fish habitat in the LSA were conducted:

- A Fisheries Mitigation and Offset Plan (FMOP) (**Appendix 5.1.2.6C**) that described how much fish habitat will be lost to Project activities, how much will be saved by mitigation measures, and how much will be gained by offsetting;
- An Instream Flow Study (IFS) (**Appendix 5.1.2.6D**) that described the relationships between stream flow and the amount and quality of fish habitat in streams of the LSA; and
- An Effects Assessment of Davidson Creek Flow Augmentation on Homing of Salmonid Fish (**Appendix 5.1.2.6E**), which assessed the potential effects on homing and spawning success of rainbow trout and kokanee due to flow augmentation of Davidson Creek with

water pumped from Tatelkuz Lake – the main mitigation measure for fish and fish habitat of the Project.

Finally, this section used modelling results from the environmental assessments for surface water flow (**Section 5.3.2**), surface water quality (**Section 5.3.3**), and sediment quality (**Section 5.3.4**) as well as habitat and instream flow modelling results to assess potential effects to fish habitat.

The Instream Flow Study relied heavily on hydrological data reported in **Appendix 5.1.2.1B** (the 2013 Hydrometeorology Report) and analyzed in **Appendix 5.1.2.1C** (the Watershed Modelling Report), **Appendix 5.3.2C** (Tatelkuz Lake Withdrawal Model) and **Section 5.3.2** (Hydrology). Because site-specific climate and stream flow data were only available for a baseline period three years (2011 to 2013), regional data were used to generate a 40 year-long synthetic hydrometeorological database (1973 to 2013). That synthetic flow database was used for instream flow modelling.

5.3.9.1.2 Relevant Legislation and Policies

Section **5.3.8.1.2** summarized relevant legislation and policies for both the fish and fish habitat VCs.

5.3.9.1.3 Spatial, Temporal, Administrative, and Technical Boundaries

Section 4.3.1 described the spatial and temporal boundaries for assessment of potential Project effects. All spatial, temporal, administrative and technical boundaries for the fish Habitat VC were identical to those for the fish VC (**Section 5.3.8.1.3**).

5.3.9.1.4 Assessment Approach

Potential effects to fish habitat were assessed qualitatively and quantitatively.

Quantitative models were used to assess the amount of physical habitat potential altered or destroyed under the mine footprint. This was done by over-laying the mine site footprint on stream habitat maps created from baseline field studies in a Geographic Information System (GIS). Similarly, changes in the amount and type of littoral habitat potentially affected by changes in water surface elevation (WSE) of Tatelkuz Lake were assessed by quantifying habitat at different WSE using GIS techniques.

Results of these analyses were incorporated into a Habitat Evaluation Procedure (HEP) model to semi-quantitatively assess the amount of habitat units (HU), a dimensionless metric that incorporates habitat quantity (i.e., m^2) and habitat quality (i.e., nil, poor, average, good, excellent), potentially affected for each fish species and life stage (e.g., spawning, rearing, foraging, overwintering). HEP was developed by the U.S. Fish and Wildlife Service (US FWS) (US FWS, 1981). This analysis was considered semi-quantitative because it required a subjective rating of habitat quality for each potentially affected habitat type (e.g., pools, riffles, cobble/gravel shorelines) for each fish species and life stage. This subjectivity was reduced by calibrating habitat suitability indices (HSI) with site-specific data collected during stream fish surveys and by updating existing HSI models with more recent scientific literature (cited in Annex C of **Appendix 5.1.2.6C**).

Quantitative instream flow models were developed for Davidson Creek, Creek 661, Creek 705 and Chedakuz Creek (**Appendix 5.1.2.6D**). These models were used to assess potential reductions in flow downstream of the mine site, with and without mitigation. These models were also used to set instream flow thresholds.

Ultimately, the evaluation of the likely effectiveness of the various mitigation and offsetting measures to eliminate, reduce or compensate for potential changes to fish habitat and, similarly, the evaluation of the significance of potential residual effects was subjective – based on professional judgment. However, those assessments were supported by the quantitative modelling described above, past experience at other similar mine projects in central BC, and by the scientific, government, and grey literature. No assessment of effect was conducted without supporting rationale.

5.3.9.1.5 Fish Habitat Indicators

The five indicators of the fish habitat VC are the following:

- Surface water flow;
- Surface water quality (including water temperature);
- Sediment quality;
- Ecological health; and
- Riparian habitat (mainly cover for fish).

Baseline information on those indicators is summarized in **Section 5.1.2.1** (surface water flow), **Section 5.1.2.2** (surface water quality and sediment quality), and **Section 5.1.2.6** (ecological health and riparian habitat). **Section 5.3.3** predicts water temperatures in Davidson Creek as a result of Project activities.

Ecological health of fish habitat was broadly defined to include the location, quantity, and quality of stream and lake habitat that supports the five life stages of fish: migration, spawning, overwintering, rearing, and feeding. Fish habitat includes measurements of size and shape. In streams, those include variables such as flow, gradient, width, depth, substrate composition, the presence or absence of barriers to fish migration, and the characteristics of riparian habitat. In lakes it includes variables such as water surface elevation, surface area, volume, depth, perimeter, and substrate composition of the littoral zone.

Fish habitat in both streams and lakes also includes water quality variables such as conductivity, pH, the concentration of dissolved oxygen (DO), temperature and transparency (as measured by Secchi depth). It includes the prey of fish and the food base of that prey. In streams, that includes the biomass, density and taxonomic composition of periphyton and BMI. In lakes that includes the biomass, density and taxonomic composition of phytoplankton, zooplankton, and BMI.

Section 5.1.2.6.3.1.1 describes the quantity and characteristics of riparian habitat in the aquatics LSA. That summary was partly based on fish habitat surveys conducted from 2011 to 2013 and reported in **Appendix 5.1.2.6A** and **Appendix 5.1.2.6B**. Those surveys recorded components of riparian habitat that are directly relevant to stream fish habitat such as the presence and absence of large woody debris, percent canopy closure and bank stability. Estimates of the area of riparian habitat were based on the same definition of riparian habitat – a 30-m wide zone on either side of a stream – that was used in the Ecosystems Baseline Summary (**Section 5.1.3.3**) and in the Vegetation Baseline Report (**Appendix 5.1.3.3A**).

The Fisheries Mitigation and Offsetting Plan (FMOP; **Appendix 5.1.2.6C**) incorporated riparian habitat into the habitat offsetting budget by including a Habitat Suitability Index (HSI) for “food and nutrients” – the primary contributions to fish of riparian habitat. Annex C of **Appendix 5.1.2.6C** explains how food and nutrient HSI values were assigned to different kinds of fish habitat.

5.3.9.1.6 Measurable Factors

The six indicators are inter-related in a complex way. Therefore, a number of measurable factors were used in effects assessment (**Table 5.3.9-2**).

5.3.9.2 Valued Component Baseline

This section summarizes baseline information on the fish habitat VC and the source of the information. **Section 5.1.2.6** provides a detailed summary of baseline conditions for the fish habitat VC in the Project LSA and RSA, including data sources, study areas, methods, results and interpretation.

5.3.9.2.1 Traditional Knowledge

Traditional Knowledge (TK) of fish and fish habitat was gathered during consultations with the various Aboriginal groups those traditional territories may be affected by the Blackwater Project. To date, these consultations have included meetings and interviews with members of the following groups:

- Lhoosk’uz Dene Nation;
- Nadleh Whut’en First Nation;
- Saik’uz First Nation;
- Stellat’en First Nation;
- Ulkatcho First Nation;
- Nazko First Nation; and
- Skin Tyee First Nation.

TK relevant to fish habitat is summarized in **Section 5.1.2.6.3.2.1**.

5.3.9.2.2 Conservation Status

Section 5.3.8 describes the conservation status of fish species in the LSA and along the transmission line.

There are no aquatic ecosystems in the LSA or RSA that are listed by the BC Conservation Data Centre (BC CDC) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC, 2013).

However, the Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet, was observed in a single sample of littoral zone BMI collected from Lake 01682LNRS with a kick-net in August 2012 (**Appendix 5.1.2.6A**). It was a rare species in that sample, representing only 0.3% of the number of organisms (i.e., 17 individuals were counted within the 5,301 benthic invertebrates in the sample).

This species is recognized as a species of Special Concern by the BC CDC (BC CDC, 2014). It has a Provincial S3 conservation status (i.e., blue-listed) and a Global status of G3 (BC CDC, 2014). COSEWIC classifies it as “Not at Risk.” It was assigned to the Provincial blue-list because it is the only species of the Family Acroloxidae found in North America, and in BC it is found only in the east-central region (Klinkenberg, 2012). Its habitat is high-altitude oligotrophic and mesotrophic lakes and ponds. It is found in rocky, exposed portions of lakes and ponds in shallow water on the underside of rocks and vegetation on wave-swept shores. Populations are not endangered, but their habitat type is limited.

Table 5.3.9-2: Selected Indicators and Measurable Factors for Fish Habitat VC

Habitat Type	Indicator	Measurable factor	Rationale
Streams	Stream flow	Wetted area	A quantitative measure of physical habitat.
		Area Weighted Suitability (equivalent to Weighted Useable Area)	A measure of habitat available to fish taking into account the quantity of habitat and the suitability of habitat under different flow conditions.
	Surface water and sediment quality	Water temperature	Water temperature is a crucial determinant of rates of various biological processes. It influences survival and growth rates of primary and secondary producers, and fish. Extreme high and low temperatures can reduce growth and increase mortality. Fish migrate during optimum temperature ranges.
		Measured water quality parameters with the potential to exceed guidelines and/or adversely affect fish	Concentrations of total and dissolved water quality parameters can affect the growth, reproduction, and survival of primary (i.e., periphyton) and secondary producers (i.e., BMI) in streams.
	Ecological health	Density and taxonomic composition of periphyton and BMI communities	Density and taxonomic composition of periphyton and BMI communities is an important measure of stream habitat productivity and, therefore, of ecosystem health. Periphyton communities are short-term indicators of nutrient status and sedimentation. BMI communities are indicators of fish habitat quality because of their high taxonomic diversity, relatively sessile nature, relatively long life span (1-3 years), and sensitivity to changes in water quality and flow.
	Riparian habitat	Area and percent cover	Quantitative measures of riparian habitat. Riparian habitat provides cover, shade, and nutrient inputs to stream habitats.
Lakes	Water surface elevation (WSE)	Littoral habitat area, by habitat type	A quantitative measure of the availability of different littoral habitat types (i.e., substrate, depth, and cover) at different WSE.
	Surface water and sediment quality	Thermocline depth and duration	Thermal stratification has important implications for the cycling of nutrients and DO concentrations and thus on the productivity and biology of a lake.
		Secchi disk depth	A measure of water transparency that determines the depth to which photosynthesis can occur. It is negatively correlated with phytoplankton density and biomass.
		Measured water quality parameters with the potential to exceed guidelines and/or adversely affect fish	Concentrations of total and dissolved water quality parameters can affect growth, reproduction, and survival of primary (i.e., phytoplankton) and secondary producers (i.e., zooplankton and BMI) in lakes.
	Ecological health	Density and taxonomic composition of phytoplankton, zooplankton, and BMI communities	The density and taxonomic composition of the phytoplankton, zooplankton and BMI communities are important measures of lake productivity, and habitat type and diversity.

5.3.9.2.3 Streams

5.3.9.2.3.1 Baseline Monthly and Annual Flows

Table 5.3.2-1 of **Section 5.3.2** (Hydrology VC) shows baseline monthly and annual flows for each of the five streams of the LSA. Monthly and annual flows are shown for the mean condition, and for the 1:5, 1:10: 1:20, and 1:50 wet and dry years. These flows were based on the 40-year synthetic time series for 1970 to 2013. **Figure 5.3.2-1** shows the locations and code numbers for the hydrometric stations of the LSA.

Figure 5.1.2.6-16 shows mean monthly flows for the five watersheds of the LSA. Lower Chedakuz Creek has mean monthly flows that are approximately four times higher than the other four streams and that those four streams have similar monthly flows. For all five streams, highest flows are in May and lowest flows are in March.

Figure 5.1.2.6-17 shows that flows increase with downstream distance in Davidson Creek, as they do in all five streams.

Flows in Davidson Creek vary substantially under wet and dry conditions. **Figure 5.1.2.6-18** shows that peak flows at station 1-DC under 1:50 year conditions are more than twice as great as mean flows and that the month of peak flow shifts from May to June. Flows under 1:50 dry conditions are half of mean flows.All three baseline years were classified as wet using the peak modelled baseline discharge of Tatelkuz Lake into lower Chedakuz Creek over the years 1973 to 2013, as shown in Figure 5 of **Appendix 5.3.2C** (of the Hydrology VC). Baseline year 2011 had a peak discharge of 12.6 m^3/s, which was the second highest of the 41 years. Baseline year 2012 had a peak discharge of 5.7 m^3/s (rank = 10), and baseline year 2013 had a peak discharge of 7.4 m^3/s (rank = 4).

5.3.9.2.3.2 General Morphology

Fish habitat surveys of the LSA from 2011 to 2013 showed a system typical of the central BC interior – steep, sub-alpine headwater tributaries of poor quality habitat (mainly due to steep gradient, low temperatures and low nutrient concentrations) draining to lower gradient reaches of higher quality habitat (i.e., lower gradient, warmer temperatures and higher nutrient concentrations) that flow into valley-bottom streams (e.g., Chedakuz and Fawnie creeks). Those streams are the inlets and/or outlets of large, valley-bottom lakes such as Tatelkuz Lake and Top Lake.

Overall, streams within the LSA have a mean gradient of 1.53%, a mean bankfull width of 5.09 m, and a mean bankfull depth of 0.56 m. Stream habitat is dominated by glides (40.8%) and riffles (38.6%) with pools making up only 16.4% of all surveyed sites (**Table 5.1.2.6-6**).

5.3.9.2.3.3 Habitat Quantity and Quality

The Davidson Creek Watershed contains a total of 104,371 m of stream length (**Table 5.3.9-3**), including the mainstem and all tributaries. This is 27.1% of the total stream length in the LSA, and it is the longest total stream length of the six watersheds in the LSA (if one includes lower Chedakuz Creek as a separate watershed). The total area of stream and pond (not lake) fish habitat in the Davidson Creek Watershed is 467,998 m^2. This is 29.2% of the total area of stream and pond fish habitat in the LSA – the largest area of fish habitat provided by a single watershed.

Table 5.3.9-3: Fish Habitat Area in Streams and Ponds of Watersheds of the LSA

Watershed	Stream Length (m)	Fish Habitat Area Streams (m^2)	Fish Habitat Area Ponds (m^2)	Fish Habitat Area Total (m^2)	Pond/Stream Area Ratio
Davidson Creek	104,371	230,665	237,333	467,998	1.03
Turtle Creek	82,693	156,376	149,532	305,908	0.96
Creek 661	85,352	125,817	95,595	221,412	0.76
Creek 705	44,805	119,134	25,474	144,608	0.21
Tatelkuz Lake Tributaries	62,750	90,996	317,800	408,796	3.49
Lower Chedakuz Creek(1)	4,485	55,458	0	55,458	0.00
Total	**384,456**	**778,446**	**825,734**	**1,604,180**	

Note: Stream and pond habitat only (no lakes included).
(1) Reach 15 only (from outlet of Tatelkuz Lake to Kluskus FSR bridge).

The total number of habitat units (HU, where 1 HU is one unit of high quality habitat) for the Davidson Creek Watershed is 574,364 (**Table 5.3.9-4**). This is 30.8% of the total number of stream and pond HU in the LSA, and it is the single largest number of stream and pond HU provided by a single watershed. The reason was the presence of riffle-pool morphology in the lower and middle reaches, combined with abundant suitably-sized gravels, stable banks, deep pools, and good channel and hydraulic habitat complexity due to the presence of large woody debris (LWD).

Habitat quality of the mainstem of Creek 661 is ranked as high for almost the entire length for the same reasons as Davidson Creek, except for two small sections of the headwaters. The Creek 661 Watershed provides the second longest length of stream in the LSA, but the fourth largest area of fish habitat and the fourth greatest number of HU provided by a single watershed (**Table 5.3.9-3** and **Table 5.3.9-4**).

Habitat quality of most of the Turtle Creek mainstem (which is in the LSA although not as affected by Project activities as Davidson Creek and Creek 661) is ranked as medium with high quality habitat in the middle of the mainstem and at the upstream end. Low-gradient pools and glides, with occasional riffles, dominate the lower to middle reaches of Turtle Creek. Fine substrates are the dominant bed materials, and spawning gravels are present only in isolated pockets. The Turtle Creek Watershed provides the third longest length of stream in the LSA, the third largest area of fish habitat, and the third largest number of HU provided by a single watershed.

Habitat quality of Creek 705 mainstem is ranked as high for the entire length of the mainstem. Deep pools, overhanging vegetation, and hydraulic habitat complexity provide good cover. Spawning habitat in the lower reaches of Creek 705 is good, particularly in Reach 1 near the confluence with Fawnie Creek. However, the Creek 705 Watershed provides only the fifth longest stream length, the fifth largest area of fish habitat, and the fifth largest number of HU provided by a single watershed due to its low pond/stream ratio.

The Tatelkuz Lake Tributaries Watershed has the fourth longest length of stream and the second largest area of fish habitat and the second largest number of HU provided by a single watershed. However, this watershed has low fish production because there is no habitat for rainbow trout spawning and egg incubation or kokanee spawning and egg incubation and there is only limited stream rearing habitat. The main reason for this apparent contradiction is that there is 3.5 times more pond habitat than stream habitat in this watershed – the highest pond/stream ratio in the LSA. Pond habitat is only useful as juvenile rainbow trout summer rearing habitat.

Habitat quality in Reach 15 of lower Chedakuz Creek (directly downstream of Tatelkuz Lake) is ranked as high because it has habitat typical of a medium-sized river. Abundant gravels provide good quality spawning habitat for rainbow trout and kokanee. Deep pools and instream vegetation provide good cover and rearing opportunities for juvenile trout. Reach 15 provides the sixth longest stream length, the sixth largest area of fish habitat, and the sixth largest number of HU provided by a single watershed.

Table 5.3.9-4: Fish Habitat Units by Life History Stage in Streams and Ponds of Watersheds of the LSA

Watershed	**RB Spawning and Egg Incubation (HU)**	**RB Fry Summer Rearing (HU)**	**RB Juvenile Summer Rearing (HU)**	**RB Adult Summer Foraging (HU)**	**RB Overwintering (HU)**	**KO Spawning and Egg Incubation (HU)**	**Food and Nutrient Production (HU)**	**Total (HU)**
Davidson Creek	42,594	127,171	124,493	0	91,523	5,017	183,565	574,364
Turtle Creek	7,987	58,440	101,672	0	54,791	0	103,146	326,036
Creek 661	20,927	43,532	69,479	0	37,286	17,221	72,777	261,221
Creek 705	17,721	41,437	42,749	0	26,403	0	64,021	192,333
Tatelkuz Lake Tributaries	0	79,450	110,351	0	79,450	0	102,199	371,450
Lower Chedakuz Creek(1)	38,950	15,027	10,556	0	8,220	40,112	25,345	138,210
Total	**128,179**	**365,057**	**459,300**	**0**	**297,673**	**62,350**	**551,054**	**1,863,613**

Note: Stream and pond habitat only (no lakes).
(1) Reach 15 only (from outlet of Tatelkuz Lake to Kluskus FSR bridge).

5.3.9.2.3.4 Overwintering Habitat

DO concentrations and water depths were measured at a total of 33 stream sites visited in March 2012 and March 2013. Quality ratings were assigned based on DO concentrations (none <3 mg/L, poor = 3 to 6 mg/L, fair = 6 to 7 mg/L, and good >7 mg/L) or on stream water depths (none <10 cm, poor = 10 to 20 cm, fair = 20 to 50 cm, and good >50 cm), whichever rating was lowest. (**Section 5.1.2.6** provides more detail on relative ranking of overwintering habitat quality, summarizing baseline data presented in **Appendix 5.1.2.6A** and **Appendix 5.1.2.6B**.)

Overwintering habitat quality ranged from none to good in both years, but the frequency distribution varied between years (**Table 5.1.2.6-9**). In March 2013, the highest percentage (45%) was classified as fair and the lowest percentage (15%) was classified as none. In March 2012, the highest percentage was none (31%) and the other three categories were lower (23%).

Eight sites were visited in March of 2012 and revisited in March 2013. There was no change in overwintering habitat quality for two of the eight sites, but habitat quality decreased from March 2012 to March 2013 for three sites and increased for three sites.

These results show that there is a range of overwintering habitat quality in streams of the Blackwater LSA, but that it varies between years. Hence, the quantity of overwintering habitat of sufficient quality to support fish (i.e., fair and good) may limit fish production in the LSA, but its effect varies between years.

5.3.9.2.3.5 Wetlands

Section 5.1.2.5 of this Application describes a survey of wetlands in the aquatics LSA. The only class of wetland that can support fish is “shallow open-water wetland”. The BC Ministry of Forests (BC MOF) defines this class as having water depths between 0.5 and 2.0 m at midsummer and a plant cover usually less than 10%. In the Blackwater LSA that plant cover consisted mainly of species of the families *Utriculatia (*bladderworts*), Potamogeton* (pondweed) and *Nuphar* (water lily).

Comparison of the locations of shallow open-water wetlands with the locations of fish habitat survey sites in **Figure 5.1.2.6-5** and **Figure 5.1.2.6-6** show that some of those wetlands that were directly connected to stream habitat were directly surveyed. Others were not surveyed as a consequence of the sub-sampling that had to be adopted to cover the long stream distances of the LSA. Information on the location, frequency of occurrence, and mean area of those wetlands that were surveyed was used to calculate the total areas of pond fish habitat for each watershed that are shown in **Table 5.1.2.6-7** and in relevant parts of the FMOP.

A total of 66.4 ha of shallow open-water wetlands were identified in the LSA (**Table 5.1.2.6-10**), of which 15.5 ha (or 23%) were not connected to any stream that supported rainbow trout, 5.8 ha (or 9%) were directly connected to confirmed rainbow trout stream habitat, and 45.0 ha (or 68%) were connected to unconfirmed rainbow trout stream habitat. “Confirmed” in this context means that the stream was surveyed for fish and fish habitat and rainbow trout were captured. “Unconfirmed” means that the stream was surveyed for fish and fish habitat (because it was connected to other fish-bearing reaches and contained fish habitat) but no rainbow trout were captured. In most cases, the status of unconfirmed was due to the low density of juvenile rainbow trout in streams of the LSA compared to BC provincial “biostandards” (Keeley et al., 1996; Koning and Keeley, 1997). As described in **Section 5.1.2.6.3.2.5**, over 70% of the 78 values of electrofishing CPUE measured in the LSA in 2011 and 2012 were below 1.0 fish/100 s.

Most shallow open-water wetlands are located in headwaters regions of watersheds, and most unconfirmed rainbow trout stream habitat is also located in headwaters. Hence, most connections were between shallow open-water wetlands and unconfirmed rainbow trout stream habitat.

Those wetlands that are connected to confirmed or unconfirmed fish habitat provide mainly rearing habitat for juvenile rainbow trout during summer months. They also provide food and nutrients to downstream habitat that directly supports fish. They do not provide overwintering habitat because they are shallow and so freeze to the bottom during winter. Nor do they provide spawning habitat because their substrates consist mainly of fines.

5.3.9.2.3.6 Riparian Habitat

Section 5.1.2.6.3.1.1 describes the area and characteristics of riparian habitat in the aquatics LSA. The total riparian area for fish-bearing watercourses in the LSA is 2,520.2 ha of which 2,343.2 (or 93%) is associated with streams and 177.0 ha (or 7%) is associated with lakes, ponds and wetlands. A total of 362.5 ha of fish-bearing riparian habitat is present in the mine site footprint of which 351.2 ha (or 97%) borders streams and 11.3 ha (or 3%) borders wetlands and ponds.

Figure 5.1.2.6-21 shows that the most common percent range of crown closure was 1 to 20% for five of the six watersheds. The most common crown closure rating for the Tatelkuz Lake Tributaries Watershed was 0%, likely due to the high relative abundance of wetlands and scarcity of forested areas in this watershed.

Total percent of instream cover for fish was rated as greater than 20% at the majority of sites in each watershed. Sources of instream cover include overhanging vegetation, large woody debris and small woody debris. Generally, overhanging vegetation was rated as the dominant or subdominant component of overall cover. Large and small woody debris were typically rated as subdominant or trace contributors to total cover.

Coniferous forests were the most abundant vegetation type in riparian habitat of all watersheds. Shrubby vegetation was the next most common type in five of the six watersheds. Mature forest was the most common succession stage, followed by the shrub stage.

5.3.9.2.3.7 Water Quality and Sediment Quality

Section 5.1.2.2 summarizes baseline information on water quality and sediment quality of streams and lakes of the LSA, and **Section 5.3.3** presents an assessment of Project effects on water quality, including predictions of water temperatures in Davidson Creek as a result of Project activities. What follows below is a brief summary of **Section 5.1.2.2**.

Baseline studies of surface water quality indicate that streams and lakes in the LSA contain relatively soft water, with low alkalinity, low concentration of nitrogen species and somewhat elevated phosphorus in lakes compared to BC guidelines. Most trace metal concentrations are low to below detection limits. Exceptions, which are often or always above guidelines, are total aluminum (CCME guideline), dissolved aluminum (BC guideline), total cadmium (current BC guideline; well within CCME guideline), total copper, total iron (above CCME guideline), and total zinc. These exceptions are the result of naturally elevated concentrations of these metals in the bedrock and soils of the LSA. Such natural exceedances are common near mineralized zones such as the Blackwater ore body.

Baseline studies of stream sediments showed that the exceedances of CCME Interim Sediment Quality guidelines (ISQG) and Probable Effects Level (PEL) guidelines and BC MOE Lowest Effects Level (LEL) and Severe Effects Level (SEL) guidelines occur for some metals. Arsenic, iron, and manganese in sediments were exceeded most frequently. These results are not atypical for streams, particularly in mineralized areas where sediment guidelines are often naturally exceeded. Healthy aquatic populations exist in all area streams, and thus exceedances of guidelines do not indicate naturally occurring impairment of aquatic ecosystems. Sediment guidelines are often not a useful indicator of metals exposure for aquatic organisms particularly where metals are present as sulphide minerals with low solubility and bioavailability at neutral pH.

5.3.9.2.3.8 Water Temperature

Continuous monitoring of stream water temperatures in the LSA for 2011 to 2013 (locations shown in **Figure 5.1.2.6-3**) showed five patterns (**Figure 5.1.2.6-22** to **Figure 5.1.2.6-25**):

- The expected dome-shaped variation with season – mean daily temperatures rose from near 0°C in early April to a maximum of between 11.2°C and 20.8°C in mid-July and early August and then fell to near 0°C in early October;
- A gradient of decreasing temperature with increasing elevation in all seasons;
- Warmer summer temperatures in 2013 and 2012 than in 2011;
- Cooler temperatures in Davidson Creek than in other watersheds of the LSA, apart from the elevational trend in temperature; and
- Warmer temperatures in lower Chedakuz Creek than in other watersheds of the LSA because it is the outlet of a large lake with high heat storage capacity.

Stream temperatures in most watersheds of the LSA generally fall below the BC MOE optimal temperature ranges for most life history stages of rainbow trout. (**Figure 5.3.8-13** shows that comparison for the Davidson Creek Watershed.) However, they fall within the range for most life history stages of kokanee (with the exception of incubation from November to May). (**Figure 5.3.8-14** shows that comparison for the Davidson Creek Watershed.) Hence, water temperatures in the LSA are more suitable for production of kokanee than they are for production of rainbow trout. In general, low temperatures rather than high temperatures limit aquatic biological processes in the LSA.

5.3.9.2.3.9 Periphyton Community

Periphyton is a complex mix of algae, bacteria, and protozoans attached as a biofilm to submerged surfaces. It is the primary photosynthetic-based community in streams, and an important food source for BMI. One hundred and sixty samples of periphyton (80 for biomass and 80 for taxonomic analysis) were collected from stream sampling sites of the LSA and RSA in 2011 and 2012 (locations shown in **Figure 5.1.2.6-4**).

Periphyton density showed substantial among-site variation (**Figure 5.1.2.6-28**). Spatial distribution of periphyton biomass was similar to the distribution of periphyton density, with the exception of the site in lower Chedakuz Creek (BI-06). Mean biomass at this site (6.18 µg/cm^3) approached the BC guidelines for the protection of aquatic life in streams (10 µg/cm^3), indicating that this site was nutrient enriched, perhaps from local agricultural run-off.

Periphyton communities at most sites were dominated by diatoms and cyanobacteria. Diatoms were predominant at 10 of 14 sites sampled and cyanobacteria were predominant at the other four sites. Relatively high proportions of cyanobacteria in streams are generally associated with high nutrient concentrations.

Motile diatom species – species in the genera *Nitzschia*, *Navicula*, *Gyrosigma*, and *Surirella* – which are general indicators of siltation, were present in samples collected from the LSA. However, on average, motile diatoms comprised less the 50% of the total diatoms at all stream sampling sites in 2011, which does not indicate a high degree of siltation from past land use activities (e.g., logging) at these stream sampling sites.

5.3.9.2.3.10 Stream Benthic Macroinvertebrate Community

Benthic Macroinverbate (BMI) are a diverse group of animals living on or in the substrates of streams, wetlands, and lakes. They include protozoans, flatworms, nematodes, aquatic worms, crustaceans (i.e., ostracods, isopods, and amphipods), molluscs (i.e., snails and clams), and larvae of aquatic insects (i.e., mayflies, dragonflies, and blackflies). Many BMI feed on periphyton and are prey for fish, thereby providing a link between primary production and fish.

One hundred and fifteen BMI samples were collected with kick nets from late August to early September in 2011 and 2012 at the same stream sites and dates as were periphyton (locations shown in **Figure 5.1.2.6-4**). Standard Canadian Aquatic Biomonitoring Network (CABIN) protocol was followed.

BMI communities in the LSA and RSA clustered into five significantly different groups (**Table 5.3.9-5**), based on multivariate analysis of their taxonomic composition.

Table 5.3.9-5: Habitat Characteristics Associated with BMI Groups

BMI Grouping (Sites)	Site Characteristics
A (BI-01, BI-02, BI-04, BI-05, BI-09, BI-11, BI-13, BI-14)	Moderate altitude, larger substrate, fast flows, medium conductivity and mix of stream orders (2-4)
B (BI-03, BI-08, BI-12)	High altitude, small streams, with larger substrate, low conductivity and slow flow
C (BI-06)	Large, low altitude stream (lower Chedakuz Creek), with low canopy coverage, high conductivity and high periphyton biomass
D (BI-07)	Mid-altitude, highest conductivity, high periphyton biomass and small substrate
E (BI-10)	Low altitude, moderate velocity, width, conductivity, and small substrate

Comparison of the BMI communities in the LSA and RSA with two candidate CABIN reference models – Fraser Model (2005) and Skeena Model (2010) – showed that they resembled most closely the Skeena model rather than the Fraser model. Using the Skeena model as a reference condition, all but one sampling site were classified as in good condition – which meant it fell within the mid-range of the frequency distribution of sites that define the Skeena reference model. The exception was site BI-06 in lower Chedakuz Creek that had also been shown to have unusually high periphyton densities and biomasses, potentially due to nutrient enrichment from local ranching activity.

A total of 17 BMI samples were analyzed for concentrations of 41 total metals: samples of stream BMI from 14 sites and three samples of littoral BMI from the three headwater lakes. (BMI metals concentrations were measured because there is one species of fish – rainbow trout – is overwhelmingly predominant in the streams of the LSA. A second receptor “species” – BMI – was chosen to provide two receptors.)

BMI metals data were pooled and subjected to Pricipal Component Analysis (PCA) to identify the major trends in the data. PCA extracted three principal components that explained a total of 75% of the total variance. The first component, PC1, was an index of the concentration of heavy metals in BMI tissue. (Note that the term “heavy metals” is conventionally used to describe a loosely defined subset of elements that exhibit metallic properties. The term does not indicate toxicity because all heavy metals, with the exception of mercury, are micro-nutrients that are essential for life and hence are found naturally in all fish tissue.)

There was no substantial variation in PC1 among watersheds and among the five BMI groups (A to E). Since BMI are fixed to the substrate, this indicates that the concentrations of metals in water and sediment to which BMI communities are exposed may not be substantially different among the watersheds of the LSA. The lack of difference in PC1 scores among the five groups indicates that concentrations of metals in BMI tissue may not be strongly influenced by differences in the physical characteristics of habitat that drives taxonomic composition.

Lake samples had much lower PC1 scores than stream samples, indicating much lower metal concentrations. This was mainly due to the difference in type of organisms that were sampled. The lake samples were "scuds" – large-bodied crustaceans of the families Gammaridae and Hyallela – but stream BMI samples were dominated by small-bodied aquatic insects.

The second component, PC2, was significantly and positively correlated with 20 metals, of which arsenic had the highest correlation. PC2 scores showed no clear spatial trends nor did they show any trends with the five groups shown in **Table 5.3.9-5**.

The third component, PC3, was most highly negatively correlated with potassium. PC3 scores decreased in a downstream direction in Davidson Creek, Turtle Creek, and Creek 705, and, to a lesser extent, in Creek 661. Since PC3 was interpreted as the absence of potassium, these trends indicate increasing potassium with downstream distance.

5.3.9.2.4 Lakes

The LSA contains one large, valley-bottom lake – Tatelkuz Lake – and four smaller headwater lakes: Lake 01682LNRS in the Davidson Creek Watershed; lakes 01538UEUT and 01428UEUT in the Creek 705 Watershed; and Snake Lake in the Tatelkuz Lake Tributaries Watershed (**Figure 5.1.2.6-1** and **Figure 5.3.8-1**).

Lake 01682LNRS is the headwater lake of Davidson Creek. It is the smallest of the headwater lakes, with one circular basin. However, its maximum depth, 16.3 m, is the deepest of the four headwater lakes (**Table 5.3.9-6**). It is deep enough to stratify thermally in summer. It has shallow basin slopes that create a large littoral area relative to its total surface area (62% of total area).

Table 5.3.9-6: Elevation and Bathymetry of Lakes of the LSA

Lake	Elevation (m)	Total Area (m^2)	Littoral Area (m^2)	Volume (m^3)	Maximum Depth (m)	Mean Depth (m)	Surface-Volume Ratio (m^{-1})	Perimeter (m)
01682LNRS	1,345	91,881	57,419	509,173	16.3	5.5	0.18	1,667
01538UEUT	1,346	357,375	187,504	1,946,905	11.2	5.5	0.18	4,304
01428UEUT	1,354	169,304	164,676	522,815	7.6	3.1	0.32	2,508
Snake	1,102	519,832	481,832	1,652,000	11.6	3.2	0.31	4,502
Tatelkuz	928	9,100,000	1,010,000	196,000,000	33.7	21.4	0.05	25,000

Note: m = metre; littoral area is area where depth < 6m.

Lake 01538UEUT is the southernmost headwater lake of the Creek 705 Watershed. It is the largest of the four headwater lakes. The lake has two distinct basins, both oriented in an east-west direction. The smaller, western basin is less than 9 m deep and has a large littoral area near the lake outlet. The eastern basin of Lake 01538UEUT is deeper (11.2 m) and larger than the western basin. This lake is too shallow to stratify and is well-mixed throughout the year. Littoral area is 52% of total area.

Lake 01428UEUT is the northernmost headwater lake of the Creek 705 Watershed. It is the shallowest of the four headwater lakes and littoral area makes up 97% of total area. This lake has one large main basin, with a small, shallow bay at the northeastern end. The main basin is deepest near the middle (7.6 m) with steep gradients along the north shore. This lake is well-mixed throughout the year.

Snake Lake is intermediate in elevation between Tatelkuz Lake and the other three headwater lakes. It has the second largest area of the four headwater lakes, and has the second greatest maximum depth (11.6 m). It has one circular basin partly intersected by a long, snake-like moraine (hence the name). This gives it the longest perimeter of the four headwater lakes. The shallow slopes of that perimeter mean that its littoral zone makes up 93% of total area.

Tatelkuz Lake is at a lower elevation and is much bigger and deeper than the four headwater lakes. For example, maximum depth of Tatelkuz Lake (33.7 m) is twice the maximum depth of Lake 01682LNRS, three times the maximum depth of Lake 01538UEUT, and over four times the maximum depth of Lake 01428UEUT (**Table 5.3.9-6**). Tatelkuz Lake is deep enough to stratify in summer. It is a narrow, elliptical, steep-sided lake compared to the shallow, lens-shaped headwater lakes. Littoral area is only 11% of total area, and the ratio of surface area to volume (0.05 m^{-1}) is one-third that of Lakes 16 and 15 (0.18 m^{-1}) and one-sixth that of Lake 14 (0.32 m^{-1}).

5.3.9.2.4.1 Elevation of Tatelkuz Lake

Table 5.3.2-30 of **Section 5.3.2** (Hydrology VC) shows seasonal and annual mean water surface elevations of Tatelkuz Lake. Elevations were measured on a monthly basis during 2011, 2012 and 2013. Those measurements were calibrated to discharges from the outlet of Tatelkuz Lake. That elevation-discharge relationship was used to estimate Tatelkuz Lake elevations for a 40-year period (1973 to 2013) using historical discharges from Tatelkuz Lake that were estimated from the synthetic time-series of watershed flows.

Mean annual lake elevation was estimated to be approximately 927.60 masl. Mean monthly elevations are lowest in January and February (926.9 masl), and highest in May (927.4 masl) – a mean seasonal difference of 0.5 m (**Figure 5.3.9-1**). Over the 40 year time period, monthly elevations fluctuated by as little as 0.2 masl in February to as much as 1.3 masl in May. The maximum fluctuation between historic minimum and maximum annual lake levels was approximately 2.0 m.

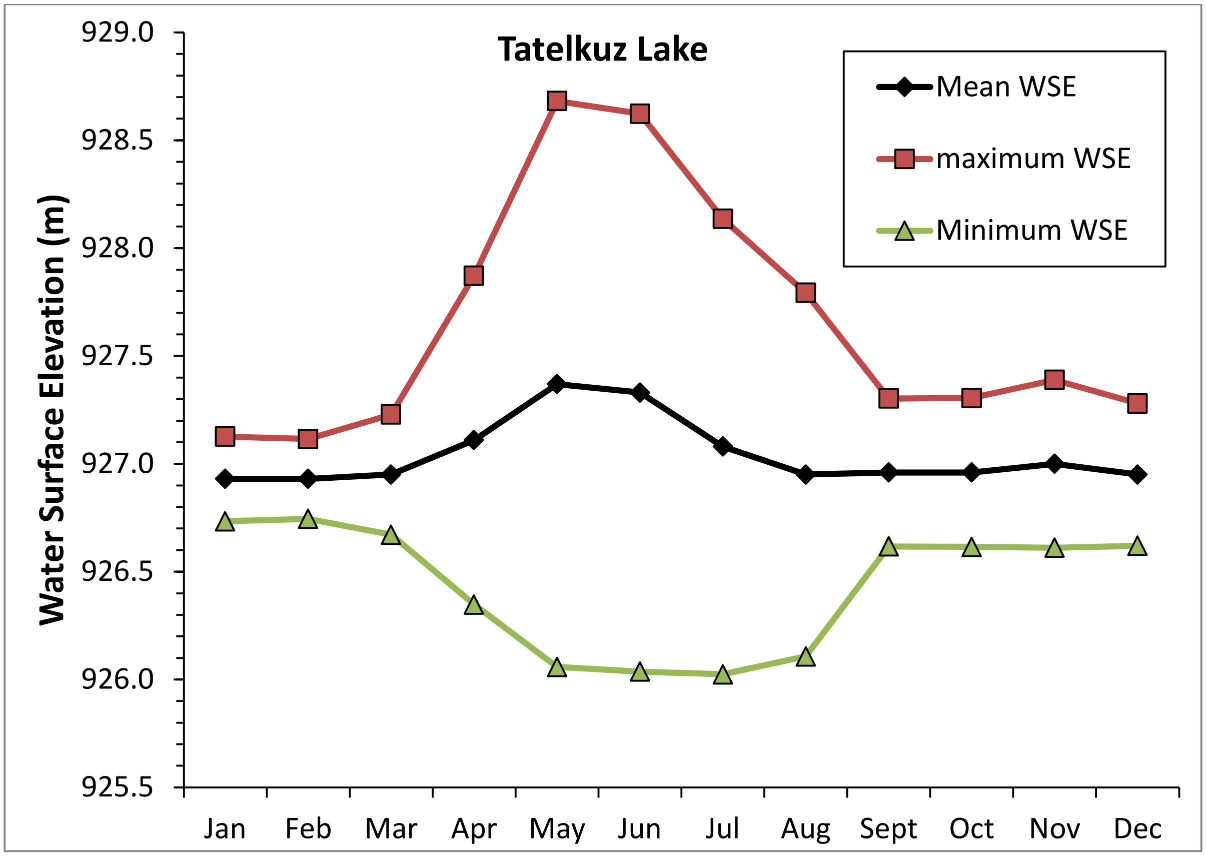


Figure 5.3.9-1: Mean Water Surface Elevation of Tatelkuz Lake

5.3.9.2.4.2 Physical Limnology

The physical limnology of Tatelkuz Lake differs from that of the headwater lakes due to differences among lakes in size, shape, elevation, and volume of inflows. Tatelkuz Lake is deep enough to stratify in summer, but only Lake 01682LNRS is deep enough to stratify. The other three headwater lakes (01428UEUT, 01538UEUT and Snake Lake) are well mixed throughout summer.

Summer surface temperatures of Tatelkuz Lake are warmer than all headwater lakes. This is due mainly to the lower elevation of Tatelkuz Lake (928 m) compared to the three headwater lakes (1,102 to 1,354 m). DO concentrations in Tatelkuz Lake never fall below 4 mg/L, but those at the bottom of Lake 01682LNRS fall to zero during summer. Lakes 01538UEUT, 01428UEUT and Snake Lake are well mixed with DO concentrations approximately 8.0 mg/L and constant with depth.

One of the most striking differences between Tatelkuz Lake and the headwater lakes is the much higher conductivity in Tatelkuz Lake. In 2013, conductivity ranged from 93 to 212 µS/cm in Tatelkuz Lake, which was three to five times higher than the ranges measured in the headwater lakes in August and September 2012. One reason for this difference is that the headwater lakes are at the head of watersheds and receive relatively little inflows per unit volume, while Tatelkuz Lake receives inflows from numerous watersheds of the Chedakuz Creek Valley. Essentially, all of the TSS and dissolved minerals from the upper and middle Chedakuz Valley eventually flow into Tatelkuz Lake. Another reason may be differences among headwater and valley-bottom lakes in mineral composition of soils and geology. A third explanation may be nutrient input from the cattle ranch at the head of Tatelkuz Lake.

Higher conductivity typically implies higher rates of biological production. This was partially confirmed by Secchi depth, which was slightly deeper in Tatelkuz Lake (3.7 m) than in Lake 01428UEUT (3.0 m), but it was exceeded by both lakes 01538UEUT (5.7 m) and 01682LNRS (5.7 m).

All headwater lakes have 1% euphotic zone depths that are greater than their respective maximum lake depths. That means photosynthesis occurs throughout the entire volumes of those lakes. In contrast, the 1% euphotic zone depth in Tatelkuz Lake ranged from 10.0 to 10.1 m. Since mean depth of the lake is 21.4 m, photosynthesis is limited to the top 10 m of the lake.

5.3.9.2.4.3 Habitat Quality

Littoral habitat area is only 11% of total area in Tatelkuz Lake compared to 52% in Lake 01538UEUT, 62% in Lake 01682LNRS, 93% in Snake Lake, and 97% in Lake 01428UEUT (**Table 5.3.9-6**).

The littoral zone of Tatelkuz Lake along the eastern and western shorelines is narrow (<25 m) and steep (>10%) and comprised of large substrates (i.e., cobble and boulders). Sand/silt/gravel beaches are located at the northwest and southeast ends where the littoral zone is wide (>150 m) and has a gradual gradient (<3%). In general, substrates in Tatelkuz Lake change from coarse to fine with increasing depth and distance from shore. This is particularly true along the longer and steeper east and west shorelines.

Rainbow trout and kokanee HU were calculated for four of the five lakes in the LSA (**Table 5.1.2.6-20**). Although Tatelkuz Lake supports an additional eight fish species, none of those species use habitat in Davidson Creek and Creek 661 – the two streams that will be most affected by Project activities. Snake Lake was excluded from the list of lakes because it does not support either rainbow trout or kokanee.

The total number of HU for those four lakes is 48,061,870. Tatelkuz Lake provides the overwhelming majority of those HU (96.5%) because it is much larger than the three headwater lakes and because it supports both rainbow trout and kokanee. (Kokanee are not present in the headwater lakes.) Even if the comparison among lakes is restricted to rainbow trout (i.e., a total HU of 22,905,015), Tatelkuz Lake would make up 92.6% of all HU for lakes in the LSA and the three headwater lakes would provide only 4.3% (Lake 01538UEUT), 2.0% (Lake 01428UEUT), and 1.0% (Lake 01682LNRS).

5.3.9.2.4.4 Phytoplankton Community

For the headwater lakes, mean phytoplankton cell density and biomass were highest in Lake 01682LNRS and lowest in Lake 01538UEUT (**Figure 5.1.2.6-36** and **Figure 5.1.2.6-37**).

Chrysophytes (i.e., golden algae and diatoms) were the predominant major taxa in Lakes 01538UEUT and 01428UEUT and in the surface and deep samples from Lake 01682LNRS.

Unlike the headwater lakes, mean phytoplankton biomass in Tatelkuz Lake was highest in the epilimnion (i.e., at a depth of 1 m) where light intensity was greatest, and decreased with increasing depth (**Figure 5.1.2.6-38**). Mean biomass was several times lower just below the thermocline at mid-depths of 13 and 15 m, and several times lower again at a bottom depth of 27 m. This pattern is the result of the decrease in light intensity with depth – a factor that was less important in the shallower headwater lakes.

In Tatelkuz Lake, a total of 114 phytoplankton taxa were present. Green algae (Chlorophyceae) was the most diverse group (51 taxa), followed by blue-green algae (Cyanophyceae; 25 taxa) and the diatoms (21 taxa). In general, surface waters of Tatelkuz Lake were numerically dominated by blue-green algae and Cryptophyte flagellates.

Clustering analysis indicated that, with the exception of two replicate outliers, Tatelkuz Lake phytoplankton communities at all depths show significant divergence in taxonomic composition from those of the headwater lakes of the LSA. The major difference in phytoplankton communities among lakes was the significantly higher density (or abundance) and biomass in surface waters of Tatelkuz Lake than the headwater lakes (**Figure 5.1.2.6-39**). This is due mainly to greater nutrient concentrations in Tatelkuz Lake than in headwater lakes.

In summary, phytoplankton communities in lakes of the LSA reflect different nutrient concentrations and degrees of thermal stratification. Elevated levels of chlorophyll *a*, greater phytoplankton abundance and biomass, lower taxonomic diversity, and elevated presence of blue-green algae in Tatelkuz Lake indicate a mesotrophic status for Tatelkuz Lake versus an oligotrophic status for headwater lakes.

5.3.9.2.4.5 Zooplankton Community

Zooplankton communities showed strong differentiation among lakes (**Figure 5.1.2.6-44**). Tatelkuz Lake had greater biomass (but not density), taxa richness and diversity than headwater lakes.

For three of the headwater lakes (excluding Snake Lake for which data were not available), mean zooplankton density and biomass were highest in Lake 01428UEUT and lowest in Lake 01682LNRS. Lake 01428UEUT is the shallowest headwater lake, with the highest percent littoral habitat and the lowest Secchi depth. This suggests that zooplankton abundance in the headwater lakes is driven by morphometry, with shallow, turbid lakes producing the most dense populations of zooplankton. Deep, clear lakes with lower percent littoral zone produce less dense populations.

Rotifers are the predominant zooplankton taxon by density in all three headwater lakes. Copepods are the second most common taxon, being predominant in Lake 01682LNRS and second-ranked in Lake 01428UEUT, and third-ranked in Lake 01538UEUT. Copepods are the predominant zooplankton taxon by density within Tatelkuz Lake. Rotifers are the second most common taxon.

5.3.9.2.4.6 Lake Benthic Macroinvertebrate (BMI) Community

The BMI communities of Tatelkuz Lake are distinct from those sampled in the headwater lakes (**Figure 5.1.2.6-45**). Abundance, taxa richness, and the Hilsenhoff Biotic Index (HBI) index are greater, but species diversity, the numbers of chironomids and the numbers of Ephemeroptera-Plecoptera-Trichoptera (EPT) are lower. These differences likely arise from a combination of the nutrient-enriched condition and the unique morphology and habitat heterogeneity of Tatelkuz Lake relative to the smaller lakes.

The higher nutrient concentration in Tatelkuz Lake is evident from its water chemistry (e.g., conductivity is three to four times higher) and its elevated phytoplankton and zooplankton biomasses compared to headwater lakes. The majority of metrics associated with the lake BMI communities of Tatelkuz Lake align well with expectations for nutrient-enriched lakes.

Within Tatelkuz Lake littoral BMI communities, the community structure reflects the habitat heterogeneity of the lake. There is a more rich and abundant BMI community in the fine substrate habitats (Fine/Gravel, Fine and Fine/Organic) than in the coarse substrate habitats (Cobble/Gravel, Gravel/Cobble and Gravel/Fine) (**Figure 5.1.2.6-46**). Abundance on fine substrates is 4.3 times greater than on coarse substrates while richness is 1.4 times greater.

Despite the influence of substrate type on abundance and richness, coarse substrates in Tatelkuz Lake still had abundances and species richness (19,670 individuals and 45 taxa per sample, respectively) that exceeded mean abundances and species richness of the three headwater lakes.

The profundal BMI community of Tatelkuz Lake is significantly different than those collected from the headwater lakes. It has higher density and higher percent chironomids. However, unlike littoral communities, profundal samples showed no additional structure within Tatelkuz Lake. Almost half of the observed dissimilarity arose from the greater abundance of two dominant taxa (*Chironomus* sp. midges and Tubificid worms) in Tatelkuz Lake relative to the headwater lakes.

5.3.9.2.5 Past, Present and Future Projects and Activities

The fish habitat VC potentially interacts with other projects or activities in the RSA as a result of spatial or temporal overlap. **Table 4.3-11** shows the Summary Project Inclusion List developed for cumulative effects assessment. Of the 13 items on that list, ten have potential relevance to the fish habitat VC, as follows:

- Pacific Gas Looping Project;
- Mining – existing;
- Mining – exploration;
- Forestry – logging;
- Hunting, trapping and guide outfitting;
- Fishing and hunting lodges;
- Recreation;

- Agriculture;
- Transportation; and
- Crown land tenures.

Section 5.3.9.5 describes in detail the cumulative impacts of those ten projects and activities on the fish habitat VC.

5.3.9.3 Potential Effects of the Proposed Project and Proposed Mitigation

This subsection identifies and analyzes potential adverse effects on the fish habitat VC resulting from the proposed Project's construction, operations, closure and post-closure phases.

It first describes the features of the six major components of the Project (mine site; mine access road; airstrip and airstrip access road; Freshwater Supply System or FSS; transmission line; and the Kluskus FSR and Kluskus-Ootsa FSR) that may potentially affect the fish VC (**Section 5.3.9.3.1**).

Then, for each of those six components, potential effects are described, mitigation measures are outlined and residual effects after mitigation are listed (**Sections 5.3.9.3.2** to **5.3.9.3.7**). Hence mitigation measures are identified in each of the six component-specific sections **Section 5.3.9.3.8** lists residual effects for all six Project components. These residual effects are then characterized and assessed in **Section 5.3.9.4**.

Identification of potential effects on fish habitat was not based on the type of interaction of mine activities and the VCs (i.e., a key interaction that has a direct effect that may be significant; a moderate interaction that has an indirect effect that is not significant; or a negligible interaction). There was no *a priori* judgement of potential effects by their mitigatability. Instead, all potential effects were listed, regardless of whether they can be mitigated or not. Then, the application of mitigation measures led to identification of residual effects that were then assessed for significance.

Methods of analysis are described in each of the component-specific sections and include the following:

- The quantity and quality of fish habitat affected by the proposed Project assessed using a Habitat Evaluation Procedures (HEP) approach. Outputs are a summation of the total area (m^2) and total habitat units (i.e., area scaled by relative quality) of fish habitat, by stream or lake, by fish species, and by life stage, affected by all stages of the proposed Project; and
- Modelled relationships between flow and the quantity and quality of fish habitat are used to assess potential effects of flow on fish habitat. Relationships between discharge and wetted width, depth, and velocity in different habitat types (e.g., runs, riffles, pools) are used to assess potential changes in the suitability of instream habitat to species and life stages potentially affected.

A detailed FMOP was developed to address any unavoidable effects on fisheries (**Appendix 5.1.2.6C**). The plan provides the information necessary to determine the potential effects on fisheries of proposed Project activities.

Section 5.3.9.5 describes in detail the cumulative impacts of reasonably foreseeable future project or activities in the proposed Project area on the fish VC.

5.3.9.3.1 Project Works and Activities

Effects assessment was conducted on six major components of the Project: the mine site, mine access road, airstrip and airstrip access road, FSS, transmission line, and the Kluskus and Kluskus-Ootsa FSRs.

Section 5.3.8.3.1 briefly describes the features of the mine site (**Figure 5.3.8-1**), mine access road (**Figure 5.3.8-2**), airstrip and airstrip access road (**Figure 5.3.8-3**), Freshwater Supply System (FSS) (**Figure 5.3.8-4** and **Figure 5.3.8-5**), transmission line (**Figure 5.3.8-6**), and Kluskus FSR and Kluskus-Ootsa FSR (**Figure 5.3.8-7**).

5.3.9.3.2 Mine Site

Four potential classes of effects on fish habitat will be caused by development of the mine site, as follows:

- Loss of fish habitat in upper Davidson Creek Watershed;
- Changes in flows in Davidson Creek, Creek 661, and Creek 705;
- Changes in water quality in Davidson Creek, Creek 661, and Creek 705; and
- Changes in water temperature of Davidson Creek.

This section studies each class of potential effects. Residual effects that cannot be mitigated were carried forward to residual effects assessment in **Section 5.3.9.4**.

5.3.9.3.2.1 Potential Effects on Fish Habitat from Mine Site Development

Potential effects on fish habitat of mine site development include the following (**Table 5.3.9-7**):

- Physical loss of fish habitat under site facilities, including the open pit, waste rock dumps, mill site, TSF and associated infrastructure;
- Isolation of fish habitat upstream of site facilities, including upstream of the open pit and the TSF;
- Changes to the quantity and/or quality of fish habitat downstream of the Project due to changes in water quantity, water quality and water temperature. These changes will occur due to: (1) impoundment of upper Davidson Creek flows; (2) diversion of a portion of flows to Creek 705; and (3) diversion of a portion of headwater flows of Creek 661 to the TSF;

- Changes to water quality downstream of the Project in Davidson Creek (because of inflow of Tatelkuz Lake water via the FSS), Creek 661 (because of seepage from the mine site), and Creek 705 (because of potential mobilization of mercury from soils flooded during enlargement of Lake 01682LNRS); and
- Changes to densities, biomasses and taxonomic composition of periphyton and benthic macroinvertebrates (BMI) under the mine site footprint.

Table 5.3.9-7: Potential Effects on Fish Habitat of the Mine Site

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Loss of fish habitat under the mine footprint	Construction/Operations/Closure/ Post-Closure	Likely
Isolation of fish habitat upstream of mine site facilities	Construction/Operations/Closure/ Post-Closure	Likely
Reduction in flow of Davidson Creek	Construction/Operations/Closure/ Post-Closure	Likely
Reduction in flow of Creek 661	Construction/Operations/Closure/ Post-Closure	Likely
Reduction in flow of lower Chedakuz Creek between Tatelkuz Lake and the confluence with Davidson Creek	Construction/Operations/Closure	Likely
Increase in flow of Creek 705	Construction/Operations/Closure/ Post-Closure	Likely
Change in downstream water quality in Davidson Creek, Creek 661, and Creek 705 including increased total suspended sediments (TSS) and concentrations of metals (specifically mercury in lakes 01682LNRS and 01538UEUT)	Construction/Operations/Closure/ Post-Closure	Likely
Change in water temperature of Davidson Creek	Construction/Operations/Closure/ Post-Closure	Likely
Changes to densities, biomasses and taxonomic composition of periphyton and BMI	Construction/Operations/Closure/ Post-Closure	Likely

5.3.9.3.2.1.1 Loss of Fish Habitat under the Mine Site Footprint

Potential Effects

Mine site facilities, waste rock dumps, and other stockpiles (i.e., low-grade ore stockpile, overburden, etc.) will be exclusively located in an area that is presently the headwater tributaries of Davidson Creek and Creek 661. At full development, the proposed TSF will be situated in the upper reaches of Davidson Creek and its headwater tributaries. Fish habitat will be permanently lost under the TSF during the early construction and operational stages. Construction of the seepage collection facilities, the Environmental Control Dam (ECD), and the freshwater reservoir will result in further loss of fish habitat in the upper and middle reaches of Davidson Creek.

The footprints of these Project components will result in permanent loss of fish habitat. **Table 5.3.8-18** lists the streams and reaches that will be affected and **Figure 5.3.8-9** shows a map of those habitat losses. **Table 5.3.9-8** lists the potential effects on fish habitat of those losses.

Table 5.3.9-8: Potential Effects on Fish Habitat of the Mine Site Footprint

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Permanent alteration or destruction of fish habitat under the mine site infrastructure	Construction/Operations/Closure/ Post-Closure	Likely
Permanent alteration or destruction of fish habitat under the mine pit	Construction/Operations/Closure/ Post-Closure	Likely
Permanent alteration or destruction of fish habitat under the ore processing area	Construction/Operations/Closure/ Post-Closure	Likely
Permanent alteration or destruction of fish habitat under the waste rock areas	Construction/Operations/Closure/ Post-Closure	Likely
Permanent alteration or destruction of fish habitat under the TSF	Construction/Operations/Closure/ Post-Closure	Likely
Permanent alteration or destruction of fish habitat under the wetland and water management areas	Construction/Operations/Closure/ Post-Closure	Likely
Permanent alteration or destruction of fish habitat under the borrow areas	Construction/Operations/Closure/ Post-Closure	Likely

Fish Habitat in Davidson Creek Watershed

Fish Habitat Lost under the TSF: TSF construction will be staged. TSF Site C will be built during the Construction phase to support mining tailings disposal during early operational stages. Construction of the larger TSF Site D will commence during early operations to manage mill process water requirements and tailings disposal for the remaining mine life. **Table 5.3.9-9** shows the reaches of each stream, and the area of each stream that will be permanently lost under the TSF.

Table 5.3.9-9: Stream Area Lost Under the TSF

Watershed ID	Stream Name	Reaches	Stream Classification(1)	Stream Area Lost (m²)
100-567134-610692-522527	Davidson Creek	9, 10, 11	S3 S4	20,203
100-567134-610692-522527-704454	Creek 704454	1, 2, 3, 4,	S3	8,939
100-567134-610692-522527-688328	Creek 688328	1, 2	S3	7,867
100-567134-610692-522527-636713	Creek 636713	1, 2, 3, 4, 5	Reaches 1-2: S3 Reaches 3-5: S4	4,173

Watershed ID	Stream Name	Reaches	Stream Classification[1]	Stream Area Lost (m^2)
100-567134-610692-522527-896157, 899664,776798, and 674890	Davidson Creek Tributaries	1	S4	3,287

Note: [1] Fish streams are classified S1–S4. Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide.

Habitat in Reaches 9 to 10 of Davidson Creek is used by the rainbow trout population that resides in Tatelkuz Lake, and habitat in Reach 11 is used by the rainbow trout population that resides in Lake 01682LNRS. A cascade at the bottom of Reach 11 acts as a semi-permeable barrier to upstream migration.

Habitat in these reaches provides good to fair summer fry and juvenile rearing habitat. There are isolated pockets of spawning gravels in Reach 9 and Reach 10 and, to a lesser extent, in Reach 11. Overwintering habitat for juvenile rainbow trout in these reaches is limited by shallow pools, low winter flow, and lack of adequate groundwater inputs.

Creek 636713 is a relatively small stream containing low-gradient wetland sections with predominantly fine substrates. Riffle-pool sections are present, but there are limited amounts of gravels suitable for spawning. Habitat in this stream is suitable mostly for summer rearing of juvenile rainbow trout. No overwintering habitat is available due to shallow water depths.

Habitat conditions in Reaches 1 and 2 of Creek 688328 provide good summer rearing opportunities for fry and juvenile rainbow trout. Suitable gravels and spawning habitat are also present. However, no spawning activity or fry have been observed or captured, and juvenile rainbow trout densities were low in Reaches 1 and 2 during summer baseline sampling. Overwintering habitat quality is limited by low winter flows and shallow pool depths.

Fish Habitat Lost Downstream of the TSF under the ECD and Freshwater Reservoir: Construction of seepage collection facilities, the ECD, and the freshwater reservoir will result in permanent loss of fish habitat in Reaches 6, 7, and 7.1 of Davidson Creek (**Table 5.3.9-10**). (Those reaches are shown in **Figure 5.3.8-8.**) During the closure phase, these facilities will be decommissioned and replaced with a treatment wetland to improve the water quality of seepage from TSF Site D. The treatment wetland will have a larger physical footprint than the operational water management components, and combined, will result in the loss of fish and fish habitat in Reaches 6 through 8 of Davidson Creek.

Table 5.3.9-10: Stream Area Lost Under the ECD, Freshwater Reservoir, and Seepage Collection Facilities

Watershed ID	Stream Name	Reaches	Stream Classification(1)	Impact Location	Stream Area Lost (m^2)
100-567134-610692-522527	Davidson Creek	6	S2	Freshwater reservoir, treatment wetland	9,389
100-567134-610692-522527	Davidson Creek	7	S2	Freshwater reservoir, treatment wetland	1,153
100-567134-610692-522527	Davidson Creek	7.1	S2	Freshwater reservoir, Treatment wetland	4,414
100-567134-610692-522527	Davidson Creek	8	S3	ECD, seepage collection facilities	908

Note: (1) Fish streams are classified S1–S4. Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide.

These reaches provide spawning, rearing, and overwintering habitat for the Davidson Creek rainbow trout population (i.e., the one whose adults reside in Tatelkuz Lake – not those that reside in headwater Lake 01682LNRS). Spawning rainbow trout were documented in these reaches during spring surveys in 2011, and suitable spawning gravels were identified in most reaches. Reach 6 contains the highest quantity of spawning habitat, while Reach 7 has limited amounts, with boulders being the predominant substrate type. Summer rearing habitat for juvenile and fry rainbow trout is available, with good cover provided by boulder and cobble substrates, LWD, overhanging vegetation, and deep pools. Overwintering quality for juvenile rainbow trout is moderate to high, due to low ice cover, good winter flows, groundwater inputs, and the presence of pools with cover.

Fish Habitat Lost Under Mine Site Facilities and Other Infrastructure: Creek 704454 and its associated tributaries have sections of stream located under the open pit, low-grade stockpile, and west waste rock dump. The majority of the affected stream sections are under the west waste rock dump (**Table 5.3.9-11**). (Those reaches are shown in **Figure 5.3.8-8**.)

Habitat quality and habitat use by rainbow trout in Creek 704454 is low, and typical of habitat conditions in first and second order streams in watershed. Fish habitat in the upper reaches of Creek 704454 provides only summer rearing opportunities for juvenile rainbow trout. Headwater reaches have steep gradients, cascade-pool morphology, cobble substrates, and shallow pools – all features that limit the spawning and overwintering potential for rainbow trout.

The lower reaches of Creek 704454 that will be affected by these Project components contain isolated pockets of spawning gravels. However, no evidence of rainbow trout spawning in spring or fry presence in summer was documented during baseline field programs. In total, only four juvenile rainbow trout were observed in Creek 704454 within these potentially affected reaches.

Table 5.3.9-11: Stream Area Lost Under Mine Site Facilities, West Waste Rock Dump, Low-Grade Stockpile, and Open Pit

Watershed ID	Stream Name	Reaches	Stream Classification[(1)]	Impact Location	Stream Area Lost (m²)
100-567134-610692-522527-704454	Creek 704454	4, 5, 6 and tributaries to those streams	S3	Associated mine infrastructure	11,031

Note: (1) Fish streams are classified S1–S4. Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide.

Fish Habitat in Creek 661 Watershed

In the Creek 661 Watershed the upper reaches of Creek 505659 will fall under the TSF and Plant site (**Table 5.3.9-12**). (Those reaches are shown in **Figure 5.3.8-8**.) The upper reaches of Creek 146920 will fall under the east waste rock dump and the upper reach of Creek 543585 will be under the mine operation and construction camps. During construction and early operation phases, all surface waters near these facilities and runoff from disturbed areas will be collected and diverted to the TSF. Settling ponds around the camp facilities will be used to collect and divert all minor surface drainage to Creek 543585.

Table 5.3.9-12: Streams Area Lost Under the Mine Site Facilities, West Waste Rock Dump, Low-Grade Stockpile, and Open Pit

Watershed ID	Stream Name	Reaches	Stream Classification	Impact Location	Stream Area Lost (m²)
100-567134-610692-671007-505659	Creek 505659	5, 6, 7	Reach 5: S3 Reach 6-7:S4	Associated Mine Infrastructure	5,783
100-567134-610692-671007-505659-146920	Creek 146920	2, 3, 4, 5	Reach2: S3 Reach 3: S4 Reaches 4-5: NCD	Associated Mine Infrastructure and East Waste Rock Dump	5,163
100-567134-610692-671007-505659-543585	Creek 543585	1, 2	NVC	Mine Site Camps	0

Note: (1) Fish streams are classified S1–S4. Class S1 streams are >20 m wide; S2 streams are >5 m to 20 m wide; S3 streams are 1.5 m to 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide.

Habitat quality and habitat use by rainbow trout in Creek 661 tributaries is low, which is typical for first and second order streams in the LSA. Creek 505659, Creek 146920, and Creek 543585 provide only summer rearing opportunities for juvenile rainbow trout. The upper reaches of Creek 505659, Creek 146920, and Creek 543585 contain low gradient, riffle-pool morphology and fine substrates, with no spawning or overwintering habitat potential. No defined channels or fish habitat are present in all uppermost reaches of these Creek 661 tributaries.

Runoff from the east waste rock dump will be intercepted by settling ponds and pumped to the TSF during operations and replaced with a diversion channel at closure. This will affect Creek 505659 and Creek 146920. All fish and fish habitat in these headwater drainages cut off by settling ponds or the closure diversion channel will be permanently lost because they will no longer be accessible by fish and will no longer provide water, nutrients, or benthic macroinvertebrate drift to downstream habitat. Furthermore, the constructed overflow spillway from TSF Site D to Davidson Creek will be built at the end of the operations phase, following the natural topography along Creek 505659. This will result in a permanent loss of fish habitat in Creek 505659 under the spillway footprint.

In summary, the loss of stream fish habitat due to the mine site will occur when the Project is developed. The effect will be of high magnitude, the loss will be of local extent because it is confined to the LSA, and the loss will be permanent.

Mitigation Measures

The following design principles were followed to mitigate the potential effects to fish habitat (**Table 5.3.9-13**):

- Minimize the spatial extent of the overall Project footprint by clustering the TSF, open pit, waste rock dumps, stockpiles, and all other mine site facilities as closely together as possible;
- Minimize the number of watersheds potentially affected, by locating the TSF and all mine site facilities within the headwaters of Davidson Creek and Creek 661; and
- Avoid and protect kokanee spawning habitat.

The mitigation/offsetting success ratings shown in **Table 5.3.9-13** are equivalent to the confidence ratings defined in **Section 4.3.5** and summarized in **Table 5.3.9-61**. Briefly, low success rating means mitigation has not been proven to be successful, moderate success rating means mitigation has been proven to be successful elsewhere, and high success rating means mitigation has been proven effective.

In the case of fish habitat on the mine site, mitigation/offsetting success rating is classified as high because all fish habitat lost to mine development will be offset by habitat created, rehabilitated or enhanced elsewhere. The total habitat area permanently altered or destroyed is estimated to be 75,867 m^2. Fish habitat under the mine footprint will be permanently altered or destroyed and will require DFO to authorize these unavoidable losses of fish habitat under section 35(2)(b) of the *Fisheries Act* (Government of Canada, 2013). **Appendix 5.1.2.6C** describes the Fisheries Mitigation and Offset Plan (FMOP).

Since the loss of fish habitat on the mine site is irreversible, this potential effect was carried forward into residual effects assessment.

Table 5.3.9-13: Mitigation Measures to Reduce the Effects on Fish Habitat of the Mine Site

Likely Environmental Effect	Project Phase	Mitigation/Enhancement Measure	Mitigation/ Offsetting Success Rating
Permanent alteration or destruction of fish habitat under the mine site infrastructure	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected Where no mitigation possible, addressed in the *Fisheries Mitigation and Offsetting Plan* (FMOP) through construction of replacement habitat in Davidson Creek and other watersheds	High
Permanent alteration or destruction of fish habitat under the mine pit	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected FMOP	High
Permanent alteration or destruction of fish habitat under the ore processing area	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected FMOP	High
Permanent alteration or destruction of fish habitat under the waste rock areas	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected FMOP	High
Permanent alteration or destruction of fish habitat under the TSF	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected FMOP	High
Permanent alteration or destruction of fish habitat under the wetland and water management areas	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected FMOP	High
Permanent alteration or destruction of fish habitat under the borrow areas	Construction/Operations/ Closure/Post-Closure	Clustering of mine site components Minimizing the number of watersheds affected FMOP	High

5.3.9.3.2.1.2 Isolation of Fish Habitat Upstream of the Mine Site

Potential Effects

Fish habitat will be isolated as a result of development of the mine site. Areas in the Davidson Creek Watershed that will be affected include (**Table 5.3.9-14**):

- Reach 12;
- Lake 01682LNRS; and
- Upper reaches of tributaries to Davidson Creek including Creek 704454, Creek 668328, and Creek 636713.

Table 5.3.9-14: Potential Effects on Fish Habitat Upstream of the Mine Site

Potential Environmental Effect	Project Phase	Likelihood of Occurrence before Mitigation
Isolation of fish habitat in Davidson Creek including Reach 12 and the headwater Lake 01682LNRS	Construction/Operations/Closure/ Post-Closure	Likely
Isolation of fish habitat in tributary Creeks 668328 and 636713 by the TSF	Construction/Operations/Closure/ Post-Closure	Likely
Isolation of fish habitat in Creek 704454 by the west waste rock dump	Construction/Operations/Closure/ Post-Closure	Likely

During initial development of TSF Site C, a saddle dam (the “Site C West Dam”) will be constructed in the upper reaches of Davidson Creek, approximately 900 m downstream of Lake 01682LNRS. This dam will permanently isolate all fish habitat in Reach 12 of Davidson Creek and Lake 01682LNRS, beginning in early construction (**Table 5.3.9-15**). (Those reaches are shown in **Figure 5.3.8-9**.)

Table 5.3.9-15: Streams Area Isolated by the Mine Footprint in Davidson Creek

Watershed ID	Stream Name	Reach	Stream Classification[1]	Impact Location	Stream Area Isolated (m^2)
100-567134-610692-522527	Davidson Creek	12	S3	Upstream of TSF	3,046
100-567134-610692-522527-688328	Creek 688328	2,3	S3	Upstream of TSF	10,657
100-567134-610692-522527-636713	Creek 636713	5	S4	Upstream of TSF	901
100-567134-610692-522527-704454	Creek 704454	6,7	S3, S4	Upstream of West waste rock dump	7,702

Note: (1) Fish streams are classified S1–S4. Class S1 streams are >20 m wide; S2 streams are >5 - 20 m wide; S3 streams are 1.5 - 5 m wide; and S4 streams are <1.5 m wide. Streams without fish are classified S5 or S6. Class S5 streams are >3 m wide, and S6 streams are <3 m wide.

Construction of TSF Site D will permanently isolate habitat in the upper reaches of Creek 688328 and Creek 704454. Fish habitat upstream of TSF Site D will not be physically altered, but the productive capacity of these tributaries will be altered because:

- Any rainbow trout isolated upstream of construction will be unable to survive due to lack of suitable overwintering habitat (pool depths are typically <0.3 m and freeze to the bottom in winter);
- No rainbow trout will be able to move up into this habitat after the mine is built; and
- Water, nutrients, and benthic macroinvertebrate drift will no longer flow from these reaches to habitat lower in Davidson Creek.

Instead, all runoff from these watersheds will be directed to the TSF during construction, operations, closure, and post-closure phases. Fish will be salvaged from these streams during TSF construction.

For the purposes of this assessment, it is assumed that the Project has the potential to permanently isolate fish habitat in these streams. Habitat in Reach 12 of Davidson Creek consists of glide and pool habitats with boulders, cobbles and fine substrates. In-stream vegetation, deep pools, and boulder cover provide fair to good summer rearing for fry and juvenile rainbow trout. Overwintering habitat in Reach 12 is limited by low flows and shallow pool depths. However, Lake 01682LNRS provides overwintering habitat (as well as summer juvenile rearing and adult foraging habitats) for the Davidson Creek Headwater population of rainbow trout upstream of the semi-permeable barrier at the bottom of Reach 11 in Davidson Creek.

Fish habitat in Reaches 2 to 4 of Creek 688328 upstream of the proposed TSF Site D provides summer rearing habitat for juvenile rainbow trout and potential spawning habitat for adults because suitable gravels are present. However, no evidence of spawning activity was documented during baseline field programs. First- and second-order tributaries of Creek 688328 provide good summer rearing habitat, but no spawning habitat or overwintering habitat due to the absence of spawning gravels and the low winter flows and shallow pools, respectively. The limited number of fish captured during baseline field programs indicates that habitat use in these headwater tributaries is low.

In summary, isolation of habitat upstream of the mine site footprint is likely once the Project is developed. The effect will be of high magnitude, but of local extent because it will be confined to the LSA. Fish habitat will be lost for the duration of the Project and some areas will be permanently lost.

Mitigation Measures

Without mitigation over 121,000 m^2 of fish habitat will be isolated upstream of the mine site within Davidson Creek, its tributaries and Lake 01682LNRS.

To minimize potential effects to the productive capacity of fish habitat, a portion of the Davidson Creek Watershed upstream of the TSF Site C West dam will be diverted into the adjacent Creek 705 drainage in the Fawnie Creek watershed (**Table 5.3.9-16**). The diversion is explained in detail in the FMOP (**Appendix 5.1.2.6C**). This approach will provide spawning habitat and maintain connectivity so that life history requirements of the rainbow trout population in Lake 01682LNRS can be met, including immigration and emigration.

Table 5.3.9-16: Mitigation Measures to Avoid and Reduce Isolation of Fish Habitat Upstream of the Mine Site

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measure	Mitigation/ Offsetting Success Rating
Isolation of fish habitat in Reach 12 of Davidson Creek, including the headwater Lake 01682LNRS by the TSF	Construction/Operations/Closure/ Post-Closure	Lake 01682LNRS and Reach 12 of Davidson Creek will be diverted into the Creek 705 watershed to ensure downstream connectivity for these water bodies	High
Isolation of fish habitat in tributary Creeks 668328 and 636713 by the TSF	Construction/Operations/Closure/ Post-Closure	Offsetting plan, construction of replacement habitat in Davidson Creek and other watersheds in the region	High
Isolation of fish habitat in Creek 704454 by the west waste rock dump	Construction/Operations/Closure/ Post-Closure	Offsetting plan, construction of replacement habitat in Davidson Creek and other watersheds in the region.	High

Total mitigated habitat resulting from the diversion of Lake 01682LNRS to the Creek 705 Watershed will be 92,000 m^2. This represents 96% of the total habitat area available under pre-mine conditions in the upper Davidson Creek Watershed above the TSF.

The Lake 01682LNRS diversion plan will maintain connectivity so that rainbow trout immigration and emigration will continue. Successful implementation of this mitigation plan is expected to avoid residual effects to fish habitat in the mainstem of Davidson Creek isolated by the mine site. Therefore, this potential effect was not carried forward to residual effects assessment. Isolation of fish habitat in tributary Creeks 668328, 636713 and 704454 cannot be mitigated and was carried forward into the effects assessment.

5.3.9.3.2.2 Potential Effects on Fish Habitat from Changes in Flow

This section first describes the effects of mine activities on stream flows for the unmitigated scenario and then the mitigated scenario so as to show the need for mitigation. For each of the two scenarios the changes in flows are first described, followed by changes in fish habitat.

5.3.9.3.2.2.1 Potential Effects without Mitigation

The TSF in the Davidson Creek Watershed will not discharge surface flows during operations and closure phases, and will capture Davidson Creek drainage between the TSF Site C West and Site D Main dams. Therefore, Davidson Creek flows will be reduced to zero at the foot of the Site D Main dam and down to the foot of the freshwater reservoir, with drainage area (at the confluence with lower Chedakuz Creek) reduced from 76 km^2 at baseline to 32 km^2 during mine operations to 35 km^2 during closure (**Table 5.3.9-17**).

Table 5.3.9-17: Total Watershed Area by Project Phase

	Area (km^2) by Phase				
Watershed	**Baseline**	**Construction**	**Operations**	**Closure**	**Post-Closure**
Davidson Creek	76.2	64.7	31.9	34.8	79.5
Chedakuz Creek(1)	593	590	590	590	590
Creek 661	56.3	55.6	51.3	50.1	50.1

Note: (1) Chedakuz Creek Watershed area reported at watershed model node (WMN) H5, downstream of the Project (**Section 5.3.2.1.2**). Because there will be no discharge from the TSF, watershed areas do not include area incorporated into the TSF during construction, operations and closure.

In addition, flows will also be diverted from some Creek 661 tributaries into the TSF, reducing the area of Creek 661 Watershed (at the confluence with middle Chedakuz Creek) from 56 km^2 to 50 km^2 during the closure and post-closure periods (**Table 5.3.9-17**). Flows in Davidson Creek and Creek 661, downstream of the Project, will be reduced as a result of these diversions. In addition, flows in lower Chedakuz Creek will be reduced as a result of the impoundment of the upper Davidson Creek Watershed and the diversion of some Creek 661 flows.

Potential effects of these changes in flow on fish habitat were considered at three scales:

- Immediate instream habitat conditions (water depths and velocities suitable for fish, by species and life stage);
- Seasonal timing of flows; and
- Maintenance of physical habitat structure in streams.

Flows affect water depths and velocities in streams, which are key drivers affecting the quantity and quality of fish habitat. Seasonal timing of flows is also important to ensure that suitable flows are provided for each fish species and life stage present (e.g., provision of high flows for rainbow trout spawning in the spring, and provision of adequate overwintering flows to protect stream-resident rainbow trout under winter conditions). Alteration of flow regimes can also affect the physical structure of streams because high flows flush fine sediments from spawning gravels, change the distribution of substrates and woody debris, and affect riparian habitat.

Instream flow models were constructed to assess these Project-related changes in stream flows and the associated changes in fish habitat. **Appendix 5.1.2.6D** describes the methods and results of the Instream Flow Study (IFS) in detail. The approach and results are summarised here.

Flow/habitat models were based on the habitat component of the Instream Flow Incremental Methodology (IFIM) (Bovee, 1982; Bovee et al., 1998) and the BC Instream Flow Methodology (BCIFM) (Lewis et al., 2014). The IFIM, or "habitat simulation modelling" approach (DFO, 2013a), was designed to evaluate aquatic habitat changes associated with incremental changes in stream flows. The IFS component of an IFIM study links a hydraulic engineering model to fish habitat suitability models based on water depth, velocity, and bed particle size. This produces a model which integrates fish habitat quantity and quality as a function of stream discharge. The approach is internationally recognised and is widely used to evaluate potential effects of flow on fish and fish habitat. Fundamentally, the approach assumes that fish habitat is related to discharge, and that this relationship can accurately be modelled. Assessment confidence relies on the application of the flow/habitat models, and conclusions are only as good as models and their input data (i.e., simulated flows by Project phase). Flow/habitat models limitations are presented in the following section.

As described in Section 3.3.1 of the Instream Flow Study (**Appendix 5.1.2.6D**), the habitat suitability curves were used to indicate the suitability of different depths, water velocities and substrates for rainbow trout and kokanee spawning, juvenile rearing, and adult foraging. Standard BC habitat suitability curves were first obtained from Ron Ptolemy of BC MOE. Those curves were then verified or adjusted, where necessary, using site-specific field data collected from Davidson Creek, Creek 661, and Creek 705 (Section 3.3.1 of the Instream Flow Study). To ensure consistency, depth, velocity and substrate data were collected using the same methods used to develop the provincial habitat suitability curves. Mean water column velocities were collected where fish were observed. Substrate composition as percent coverage was recorded using BC-standard substrate categories (RISC, 2001).

Stream flows under baseline conditions and for each Project phase were estimated using a monthly time-step spreadsheet watershed model developed by Knight Piésold (Knight Piésold, 2013c). **Section 5.3.2.1.2** describes in detail the model, the watershed model nodes (WMN) for which modelled flows were generated and the modelling results. For each WMN, and for both baseline conditions and each Project phase, the watershed model estimated flows for the following conditions:

- Mean conditions;
- 1 in 5 dry and wet years;
- 1 in 10 dry and wet years;
- 1 in 20 dry and wet years;
- 1 in 50 dry and wet years; and
- 7Q10 and 7Q20 low flows (where 7Q10 is the lowest 7-day mean flow that occurs, on average, every 10 years, and 7Q20 is the lowest 7-day mean flow that occurs, on average, every 20 years).

A synthetic 15-year flow time series based on a monthly time step was also developed for each WMN for baseline and for each Project phase.

Section 5.3.2 presents the potential effects of the project on stream flows, without augmentation of Davidson Creek flows via the FSS. **Table 5.3.9-18** summarizes those results.

Table 5.3.9-18: Surface Water Flows for Selected Watershed Model Nodes, Baseline and Percent Change by Project Phase, for the Unmitigated Scenario

		Estimated Average Monthly and Annual Surface Water Flows (L/s and Percent Change Relative to Baseline)												
Stream	**Mine Phase**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Annual**
Davidson Creek	H2													
	Baseline	133	123	115	204	816	834	318	191	163	166	160	141	281
	Construction % change	-24%	-24%	-24%	-29%	-24%	-22%	-21%	-22%	-23%	-24%	-24%	-24%	-23%
	Operations % change	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%
	Closure % change	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%
	Post-closure % change	-14%	-14%	-12%	11%	20%	-22%	-34%	-36%	-21%	-4%	-14%	-15%	-9%
	1-DC													
	Baseline	203	185	184	404	1104	1033	441	286	247	260	258	223	403
	Construction % change	-15%	-15%	-15%	-14%	-18%	-17%	-15%	-15%	-15%	-15%	-15%	-15%	-16%
	Operations % change	-72%	-74%	-69%	-54%	-76%	-83%	-78%	-74%	-74%	-71%	-69%	-71%	-74%
	Closure % change	-72%	-73%	-68%	-51%	-70%	-79%	-75%	-73%	-73%	-69%	-67%	-70%	-71%
	Post-closure % change	-14%	-13%	-11%	2%	11%	-21%	-29%	-30%	-20%	-8%	-14%	-14%	-10%
Chedakuz Creek	15-CC													
	Baseline	954	942	1,071	2,027	4,301	3,913	1,811	1,070	1,123	1,106	1,341	1,066	1,727
	Construction % change	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Operations % change	0%	0%	0%	-1%	-2%	-3%	-2%	-1%	-1%	-1%	-1%	0%	-1%
	Closure % change	-1%	0%	0%	-1%	-3%	-4%	-3%	-2%	-1%	-2%	-1%	-1%	-2%
	Post-closure % change	1%	1%	1%	1%	2%	-1%	-1%	0%	0%	1%	0%	1%	0%
	H5													
	Baseline	1,434	1,416	1,609	3,047	6,464	5,880	2,721	1,607	1,688	1,662	2,015	1,602	2,595
	Construction % change	-2%	-2%	-2%	-2%	-3%	-3%	-2%	-3%	-2%	-2%	-2%	-2%	-2%
	Operations % change	-10%	-10%	-8%	-8%	-14%	-16%	-14%	-14%	-11%	-12%	-9%	-10%	-12%
	Closure % change	-11%	-10%	-8%	-7%	-14%	-16%	-14%	-14%	-11%	-12%	-9%	-10%	-12%
	Post-closure % change	-1%	-1%	-1%	1%	3%	-4%	-5%	-6%	-3%	-1%	-2%	-2%	-1%

		Estimated Average Monthly and Annual Surface Water Flows (L/s and Percent Change Relative to Baseline)												
Stream	**Mine Phase**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Annual**
Creek 661	H1													
	Baseline	6	4	3	20	117	122	38	16	11	11	11	8	31
	Construction % change	-1%	0%	0%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-1%	-2%
	Operations % change	-36%	-54%	-64%	-10%	-1%	-1%	-2%	-8%	-13%	-15%	-18%	-27%	-5%
	Closure % change	-36%	-54%	-64%	-10%	-1%	-1%	-2%	-8%	-13%	-15%	-18%	-27%	-5%
	Post-closure % change	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	1-505659													
	Baseline	12	9	8	60	289	275	89	36	26	37	34	17	75
	Construction % change	0%	0%	1%	5%	4%	3%	0%	-1%	0%	2%	2%	-1%	3%
	Operations % change	-10%	-8%	-6%	-16%	-27%	-38%	-32%	-23%	-16%	-18%	-16%	-10%	-28%
	Closure % change	-34%	-30%	-18%	-31%	-42%	-60%	-55%	-48%	-44%	-45%	-44%	-38%	-48%
	Post-closure % change	-31%	-27%	-13%	-31%	-42%	-59%	-54%	-46%	-43%	-44%	-43%	-35%	-47%
	H+													
	Baseline	18	13	11	80	406	397	126	53	37	49	44	25	105
	Construction % change	-1%	0%	1%	3%	3%	2%	-1%	-1%	0%	1%	1%	-1%	1%
	Operations % change	-18%	-22%	-23%	-15%	-19%	-27%	-23%	-18%	-15%	-17%	-17%	-15%	-21%
	Closure % change	-35%	-38%	-32%	-26%	-30%	-42%	-39%	-35%	-35%	-38%	-38%	-35%	-36%
	Post-closure % change	-21%	-19%	-9%	-23%	-30%	-41%	-38%	-32%	-30%	-34%	-32%	-25%	-34%
	1-661													
	Baseline	97	85	82	293	934	852	307	162	134	169	164	114	283
	Construction % change	0%	0%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%	1%
	Operations % change	-3%	-3%	-3%	-4%	-8%	-12%	-10%	-6%	-4%	-5%	-4%	-3%	-8%
	Closure % change	-6%	-5%	-3%	-7%	-13%	-19%	-16%	-11%	-9%	-11%	-10%	-7%	-13%
	Post-closure % change	-4%	-3%	-1%	-6%	-13%	-19%	-16%	-10%	-8%	-10%	-9%	-5%	-13%

Note: Table summarized from **Appendix 5.3.2A**. Percent changes represent change from baseline conditions. H+ is a calculated node at the confluence of Creek 661 with Creek 505659 (WMN 1-661 + WMN 1-505659). Nodes are listed in **Section 5.3.2** and shown in **Figure 5.3.2-4**.

Flows in Davidson Creek will be reduced during construction. During operations and closure, flows will be reduced to zero at the base of the TSF dam (i.e., at WMN H2) due to construction of the TSF, the interception trench and the environmental control dam. Watershed area at H2 and semi-natural flows will be restored at post-closure, when the TSF will be discharged to Davidson Creek via a spillway.

Flows during post-closure will be lower than during baseline due to:

- Permanent diversion of the area upstream of the Site C West dam to the Creek 705 Watershed;
- Permanent diversion of some headwater streams of the Creek 661 Watershed to the Davidson Creek Watershed; and
- Increased evaporation in the Davidson Creek Watershed during post-closure due to the presence of a pit lake and a lake within the reclaimed TSF in Davidson Creek.

Changes in flows of lower Chedakuz Creek upstream of the confluence with Davidson Creek (i.e., at WMN 15-CC) will be smaller than those in Davidson Creek because of:

- Pumping 33 L/s from Tatelkuz Lake to the mine site via the FSS during operations to supply mill needs; and
- Diverting a portion of the Creek 661 Watershed to the TSF during operations and closure and to Davidson Creek at post-closure.

Changes in lower Chedakuz Creek downstream of the confluence with Davidson Creek include the effects of the TSF during construction, operations and closure. At post-closure, flows will return to a volume and timing similar to that at baseline (**Table 5.3.9-18**).

In the Creek 661 Watershed, flows in the headwaters (i.e., at WMN H1 and WMN 1-505659) will show small changes during construction and then larger reductions during operations, closure and post-closure, particularly for Creek 505659. Because winter flows in these headwater streams are low, the large percent changes during the winter result from very small flow changes in real terms, particularly for Creek 661 (**Section 5.3.2**).

Flows in Creek 661 downstream of the confluence with Creek 505659 are presented here for WMN H+ (a calculated node representing the sum of flows at H1 and 1-505659, both immediately upstream of this confluence) (**Table 5.3.9-18**). Creek 661 flows are also presented for WMN 1-661 (at the confluence with Chedakuz Creek). Changes in flows in Creek 661 are largest in June and July, are larger in closure and post-closure than during operations, and will persist at post-closure due to permanent diversion of some area to the Davidson Creek Watershed.

Potential effects of stream flow changes on fish habitat, without augmentation of Davidson Creek flows via the FSS, were assessed based on the conclusions of the IFS, considering the extent, magnitude, and duration of anticipated flow changes. Flow/habitat models developed as part of the IFS were used to convert the 15-year time series of flow data for appropriate WMN into a time series of habitat availability, by life stage, for the two fish VC species (rainbow trout and kokanee) and for each Project phase.

The potential for adverse effects on fish habitat was considered by comparing baseline habitat time series with habitat time series for each Project phase. Direct comparisons are possible because the synthetic 15-year flow record was modelled for each Project phase by applying Project effects by phase to the same underlying baseline hydraulic model for January 1998 through December 2012 (Knight Piésold, 2013c). Habitat time series were developed for modelled stream sections in Davidson Creek, Chedakuz Creek, and Creek 661 for rainbow trout spawning, rainbow trout fry and parr, and for kokanee spawning. Potential effects of changes in flows in Creek 705 due to the diversion of Lake 01682LNRS (described in preceding section) are addressed below in **Section 5.3.9.3.2.2.3** because the diversion is a mitigation component.

Seasonal timing of flows was addressed by evaluating instream habitat conditions over biologically relevant time periods for the two VC species (**Table 5.3.9-19**). Five biological stanzas were defined such that stream conditions within each time period reflect potential constraints on habitat productivity for rainbow trout and kokanee. These stanzas were based on the results of the baseline studies of fish populations reported in **Appendix 5.1.2.6A** and **Appendix 5.1.2.6B** and summarized in **Section 5.1.2.6**.

Table 5.3.9-19: Biological Stanzas for IFS Analyses in Streams of the LSA

Stream	Stanza	Rationale
Davidson Creek and Creek 661	1 December – 30 April	Juvenile overwintering
	1 May – 15 May	Freshet flows: substrate scour and cleaning of fine sediments from spawning gravels
	16 May – 30 June	Rainbow trout migration and spawning
	1 July - 31 August	Kokanee spawning, rainbow trout incubation and rearing
	1 September – 30 November	Kokanee egg incubation, rainbow trout rearing
Lower Chedakuz Creek	1 December – 1 May	Juvenile overwintering
	1 May – 15 May	Freshet flows: substrate scour and cleaning of fine sediments from spawning gravels
	16 May – 30 June	Rainbow trout migration and spawning
	1 July – 31 July	Rainbow trout incubation and rearing
	1 August – 31 September	Kokanee spawning, rainbow trout rearing
	1 October – 30 November	Kokanee egg incubation, rainbow trout rearing

Total habitat area for each species and life stage for baseline conditions and for each Project phase was calculated by summing each 15-year habitat time series for each biological stanza. Mean monthly habitat area (m^2) was calculated from the total stanza habitat over the time series. Potential flow-related effects are presented here by comparing available habitat at each Project phase to baseline habitat, by species, life stage, and biological stanza.

Flow/habitat relationships were not developed for overwintering conditions, because hydraulic models are not accurate once flows are affected by ice formation, and winter fish habitat use models are not available. During the winter, fish reduce metabolic activity and seek refuge habitat. As a result, fish are vulnerable to changes in winter conditions (Huusko et al., 2007). Reduced overwinter flows have been identified as a management concern for BC streams (Hatfield, 2012; Faulkner et al., 2012). The potential for effects due to changes in winter conditions was evaluated qualitatively because scientifically defensible models cannot be constructed.

Davidson Creek

The 13.6 km of Davidson Creek downstream of the Project was modelled in two sections. The lower Davidson Creek section extends approximately 6.0 km upstream from the confluence with Chedakuz Creek. It contains low gradient, riffle-pool habitat with abundant spawning gravels for kokanee and rainbow trout. It also supports rainbow trout juvenile rearing. Kokanee spawn in the lower 5.2 km only; there is no barrier preventing kokanee passage, but spawning gravel quality for kokanee declines upstream of this point. The middle Davidson Creek section extends 7.6 km from the top of the lower Davidson section to the foot of the ECD, and is characterised by productive rainbow trout spawning and rearing habitat, with intermittent patches of gravel among cobble-boulder substrates.

Unmitigated Project flows in Davidson Creek will be lower than baseline flows due to capture of discharge within the TSF. During operations and closure, flows will be reduced to zero at the foot of the TSF Site D dam (i.e., at WMN H2) (**Table 5.3.9-18**). At post-closure, the baseline watershed area will largely be restored, with drainage area at the confluence of Davidson Creek with lower Chedakuz Creek increased by 3.3 km^2, despite the continued isolation of the Lake 01682LNRS watershed upstream of the Site C West dam. However, the timing and volume of post-closure flows in Davidson Creek will differ from baseline conditions because a portion of the natural watershed will be replaced by the residual TSF pond and spillway (**Section 5.3.2**).

In general, unmitigated flow conditions reduce habitat availability across the species and life stages that use Davidson Creek (**Table 5.3.9-20**). During construction, changes in habitat availability over the two sections downstream of the Project include reductions in kokanee and rainbow spawning habitat; increased rainbow trout fry rearing habitat; increased rainbow trout parr rearing habitat during May/June, and decreased habitat in July/August (3%) and in September – November (7%). Increases in habitat availability occur when the depth and velocity preferences for rainbow trout fry and parr favour lower flows than occur during baseline.

During operations and closure without the FSS, there will be substantial reductions in the availability of habitat downstream of the Project (**Table 5.3.9-20**). For example, during operations the reductions in kokanee and rainbow trout spawning habitat area will be 61% and 83%, respectively. Rainbow trout fry rearing habitat area will be reduced by 12% during July/August and by 30% in September to November. Habitat area for rainbow trout parr will be reduced by 46% to 75%, depending on time period.

Table 5.3.9-20: Summary of Potential Flow-Related Effects by Stream Section for the Unmitigated Scenario in Davidson Creek

Stream Section	Species/Life Stage	Stanza	Project Phase								
			Baseline	**Construction**		**Operations**		**Closure**		**Post-closure**	
			(m^2)	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**
Lower	Kokanee spawning	Jul – Aug	8,519	8,176	-4%	3,314	-61%	3,616	-58%	7,447	-13%
	Rainbow spawning	May – Jun	9,152	8,791	-4%	2,378	-74%	3,180	-65%	8,859	-3%
	Rainbow fry rearing	Jul – Aug	11,623	12,788	10%	17,737	53%	17,722	52%	14,147	22%
		Sep – Nov	14,052	15,032	7%	17,059	21%	17,071	21%	15,010	7%
	Rainbow parr rearing	May – Jun	10,151	10,765	6%	9,952	-2%	10,679	5%	10,264	1%
		Jul – Aug	11,620	11,336	-2%	6,150	-47%	6,568	-43%	10,699	-8%
		Sep – Nov	10,838	10,338	-5%	5,316	-51%	5,523	-49%	10,276	-5%
Middle	Kokanee spawning	N/A	-	-	-	-	-	-	-	-	-
	Rainbow spawning	May – Jun	6,579	6,066	-8%	245	-96%	245	-96%	6,432	-2%
	Rainbow fry rearing	Jul – Aug	17,855	19,583	10%	8,322	-53%	8,322	-53%	20,688	16%
		Sep – Nov	21,031	22,371	6%	7,673	-64%	7,673	-64%	21,761	3%
	Rainbow parr rearing	May – Jun	14,973	16,575	11%	3,592	-76%	3,592	-76%	14,997	0%
		July – Aug	18,234	17,479	-4%	2,071	-89%	2,071	-89%	16,415	-10%
		Sep – Nov	16,679	15,268	-8%	1,605	-90%	1,605	-90%	15,783	-5%
Sum	Kokanee spawning	Jul – Aug	8,519	8,176	-4%	3,314	-61%	3,616	-58%	7,447	-13%
	Rainbow spawning	May – Jun	15,731	14,857	-6%	2,622	-83%	3,425	-78%	15,291	-3%
	Rainbow fry rearing	Jul – Aug	29,477	32,372	10%	26,059	-12%	26,044	-12%	34,835	18%
		Sep – Nov	35,083	37,403	7%	24,731	-30%	24,744	-29%	36,770	5%
	Rainbow parr rearing	May – Jun	25,125	27,340	9%	13,544	-46%	14,271	-43%	25,262	1%
		Jul – Aug	29,854	28,814	-3%	8,221	-72%	8,639	-71%	27,114	-9%
		Sep – Nov	27,517	25,607	-7%	6,920	-75%	7,128	-74%	26,059	-5%

Note: N/A = not applicable; there is no kokanee spawning habitat in the middle Davidson Creek. Percent change is percent difference from baseline conditions. Dashes indicate no data were available.

In aggregate, over the two Davidson Creek sections downstream of the Project, post-closure habitat changes will include reduced kokanee and rainbow trout spawning habitat and increased rainbow trout fry rearing habitat. There will be no change in rainbow trout parr rearing habitat during May and June, but rearing habitat will decrease in July and August (9%) and in September to November (5%).

Lower Chedakuz Creek

Potential downstream effects of the Project were considered by examining Reach 15 of lower Chedakuz Creek, immediately downstream of Tatelkuz Lake. Project-related changes to the timing and volume of flows in Chedakuz Creek will affect fish habitat, with effects differing upstream and downstream of the confluence with Davidson Creek.

From Tatelkuz Lake downstream to Davidson Creek flow reductions (and changes to fish habitat) will be due to extraction of water from Tatelkuz Lake to supply mill operations, as well as small changes to watershed area due to diversion of water from the headwaters of Creek 661 to Davidson Creek (**Table 5.3.9-18**). Downstream of Davidson Creek, there will be additional flow and habitat changes driven by the changes in Davidson Creek detailed above.

The assessment considers Reach 15 of Chedakuz Creek, which begins 0.9 km upstream of Davidson Creek and ends 2.9 km downstream of Davidson Creek (for a total length of 3.8 km). Habitat throughout the reach is characterised as low gradient with abundant spawning gravels for rainbow trout and kokanee and good cover and rearing opportunities for juvenile rainbow trout (**Section 5.1.2.6.3.1.1**).

Flow reductions and associated habitat changes will occur for the unmitigated operations and closure scenarios, when no flows are pumped from Tatelkuz Lake to Davidson Creek via the FSS. These changes reflect pumping from Tatelkuz Lake to the mill, and retention of Davidson Creek runoff from upstream of the TSF dam (refer to **Table 5.3.9-18** for associated areas). At post-closure, changes will remain that will affect the flow regime in Chedakuz Creek. Flows in Chedakuz Creek above Davidson Creek will be altered by permanent diversion of about 6 km^2 from the Creek 661 Watershed to the Davidson Creek Watershed. Flows from this area will report to Chedakuz Creek downstream of the confluence with Davidson Creek. Changes in Chedakuz Creek downstream of Davidson Creek include a net reduction in watershed area by 3 km^2 at WMN H5 (**Table 5.3.9-18**), due to permanent isolation of Lake 01682LNRS from the Davidson Creek Watershed at post-closure. In addition, the timing and volume of flows will be affected by changes to the Davidson Creek flow regime caused by the replacement of natural watershed area with permanent facilities including the pit lake and the reclaimed TSF pond and spillway (**Section 5.3.2**).

Changes in total habitat area in these two affected sections of lower Chedakuz Creek are summarized for each Project phase in **Table 5.3.9-21**. For rainbow trout fry rearing, reduced flows increase the availability of habitat. For rainbow trout parr, reduced flows increase habitat availability during spring freshet and reduce availability from July through November. Availability of rainbow trout and kokanee spawning habitat is reduced, but all reductions are less than 5% relative to baseline.

Table 5.3.9-21: Summary of Potential Flow-Related Effects for Unmitigated Scenario in Lower Chedakuz Creek

			Project Phase								
			Baseline	Construction		Operations		Closure		Post-Closure	
Model	**Species/Life Stage**	**Stanza**	**(m^2)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**
15-CC	Kokanee spawning	Aug – Sep	2,159	2,159	0%	2,158	0%	2,157	0%	2,160	0%
	Rainbow spawning	May – Jun	2,457	2,458	0%	2,446	0%	2,442	-1%	2,457	0%
	Rainbow fry rearing	Jul – Aug	6,457	6,460	0%	6,522	1%	6,569	2%	6,490	1%
		Sep – Nov	7,228	7,227	0%	7,260	0%	7,297	1%	7,207	0%
	Rainbow parr rearing	May – Jun	5,398	5,398	0%	5,395	0%	5,395	0%	5,397	0%
		Jul – Aug	5,169	5,168	0%	5,157	0%	5,148	0%	5,163	0%
		Sep – Nov	5,023	5,023	0%	5,015	0%	5,005	0%	5,029	0%
H5	Kokanee spawning	Aug – Sep	12,065	12,016	0%	11,708	-3%	11,704	-3%	11,954	-1%
	Rainbow spawning	May – Jun	12,502	12,615	1%	12,529	0%	12,542	0%	12,515	0%
	Rainbow fry rearing	Jul – Aug	8,903	9,103	2%	10,104	13%	10,118	14%	9,368	5%
		Sep – Nov	10,023	10,199	2%	10,971	9%	10,985	10%	10,188	2%
	Rainbow parr rearing	May – Jun	10,849	11,172	3%	12,517	15%	12,496	15%	10,907	1%
		Jul – Aug	17,289	17,332	0%	17,425	1%	17,425	1%	17,363	0%
		Sep – Nov	17,692	17,681	0%	17,552	-1%	17,550	-1%	17,666	0%
Sum	Kokanee spawning	Aug – Sep	14,224	14,175	0%	13,866	-3%	13,861	-3%	14,114	-1%
	Rainbow spawning	May – Jun	14,959	15,073	1%	14,974	0%	14,984	0%	14,972	0%
	Rainbow fry rearing	Jul – Aug	15,360	15,563	1%	16,627	8%	16,687	9%	15,858	3%
		Sep – Nov	17,251	17,426	1%	18,231	6%	18,282	6%	17,395	1%
	Rainbow parr rearing	May – Jun	16,247	16,570	2%	17,913	10%	17,891	10%	16,303	0%
		Jul – Aug	22,458	22,501	0%	22,581	1%	22,573	1%	22,526	0%
		Sep – Nov	22,715	22,704	0%	22,567	-1%	22,555	-1%	22,695	0%

Note: % change is percent change from baseline conditions.

Creek 661

Potential downstream effects in the Creek 661 Watershed were considered for three sections:

- Creek 661 from middle Chedakuz Creek upstream to the confluence with Creek 505659;
- Creek 661 upstream of the confluence with Creek 505659; and
- Creek 505659 upstream of the confluence with Creek 661.

An instream flow model was constructed to assess potential downstream flow effects for a single section encompassing all habitat downstream of the confluence with Creek 505659. Instream flow models were not constructed for the two headwaters sections upstream of the confluence between the two creeks, because the streams are small and the flows are low and so flow predictions would be inaccurate and unreliable.

Between middle Chedakuz Creek and the confluence with Creek 505659, Creek 661 extends a distance of 9.8 km through generally low-gradient, riffle-pool habitat. High-quality spawning gravels provide good spawning habitat for rainbow trout and kokanee extending 7.5 km upstream. Only rainbow trout are present upstream of this location. There is no barrier preventing kokanee passage, but spawning gravel quality for kokanee declines above this point.

Upstream of the confluence with Creek 505659, Creek 661 comprises 8.5 km of medium and low quality fish habitat, generally characterized by good substrates and cover for juvenile summer rearing, but no habitat for rainbow trout spawning or overwintering.

Creek 505659 comprises 8.2 km of habitat. High quality rainbow trout spawning and summer rearing habitat is present in the lower 1.5 km, along with good overwintering habitat. Upstream of this point, fish habitat quality is low.

Flow changes in Creek 661 upstream of the confluence with Creek 505659 (i.e., WMN H1) during construction will reduce flows by an annual average of 1 L/s (or -2%), with a range from 0 to -2 L/s (or 0 to -2%) on a monthly basis (**Section 5.3.2**; **Table 5.3.9-22**).

During operations and closure, changes in flow will be similarly small (i.e., reductions of 1 to 2 L/s). However, some of these small changes will occur during months with very low baseline flows, so they will represent larger changes in proportional terms (i.e., a range of -1 to -64% reductions during operations and closure). The largest changes in proportional terms will occur during winter, when Creek 661 is frozen to the bottom (**Appendix 5.1.2.6B**). Flows at WMN H1 will be restored to baseline at post-closure. No ecological effects are anticipated because changes in flows upstream of the confluence with Creek 505659 are relatively small or occur in the winter when the stream is frozen.

Flow changes in Creek 505659 upstream of the confluence with Creek 661 (i.e., WMN 1-505659) will be relatively large, and will persist after post-closure. During construction, flows will increase by an average of 2 L/s (3%) annually, with a range from 0 to 13 L/s (-1 to 5%) on a monthly basis (**Section 5.3.2**; **Table 5.3.9-23**).

Table 5.3.9-22: Summary of Potential Flow Effects for the Unmitigated Scenario in Upper Creek 661 (WMN H1)

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Max**	**Min**
Baseline	Flow (L/s)	6	4	3	20	117	122	38	16	11	11	11	8	31	**122**	**3**
Construction	Change (L/s)	0	0	0	0	-2	-2	-1	0	0	0	0	0	-1	**0**	**-2**
	Change (%)	-1%	0%	0%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-1%	-2%	**0%**	**-2%**
Operations	Change (L/s)	-2	-2	-2	-2	-2	-1	-1	-1	-1	-2	-2	-2	-2	**-1**	**-2**
	Change (%)	-36%	-54%	-64%	-10%	-1%	-1%	-2%	-8%	-13%	-15%	-18%	-27%	-5%	**-1%**	**-64%**
Closure	Change (L/s)	-2	-2	-2	-2	-2	-1	-1	-1	-1	-2	-2	-2	-2	**-1**	**-2**
	Change (%)	-36%	-54%	-64%	-10%	-1%	-1%	-2%	-8%	-13%	-15%	-18%	-27%	-5%	**-1%**	**-64%**
Post-closure	Change (L/s)	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	Change (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**	**0%**

Note: Percent change represents difference from baseline conditions.

Table 5.3.9-23: Summary of Potential Flow Effects for the Unmitigated Scenario in Creek 505659 (WMN 1-505659)

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Max**	**Min**
Baseline	Flow (L/s)	12	9	8	60	289	275	89	36	26	37	34	17	75	**289**	**8**
Construction	Change (L/s)	0	0	0	3	13	8	0	0	0	1	1	0	2	**13**	**0**
	Change (%)	0%	0%	1%	5%	4%	3%	0%	-1%	0%	2%	2%	-1%	3%	**5%**	**-1%**
Operations	Change (L/s)	-1	-1	0	-10	-77	-105	-29	-8	-4	-7	-5	-2	-21	**0**	**-105**
	Change (%)	-10%	-8%	-6%	-16%	-27%	-38%	-32%	-23%	-16%	-18%	-16%	-10%	-28%	**-6%**	**-38%**
Closure	Change (L/s)	-4	-3	-1	-19	-122	-164	-48	-17	-12	-17	-15	-7	-36	**-1**	**-164**
	Change (%)	-34%	-30%	-18%	-31%	-42%	-60%	-55%	-48%	-44%	-45%	-44%	-38%	-48%	**-18%**	**-60%**
Post-closure	Change (L/s)	-4	-2	-1	-19	-121	-164	-48	-17	-11	-16	-14	-6	-35	**-1**	**-164**
	Change (%)	-31%	-27%	-13%	-31%	-42%	-59%	-54%	-46%	-43%	-44%	-43%	-35%	-47%	**-13%**	**-59%**

Note: Percent change represents difference from baseline conditions.

During operations, reductions in flows will occur due to diversion of run-off from the open pit and waste rock dumps within the watershed. The mean annual change will be a reduction of 21 L/s (or -28%). At closure, the TSF spillway will be constructed to route flows from the TSF to Davidson Creek. Much of the footprint of this infrastructure is in the Creek 661 drainage. Footprint effects and continued diversion of surface drainage from waste rock dumps through closure and post-closure will result in a substantial, permanent reduction in flows in Creek 505659. These changes in flows in Creek 505659 have the potential to reduce the productivity of fish habitat in this stream.

Downstream of the confluence between Creek 661 and Creek 505659, potential flow changes were assessed using an instream flow model (**Table 5.3.9-24**). Flow reductions in Creek 661 will result in modest reductions in habitat for rainbow trout and kokanee spawning, and for rainbow trout parr rearing. Modelled habitat availability will improve for rainbow trout fry.

Potential for Winter Effects

The availability and suitability of overwintering habitat is a driver of fish habitat quality. In general, overwintering salmonids seek out refuges from high-velocity water, reduce activity and feeding, and limit interactions with other fish (Cunjak, 1996; Huusko et al., 2007). A major factor limiting salmonid densities in BC streams may be the amount of overwintering habitat (Bustard and Narver, 1975), although more recent reviews suggest that more research is required (Huusko et al., 2007). Nevertheless, overwintering habitat is essential for juvenile rainbow trout in streams. Project-related changes in flow conditions have the potential to cause changes in the quantity and quality of overwintering habitat for juvenile rainbow trout.

Juvenile kokanee emigrate from streams to lakes before winter, and therefore do not use overwintering habitat in streams. Their embryos, however, incubate over winter in stream gravels.

Instream flow models were not constructed to evaluate potential Project effects on overwintering habitat because fish habitat use preference data are not available for the winter (Hatfield, 2012; Faulkner et al., 2012; Huusko et al., 2007). In addition, the hydraulic component of flow models is not accurate when ice cover is present. Therefore, Project-related changes in flows were used as proxies to evaluate potential of habitat changes. The minimum monthly flow for the winter stanza (1 December – 30 April), for baseline and for each Project phase, is presented in **Table 5.3.9-25** for each relevant WMN. This information is summarized from **Section 5.3.2**. Comparisons are in terms of flows because no models are available to convert flow changes into habitat effects.

Table 5.3.9-24: Summary of Potential Flow-Related Effects for the Unmitigated Scenario in Creek 661

		Project Phase								
		Baseline	**Construction**		**Operations**		**Closure**		**Post-Closure**	
Species/Life Stage	**Stanza**	**(m^2)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**
Kokanee spawning	Jul – Aug	11,006	11,006	0%	10,693	-3%	10,373	-6%	10,419	-5%
Rainbow spawning	May – Jun	8,719	8,707	0%	8,627	-1%	8,465	-3%	8,475	-3%
Rainbow fry rearing	Jul – Aug	16,116	16,137	0%	16,320	1%	16,342	1%	16,394	2%
	Sep – Nov	16,381	16,371	0%	16,375	0%	16,194	-1%	16,311	0%
Rainbow parr rearing	May – Jun	13,153	13,118	0%	13,520	3%	13,729	4%	13,724	4%
	Jul – Aug	13,538	13,543	0%	13,049	-4%	12,562	-7%	12,631	-7%
	Sep – Nov	6,288	11,171	0%	6,206	-1%	6,116	-3%	6,133	-2%

Note: % change is percent difference from baseline conditions.

Table 5.3.9-25: Summary of Minimum Monthly Winter Stanza Flows for Each Project Phase for the Unmitigated Scenario, and Comparison to Baseline Minimum Monthly Winter Stanza Flows

Stream	WMN		Baseline	Construction	Operations	Closure	Post-Closure
Davidson Creek	H2	Flow (L/s)	115	87	0	0	101
		% change		-24%	-100%	-100%	-12%
	1-DC	Flow (L/s)	184	156	49	50	160
		% change		-15%	-74%	-73%	-13%
Chedakuz Creek	15-CC	Flow (L/s)	942	942	940	938	951
		% change		0%	0%	0%	1%
	H5	Flow (L/s)	1,416	1,388	1,278	1,277	1,400
		% change		-2%	-10%	-10%	-1%
Creek 661	H1	Flow (L/s)	3	3	1	1	3
		% change		0%	-64%	-64%	0%
	1-505659	Flow (L/s)	8	8	7	6	6
		% change		1%	-6%	-18%	-13%
	H+	Flow (L/s)	11	11	8	7	10
		% change		1%	-23%	-32%	-9%
	1-661	Flow (L/s)	82	82	80	80	81
		% change		0%	-3%	-3%	-1%

Note: % change refers to percent change from baseline conditions. WMH = Watershed Model Node. Data summarized from **Section 5.3.2**.

In Davidson Creek, reductions in minimum winter flows will occur during construction, from 24% reduction at the upper extent (i.e., WMN H2), to 15% reduction in the lower creek (i.e., WMN 1-DC). During operations and closure, there will be substantial reductions due to capture of flows in the TSF. Reductions will range between 100% at the foot of the TSF dam to 73% at the mouth of Davidson Creek.

At post-closure, winter flows from the upper watershed will be restored via the spillway, with net reductions of 12 to 15% across the creek. The substantial reductions in overwintering flows during the operational and closure phases are expected to reduce the availability and quality of overwintering habitat in Davidson Creek.

Winter flows in lower Chedakuz Creek between Tatelkuz Lake and Davidson Creek will not be affected during construction, and will be marginally reduced by pumping from Tatelkuz Lake to the mill during operations and closure (**Table 5.3.9-25**). There will be a marginal increase at post-closure, but the effect is within the margin of error of models and could not be detected if it does occur. Downstream of Davidson Creek, effects during construction and post-closure are again marginal, but there will be a 10% reduction in overwinter flows during the operations and closure periods, due to changes in inputs from Davidson Creek. Lower Chedakuz Creek is deep, characterized by pool and glide habitat, and is supplied by Tatelkuz Lake, so it maintains warmer water temperatures during the winter. Changes in flows are not anticipated to result in adverse effects on overwintering fish.

For Creek 661, reductions in winter flows will occur in headwater reaches where no overwintering habitat is present, so they will not affect fish habitat (**Table 5.3.9-25**). In Creek 505659, reductions on the order of 1 to 2 L/s will occur during operations, closure and at post-closure (-6 to -18% reductions). Good quality overwintering habitat is present in Creek 505659. Changes in flows may reduce the abundance and quality of this overwintering habitat. Within the mainstem of Creek 661, the magnitude of change to overwinter flows will be reduced with distance downstream of the confluence with Creek 505659, and falls to -3% at the mouth of Creek 661. No ecological effects of changes in overwinter flows are anticipated in Creek 661 downstream of Creek 505659.

Potential for Physical Effects

Construction of the TSF dam will cause extensive changes to the upper Davidson Creek Watershed. In addition to flooding habitat upstream, the TSF dam will prevent sediment transport from the upper Davidson Creek Watershed into the lower portion of the drainage. Freshet flushing flows during operations and closure will be limited to flows provided by the remaining drainage downstream of the TSF. The combination of impeded delivery of spawning gravels, and reduced flushing flows to clean fine sediments from existing spawning gravels is expected to result in a reduction in the extent and quality of rainbow trout and kokanee spawning habitat downstream of the project.

Changes to the Creek 661 drainage will be much smaller by comparison, will occur in small headwater streams, and are not considered likely to result in changes to physical habitat structure, sediment supply or sediment transport rates.

5.3.9.3.2.2.2 Potential Effects with Mitigation Measures

Proposed mitigation measures to minimize potential Project effects on fish habitat include:

- Pumping water from Tatelkuz Lake via the FSS to augment flows in Davidson Creek; and
- Diversion of the Davidson Creek Watershed area upstream of the TSF Site C West Dam into the adjacent Creek 705 Drainage.

An additional mitigation measure with the potential to affect fish habitat is pumping of water from Tatelkuz Lake to the open pit during closure. During operations, 33 L/s will be pumped from Tatelkuz Lake to the mine site to supply mill needs. To speed pit filling and to reduce potential for acid rock drainage (ARD), mitigation pumping from Tatelkuz Lake will continue at this rate through closure.

These proposed mitigation measures will affect flows, and therefore have the potential to affect fish habitat in Davidson Creek, Chedakuz Creek and Creek 705. These mitigation measures will have no effect on previously presented conditions in Creek 661.

Mitigation Flow Regime for Davidson Creek

Pumping of water from Tatelkuz Lake to Davidson Creek via the FSS is the principal mitigation measure proposed to address potential Project-related flow effects in Davidson Creek. Water will be drawn from Tatelkuz Lake and pumped to the freshwater reservoir in the Davidson Creek valley, downstream of the TSF Site D dam, during the operations and closure phases of the Project. In concert with water supply to the mill, mitigation will slightly lower the water surface elevation of Tatelkuz Lake and reduce flows in lower Chedakuz Creek downstream of Tatelkuz Lake. Potential effects of FSS operations on stream flows were addressed here. **Section 5.3.8.3.1.4** provides an overview of flow augmentation, the flow regimes, and their contingencies.

The mitigated flow regime supplied by the FSS was defined based on the conclusions of the IFS. The study was used to define Instream Flow Needs (IFN) for Davidson Creek – flows that are required to protect aquatic values to an appropriate standard. The mitigated flow regime was based on Davidson Creek IFN for each biological stanza of the two indicator fish species, as well as consideration of spring flushing flows, and of transitional flows between stanzas (**Appendix 5.1.2.6D**). The FSS design will maintain fish habitat and critical hydrological processes, and consequently protect fisheries and other aquatic resources associated with Davidson Creek. The mitigated flow regime will enable rainbow trout and kokanee to complete spawning, incubation, rearing, and overwintering activities stream during the operations and closure phases of the Project.

A limiting habitat approach was taken to define seasonal IFN. Stream productivity for each life stage of rainbow trout and kokanee present, and for each biological stanza, were assumed to be limited by low-flow conditions (Jowett et al., 2005). IFN were calculated as the flows required to maintain 90% of the baseline habitat available for each stanza where baseline habitat was defined as the mean annual stanza 30-day low flow for baseline conditions. Equal consideration was given to all life stages and stanzas. Given the range of baseline variability, no significant adverse effect on fish populations was anticipated from reductions in total habitat availability up to and including 10%.

Because hydraulic models are not accurate once flows are affected by ice, and data for winter fish habitat use are not available, a conservative approach was taken to define winter IFN for Davidson Creek. Winter needs were defined as the baseline mean 30-day low flow for the winter stanza.

Flushing flows are defined as short-term flow pulses that mobilize and transport fine sediment and organic material, and provide the environmental cues and hydraulic conditions necessary for fish to migrate and gain access to critical habitat. Flushing flows provide for the processes, conditions, and benefits associated with naturally occurring flows of moderately high magnitude and relatively short duration (i.e., lasting for several days). Flushing flows exert enough tractive force to remove fine organic matter and sediment from gravel and transport these fine materials downstream. Flushing flows are generally not strong enough to scour or move gravels or to alter the alignment or morphology of the channel. Flows in the latter category are referred to as channel maintenance or channel forming flows (Milhous, 1998; Wald, 2009).

Flushing flow recommendations for Davidson Creek were based on available research for salmonid-bearing streams. In its lower reaches, Davidson Creek is a low-gradient, meandering stream, which reduces the potential for erosion and sediment transport. Therefore, higher magnitude flushing flows appear warranted; flushing flows were defined as 400% of mean annual discharge (MAD) for Davidson Creek (**Appendix 5.1.2.6D**).

Transitional flows are flow levels and associated rates of change that ensure that physical conditions do not cause undue stress or other impacts to fish and other aquatic biota. Transitional flows are meant to ensure a smooth progression from one flow level to the next so that survival is maximized as fish transition between life stages. By providing hydrologic continuity in the form of gradual changes in flow over extended periods of time, transitional flows ensure that ecological benefits are propagated from one life history stage to the next. The overriding benefit of providing transitional flows following rainbow trout and kokanee spawning is to avoid dewatering redds as flows subside. The magnitudes and durations of transitional flows were set to ensure that redds remain covered with water through the incubation period.

Diversion to Creek 705 Watershed

To mitigate for the isolation of Lake 01682LNRS upstream of the Project, a portion of the Davidson Creek Watershed upstream of the TSF Site C West dam will be diverted into the adjacent Creek 705 drainage in the Fawnie Creek Watershed. This will increase the watershed area of Creek 705 at the confluence with Fawnie Creek from 45 km^2 to 48 km^2 (**Table 5.3.9-26**), and will increase flows in Creek 705.

Table 5.3.9-26: Changes in Total Watershed Area by Project Phase for the Mitigated Scenario

	Area (km^2) by Project Phase				
Watershed	**Baseline**	**Construction**	**Mitigated Operations**	**Mitigated Closure**	**Post Closure**
Creek 705	45.3	47.9	47.9	47.9	47.9

Potential Effects on Flow of Mitigation Measures

Mitigation flows will be supplied to Davidson Creek during operations and closure. These flows will be lower than mean baseline flows. Flows for the mitigated scenario were modelled for appropriate WMN by incorporating into the watershed model the mitigated Davidson Creek flow regime (for the operations and closure phases), and the diversion to Creek 705 (Knight Piésold, 2013a). Construction and post-closure flows in Davidson Creek will be the same as presented previously. Details and results of flow modelling are presented in **Section 5.3.2** and are summarised in **Table 5.3.9-27**. Mean monthly flows are plotted for baseline and mitigation scenarios for lower Davidson Creek (**Figure 5.3.9-2**), Chedakuz Creek (**Figure 5.3.9-3**), Creek 661 (**Figure 5.3.9-4**) and Creek 705 (**Figure 5.3.9-5**).

Mitigation flows supplied to Davidson Creek during operations and closure will result in reduced flows in lower Chedakuz Creek. However, construction and post-closure flows in lower Chedakuz Creek will be the same as unmitigated flows.

Flows in Creek 661 will be reduced during operations, closure and post-closure, mainly in summer, due to impoundment of sections of some headwater streams during construction.

Flows in Creek 705 will increase at construction due to permanent diversion of the Davidson Creek headwaters upstream of the Site C West dam. This diversion will remain in place throughout operations, closure and post-closure phases, so there will be no change in effects over Project phases.

Potential Effects on Fish Habitat

Potential flow effects were assessed using flow/habitat models and flow time-series as detailed previously for Davidson Creek and Chedakuz Creek.

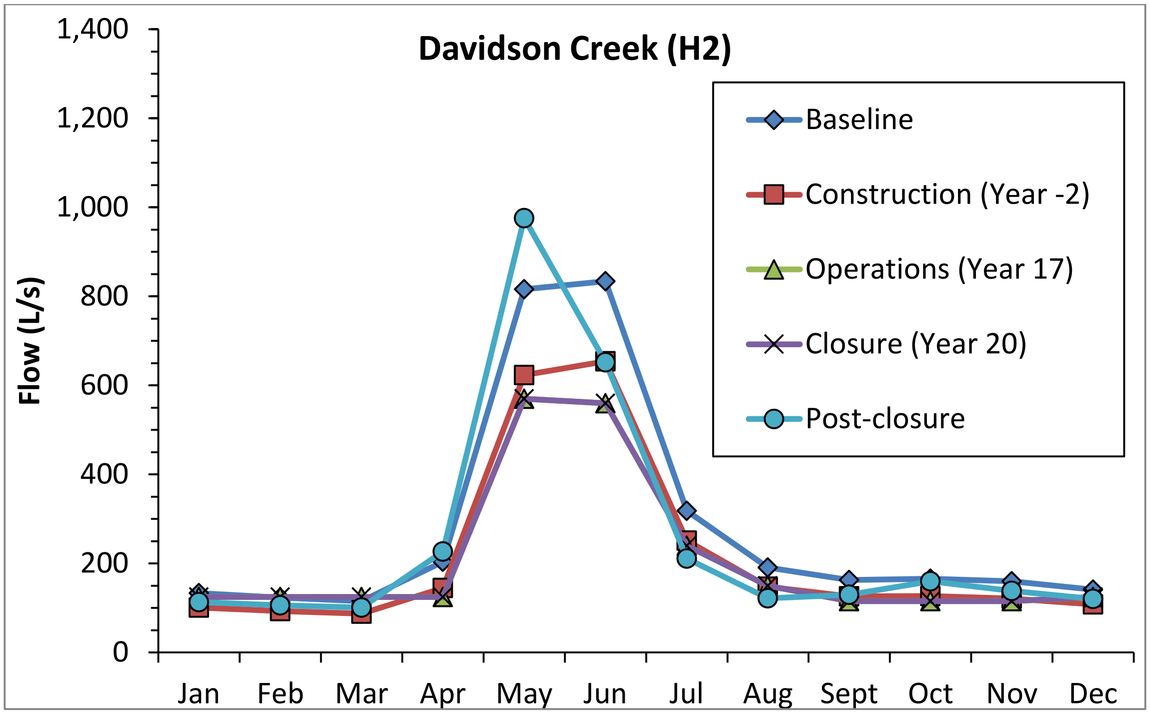
To extend the analysis to Creek 705, flow/habitat models were constructed for two sections of Creek 705. The lower Creek 705 section is 0.8 km long, extending upstream from the confluence with Fawnie Creek. This section is characterised by low-gradient, high-quality spawning and rearing habitat for rainbow trout. (Kokanee do not spawn in Creek 705.) The middle Creek 705 section is 6.8 km long, is characterized by a narrower, steeper channel, and also supports rainbow trout spawning and rearing habitat. Since kokanee are not present in Creek 705, four biological stanzas were defined (**Table 5.3.9-28**).

Table 5.3.9-27: Surface Water Flows for Selected Watershed Model Nodes, Baseline and Percent Change by Project Phase for the Mitigated Scenario

Stream	Mine Phase	Estimated Average Monthly and Annual Surface Water Flows (L/s or % Change Relative to Baseline)												
		January	February	March	April	May	June	July	August	September	October	November	December	Annual
Davidson Creek	H2													
	Baseline (L/s)	133	123	115	204	816	834	318	191	163	166	160	141	281
	Construction % change	-24%	-24%	-24%	-29%	-24%	-22%	-21%	-22%	-23%	-24%	-24%	-24%	-23%
	Operations % change	-6%	2%	9%	-39%	-30%	-33%	-25%	-21%	-30%	-31%	-28%	-11%	-26%
	Closure % change	-6%	2%	9%	-39%	-30%	-33%	-25%	-21%	-30%	-31%	-28%	-11%	-26%
	Post-closure % change	-14%	-14%	-12%	11%	20%	-22%	-34%	-36%	-21%	-4%	-14%	-15%	-9%
	1-DC													
	Baseline (L/s)	203	185	184	404	1,104	1,033	441	286	247	260	258	223	403
	Construction % change	-15%	-15%	-15%	-14%	-18%	-17%	-15%	-15%	-15%	-15%	-15%	-15%	-16%
	Operations % change	-11%	-6%	-1%	-23%	-24%	-29%	-23%	-22%	-28%	-27%	-24%	-14%	-23%
	Closure % change	-11%	-5%	-1%	-20%	-19%	-25%	-21%	-20%	-26%	-25%	-23%	-14%	-20%
	Post-closure % change	-14%	-13%	-11%	2%	11%	-21%	-29%	-30%	-20%	-8%	-14%	-14%	-10%
Chedakuz Creek	15-CC													
	Baseline (L/s)	954	942	1,071	2,027	4,301	3,913	1,811	1,070	1,123	1,106	1,341	1,066	1,727
	Construction % change	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Operations % change	-17%	-17%	-15%	-8%	-16%	-18%	-17%	-18%	-14%	-14%	-12%	-15%	-15%
	Closure % change	-14%	-14%	-12%	-7%	-16%	-18%	-16%	-16%	-11%	-12%	-10%	-12%	-14%
	Post-closure % change	1%	1%	1%	1%	2%	-1%	-1%	0%	0%	1%	0%	1%	0%
	H5													
	Baseline (L/s)	1,434	1,416	1,609	3,047	6,464	5,880	2,721	1,607	1,688	1,662	2,015	1,602	2,595
	Construction % change	-2%	-2%	-2%	-2%	-3%	-3%	-2%	-3%	-2%	-2%	-2%	-2%	-2%
	Operations % change	-13%	-12%	-10%	-9%	-15%	-17%	-15%	-16%	-13%	-14%	-11%	-12%	-14%
	Closure % change	-11%	-10%	-8%	-7%	-14%	-16%	-14%	-14%	-11%	-12%	-9%	-10%	-12%
	Post-closure % change	-1%	-1%	-1%	1%	3%	-4%	-5%	-6%	-3%	-1%	-2%	-2%	-1%
Creek 705	6-705													
	Baseline (L/s)	2	1	1	18	130	75	29	12	9	12	10	4	25

Stream	Mine Phase	Estimated Average Monthly and Annual Surface Water Flows (L/s or % Change Relative to Baseline)												
		January	February	March	April	May	June	July	August	September	October	November	December	Annual
	All phases % change	Increase	Increase	Increase	60%	40%	66%	51%	52%	57%	48%	53%	Increase	54%
	H7													
	Baseline (L/s)	27	17	16	252	1,181	670	222	100	80	131	116	46	239
	All phases % change	13%	20%	18%	4%	4%	7%	7%	6%	6%	4%	5%	9%	6%
	1-705													
	Baseline (L/s)	41	30	31	282	1,218	694	239	114	94	146	132	61	258
	All phases % change	9%	11%	10%	4%	4%	7%	6%	6%	5%	4%	4%	7%	5%

Note: Table summarised from **Appendix 5.3.2B**. Percent changes represent change from baseline conditions. Flows in Creek 705 are the same across all Project phases, because conditions do not change once the diversion has been installed during construction.



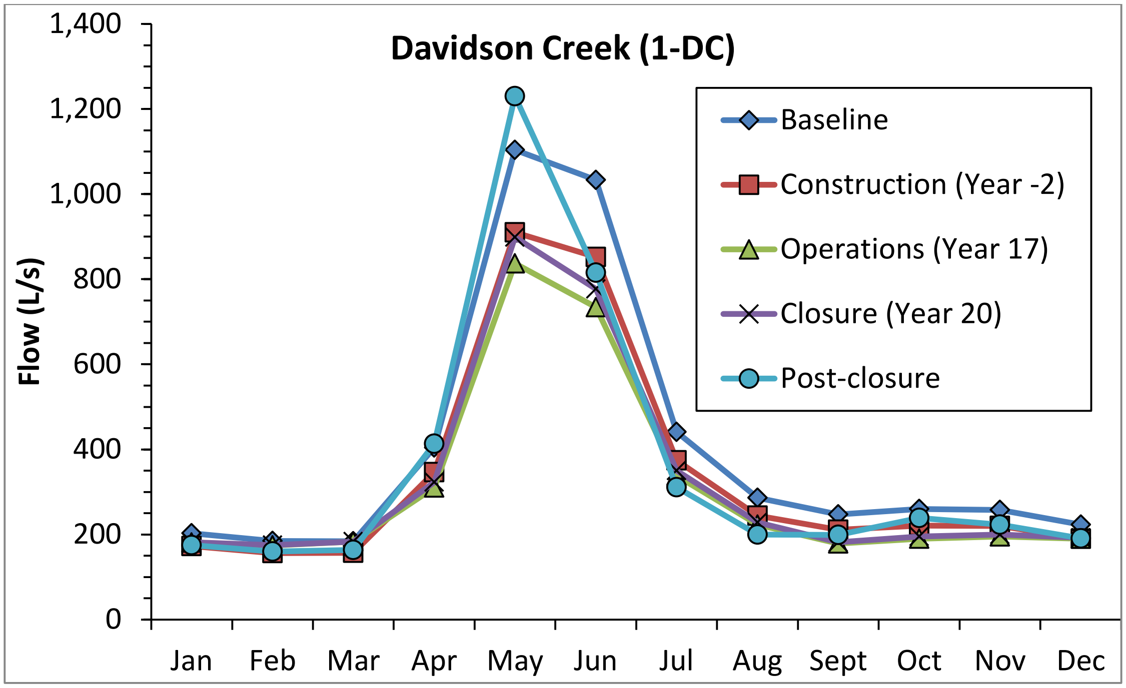
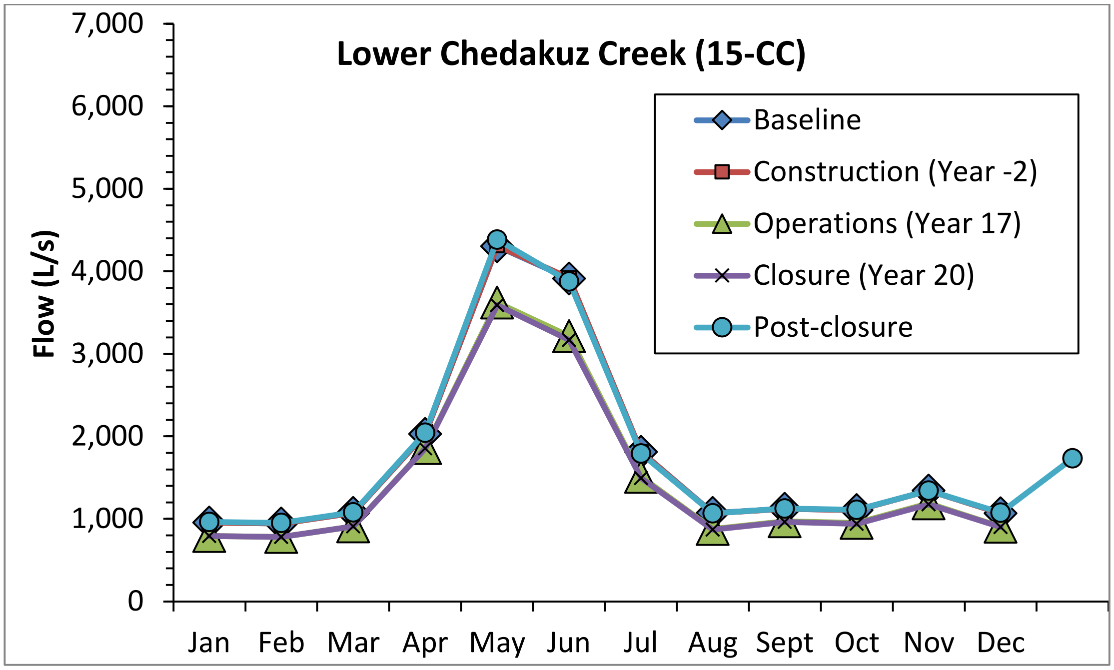


Figure 5.3.9-2: Monthly Flows in Davidson Creek at Nodes H2 and 1-DC for Baseline and Mitigated Scenarios



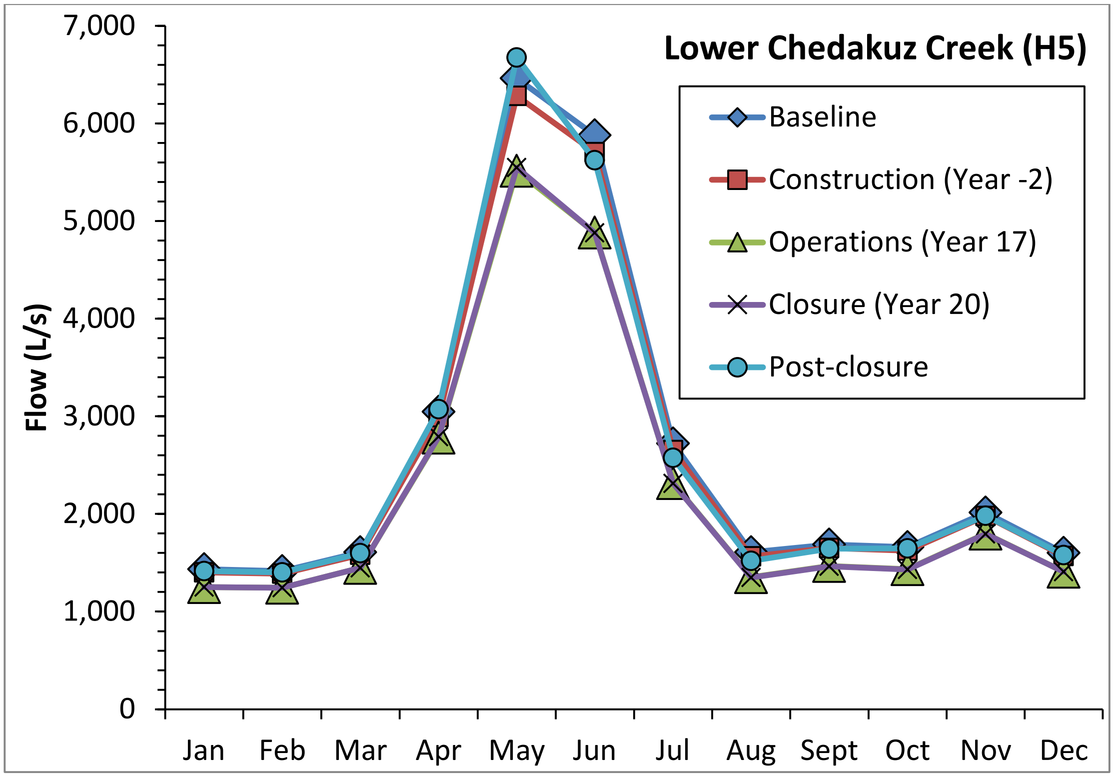
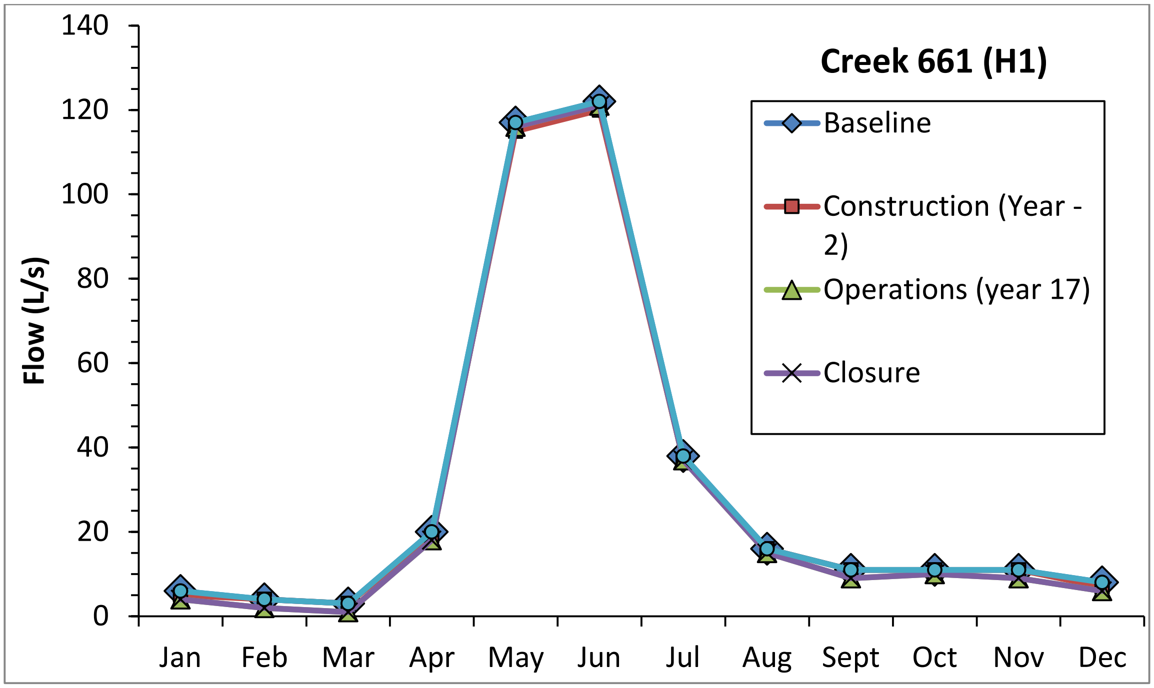


Figure 5.3.9-3: Monthly Flows in Lower Chedakuz Creek at Nodes 15-CC and H5 for Baseline and Mitigated Scenarios



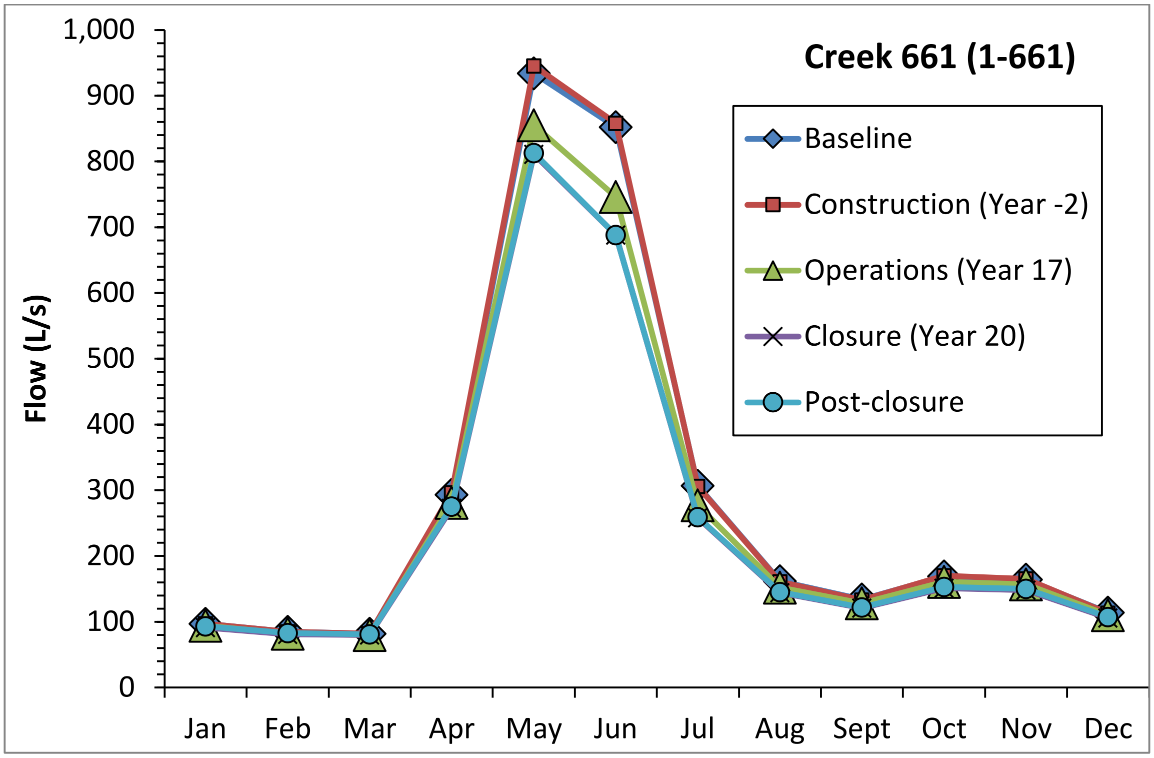
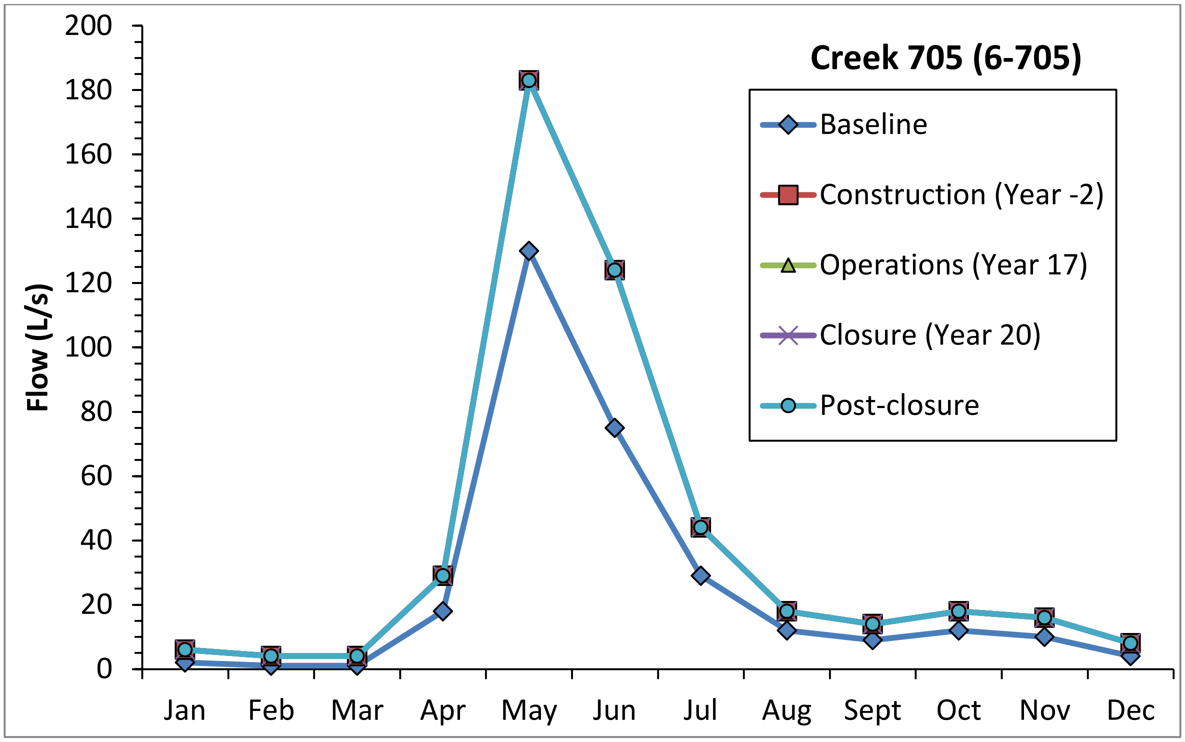


Figure 5.3.9-4: Monthly Flows in Creek 661 at Nodes H1 and 1-661 for Baseline and Mitigated Scenarios



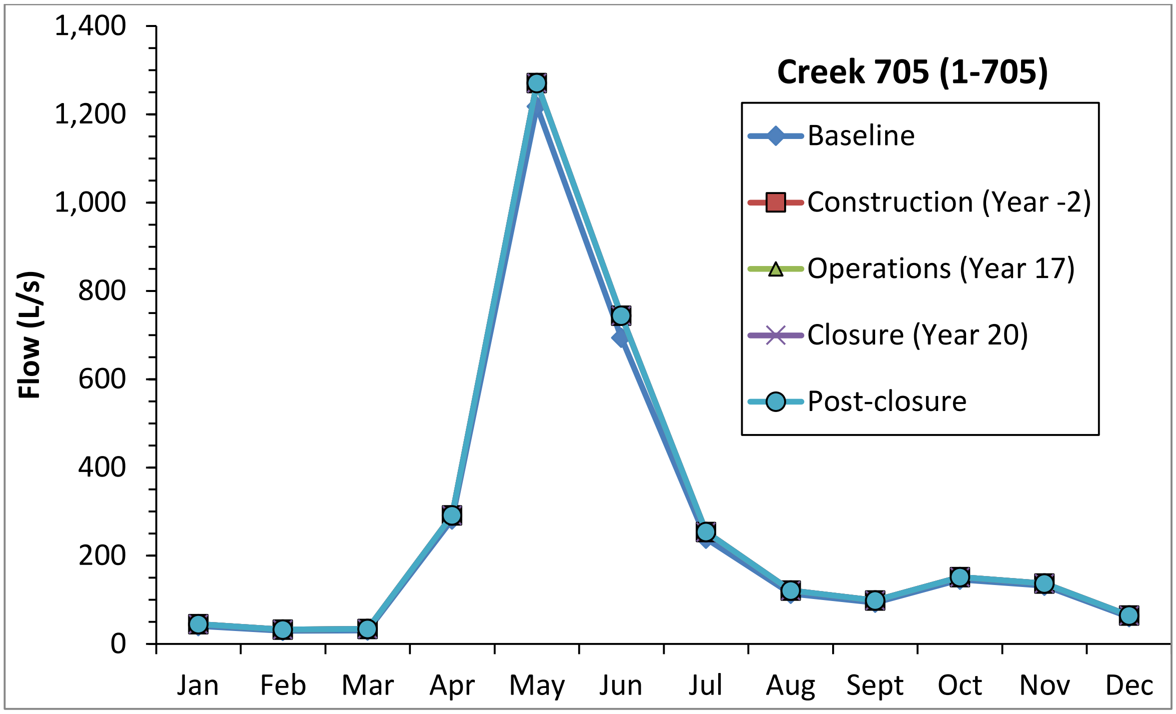


Figure 5.3.9-5: Monthly Flows in Creek 705 at Nodes 6-705 and 1-705 for Baseline and Mitigated Scenarios

Table 5.3.9-28: Biological Stanzas for Analyses in Creek 705

Stream	Stanza	Rationale
Creek 705	1 December – 1 May	Juvenile overwintering
	1 May – 15 May	Freshet flows: substrate scour and cleaning of fine sediments from spawning gravels
	16 May – 30 June	Rainbow trout migration and spawning
	1 July – 30 November	Rainbow trout incubation and rearing

Instream flow transects were not installed further upstream in the Creek 705 drainage. Physical structure and fish habitat immediately downstream of Lake 01538UEUT is characterized by low flows and narrow channels, physically unsuited to the collection of accurate discharge data and the development of reliable instream flow models. A qualitative field assessment of the potential for flow-related effects was completed for reaches immediately downstream of Lake 01538UEUT.

Changes in mean monthly habitat area in Davidson Creek, downstream of the Project, were summarized for each Project phase in **Table 5.3.9-29**.

Conditions for construction and post-closure will be as described previously. Mitigated flow conditions will, when compared to the unmitigated scenario, substantially improve habitat availability for rainbow trout and kokanee in Davidson Creek during operations and closure. For rainbow trout fry rearing, reduced flows will increase the availability of habitat. For rainbow trout parr, reduced flows (relative to baseline) will increase habitat availability during spring freshet, and reduce habitat availability from July through November when flows are reduced. Availability of rainbow trout and kokanee spawning habitat will be reduced by 4 to 6% during operations and closure. As changes relative to baseline will occur despite mitigation, potential effects were carried forward to residual effects assessment.

Table 5.3.9-29: Summary of Potential Flow-Related Effects for Mitigated Scenario in Davidson Creek

			Project Phase								
			Baseline	Construction		Mitigated Operations		Mitigated Closure		Post-closure	
Model	**Species/Life Stage**	**Stanza**	**(m^2)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**
Lower	Kokanee spawning	Jul – Aug	8,519	8,176	-4%	8,033	-6%	8,101	-5%	7,447	-13%
	Rainbow spawning	May – Jun	9,152	8,791	-4%	8,821	-4%	9,047	-1%	8,859	-3%
	Rainbow fry rearing	Jul – Aug	11,623	12,788	10%	13,396	15%	13,199	14%	14,147	22%
		Sep – Nov	14,052	15,032	7%	15,810	13%	15,691	12%	15,010	7%
	Rainbow parr rearing	May – Jun	10,151	10,765	6%	11,147	10%	10,948	8%	10,264	1%
		Jul – Aug	11,620	11,336	-2%	11,216	-3%	11,275	-3%	10,699	-8%
		Sep – Nov	10,838	10,338	-5%	9,993	-8%	10,060	-7%	10,276	-5%
Middle	Kokanee spawning	N/A	-	-	-	-	-	-	-	-	-
	Rainbow spawning	May – Jun	6,579	6,066	-8%	6,007	-9%	6,007	-9%	6,432	-2%
	Rainbow fry rearing	Jul – Aug	17,855	19,583	10%	19,686	10%	19,686	10%	20,688	16%
		Sep – Nov	21,031	22,371	6%	22,804	8%	22,804	8%	21,761	3%
	Rainbow parr rearing	May – Jun	14,973	16,575	11%	17,401	16%	17,401	16%	14,997	0%
		July – Aug	18,234	17,479	-4%	17,645	-3%	17,645	-3%	16,415	-10%
		Sep – Nov	16,679	15,268	-8%	15,070	-10%	15,070	-10%	15,783	-5%
Sum	Kokanee spawning	Jul – Aug	8,519	8,176	-4%	8,033	-6%	8,101	-5%	7,447	-13%
	Rainbow spawning	May – Jun	15,731	14,857	-6%	14,828	-6%	15,054	-4%	15,291	-3%
	Rainbow fry rearing	Jul – Aug	29,477	32,372	10%	33,082	12%	32,885	12%	34,835	18%
		Sep – Nov	35,083	37,403	7%	38,614	10%	38,495	10%	36,770	5%
	Rainbow parr rearing	May – Jun	25,125	27,340	9%	28,548	14%	28,349	13%	25,262	1%
		Jul – Aug	29,854	28,814	-3%	28,862	-3%	28,920	-3%	27,114	-9%
		Sep – Nov	27,517	25,607	-7%	25,063	-9%	25,130	-9%	26,059	-5%

Note: N/A = not applicable; there is no kokanee spawning habitat in the middle Davidson Creek. % change is percent difference from baseline conditions.

Changes in total habitat area in Creek 705, based on the two sections for which flow/habitat models were constructed, are presented in **Table 5.3.9-30**.

Table 5.3.9-30: Summary of Potential Flow-Related Effects for Mitigated Scenario for Creek 705

			Project Phase		
			Baseline	**Operations**	
Model	**Species/Life Stage**	**Stanza**	**(m^2)**	**(% change)**	**% change**
Lower	Rainbow spawning	May – Jun	4,812	4,872	1%
	Rainbow fry rearing	Jul – Aug	15,719	15,512	-1%
		Sep – Nov	16,203	16,350	1%
	Rainbow parr rearing	May – Jun	11,276	11,129	-1%
		Jul – Aug	10,743	10,957	2%
		Sep – Nov	7,755	8,074	4%
Middle	Rainbow spawning	May – Jun	1,476	1,503	2%
	Rainbow fry rearing	Jul – Aug	1,712	1,674	-2%
		Sep – Nov	1,879	1,876	0%
	Rainbow parr rearing	May – Jun	1,237	1,209	-2%
		Jul – Aug	1,230	1,254	2%
		Sep - Nov	940	965	3%
Sum	Rainbow spawning	May – Jun	6,288	6,375	1%
	Rainbow fry rearing	Jul – Aug	17,431	17,186	-1%
		Sep – Nov	18,082	18,226	1%
	Rainbow parr rearing	May – Jun	12,514	12,338	-1%
		Jul – Aug	11,973	12,211	2%
		Sep – Nov	8,695	9,039	4%

Note: % change is percent difference from baseline conditions.

Changes in total habitat area in the two affected sections of lower Chedakuz Creek (upstream and downstream of the confluence with Davidson Creek) are summarized in **Table 5.3.9-31**. Construction and post-closure conditions will be as described previously. Pumping of mitigation flows to Davidson Creek will change habitat availability in lower Chedakuz Creek during operations and closure. Mitigation will change habitat availability during operations and closure. For rainbow trout fry rearing, reduced flows will increase the availability of habitat. For rainbow trout parr, reduced flows will increase habitat availability during spring freshet, and reduce availability from July through November. Availability of rainbow trout and kokanee spawning habitat will be reduced by 4 to 6% during operations and closure. As changes to fish habitat availability relative to baseline occur, this potential effect is carried forward to the residual effects assessment.

Table 5.3.9-31: Summary of Potential Flow-Related Effects for Mitigated Scenario in Lower Chedakuz Creek.

			Project Phase								
			Baseline	**Construction**		**Mitigated Operations**		**Mitigated Closure**		**Post-closure**	
Model	**Species/Life Stage**	**Stanza**	**(m^2)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**	**(m^2)**	**(% change)**
15-CC	Kokanee spawning	Aug – Sep	2,159	2,159	0%	2,054	-5%	2,079	-4%	2,160	0%
	Rainbow spawning	May – Jun	2,457	2,458	0%	2,228	-9%	2,231	-9%	2,457	0%
	Rainbow fry rearing	Jul – Aug	6,457	6,460	0%	7,512	16%	7,401	15%	6,490	1%
		Sep – Nov	7,228	7,227	0%	7,990	11%	7,858	9%	7,207	0%
	Rainbow parr rearing	May – Jun	5,398	5,398	0%	5,301	-2%	5,305	-2%	5,397	0%
		Jul – Aug	5,169	5,168	0%	4,894	-5%	4,933	-5%	5,163	0%
		Sep – Nov	5,023	5,023	0%	4,780	-5%	4,829	-4%	5,029	0%
H5	Kokanee spawning	Aug – Sep	12,065	12,016	0%	11,620	-4%	11,704	-3%	11,954	-1%
	Rainbow spawning	May – Jun	12,502	12,615	1%	12,503	0%	12,542	0%	12,515	0%
	Rainbow fry rearing	Jul – Aug	8,903	9,103	2%	10,269	15%	10,118	14%	9,368	5%
		Sep – Nov	10,023	10,199	2%	11,152	11%	10,985	10%	10,188	2%
	Rainbow parr rearing	May – Jun	10,849	11,172	3%	12,575	16%	12,496	15%	10,907	1%
		Jul – Aug	17,289	17,332	0%	17,403	1%	17,425	1%	17,363	0%
		Sep – Nov	17,692	17,681	0%	17,502	-1%	17,550	-1%	17,666	0%
Sum	Kokanee spawning	Aug – Sep	14,224	14,175	0%	13,674	-4%	13,782	-3%	14,114	-1%
	Rainbow spawning	May – Jun	14,959	15,073	1%	14,731	-2%	14,773	-1%	14,972	0%
	Rainbow fry rearing	Jul – Aug	15,360	15,563	1%	17,780	16%	17,520	14%	15,858	3%
		Sep – Nov	17,251	17,426	1%	19,141	11%	18,843	9%	17,395	1%
	Rainbow parr rearing	May – Jun	16,247	16,570	2%	17,876	10%	17,801	10%	16,303	0%
		Jul – Aug	22,458	22,501	0%	22,298	-1%	22,359	0%	22,526	0%
		Sep – Nov	22,715	22,704	0%	22,282	-2%	22,379	-1%	22,695	0%

Note: % change is percent difference from baseline conditions.

Flow changes resulting from diversion of Lake 01682LNRS to Lake 01538UEUT will result in a net change of less than ± 5% in the baseline habitat area in the lower sections of Creek 705 that were modelled. Flow increases immediately downstream of Lake 01538UEUT may affect channel structure and fish habitat by widening the channel at some locations where the banks are soft and erodible. Dissipation of the flow is likely to occur in fen and wetland complex habitats. Channel widening may improve some areas where there is good cobble and gravel habitat. Other sections may have increased sedimentation from bank erosion, but any disturbed sediments will most likely settle in the pre-existing wetlands. As changes to fish habitat availability relative to baseline occur, this potential effect was carried forward to the residual effects assessment.

Potential for Winter Effects

Relative to the unmitigated scenario presented previously, mitigation will increase winter flows in Davidson Creek and in Creek 705, and will reduce winter flows in lower Chedakuz Creek downstream of Tatelkuz Lake (**Table 5.3.9-32**). In Davidson Creek, minimum winter flows during construction and post-closure will be unchanged relative to data presented previously. During operations and closure, winter flows provided via the FSS are defined by the baseline 30-day winter stanza low flow, which results in small reductions relative to mean baseline conditions.

Above Davidson Creek, winter flows in lower Chedakuz Creek will not be affected during construction, and will be reduced by 17% in operations and 14% during closure. Below Davidson Creek, reductions will be 12% in operations and 10% during closure.

Changes to winter flows in Creek 705 will be small (3 L/s, which amounts to an 11% increase at WHN 1-705) and so are not anticipated to result in detectable change in overwintering habitat quality.

The potential for changes in winter flows to result in residual effects to overwintering habitat for fish was carried forward to the residual effects assessment.

Potential for Physical Effects

Mitigation flows to Davidson Creek will not alter the previously discussed effects of TSF dam construction on sediment transport from the upper Davidson Creek Watershed into the lower portion of the drainage. However, mitigation flushing flows will be implemented in Davidson Creek to maintain suitable conditions for fish spawning and food production. Flushing flows displace fine-grained sediment and organic material from the interstitial voids of spawning substrates, leading to improved intragravel flow, which in turn is associated with higher incubation survival and increased production of benthic invertebrates. Flushing flows that occur at the beginning of the spawning season, especially when they follow a prolonged period of low flows, also serve as an environmental cue for sexually mature fish to commence their migration to spawning areas upstream. Water depths and velocities that occur during flushing flows are generally favourable for fish migration.

Table 5.3.9-32: Summary of Minimum Monthly Winter Stanza Flows for Each Project Phase, and Comparison to Baseline Minimum Monthly Winter Stanza Flows, Mitigated Scenario

Stream	WMN		Baseline	Construction	Mitigated Operations	Mitigated Closure	Post-Closure
Davidson Creek	H2	Flow (L/s)	115	87	125	125	101
		% change		-24%	9%	9%	-12%
	1-DC	Flow (L/s)	184	156	174	175	160
		% change		-15%	-6%	-5%	-13%
Chedakuz Creek	15-CC	Flow (L/s)	942	942	782	813	951
		% change		0%	-17%	-14%	1%
	H5	Flow (L/s)	1416	1388	1245	1277	1400
		% change		-2%	-12%	-10%	-1%
Creek 705	6-705	Flow (L/s)	1	4	4	4	4
		% change		370%	370%	370%	370%
	H7	Flow (L/s)	16	19	19	19	19
		% change		18%	18%	18%	18%
	1-705	Flow (L/s)	30	33	33	33	33
		% change		11%	11%	11%	11%

Note: % change refers to percent change from baseline conditions. Data summarized from **Section 5.3.2**.

Channel maintenance flows are not provided by the mitigation flow regime. Floods capable of transporting bedload and large wood, scouring riparian and stream bank areas, and connecting the channel to the floodplain are generally desirable, and would be expected to occur naturally over the 35-year period of operations and closure. However, the TSF will intercept coarse sediment that would normally be transported to downstream reaches during high flow events. Therefore, flows sufficient to mobilize and transport bedload in reaches downstream of the TSF are undesirable because, with reduced sources of new material, such transport of materials might erode the channel and should therefore be avoided.

Flow changes in Chedakuz Creek are insufficient to result in changes to physical structure.

Changes to flows in the Creek 705 Watershed are mediated by Lake 01538UEUT downstream of the diversion location. Potential channel effects immediately downstream of Lake 01538UEUT may include channel widening and erosion in some areas with soft banks.

Summary of Potential Residual Effects

In summary, potential effects of changes in flows of Davidson Creek, lower and middle Chedakuz Creek, Creek 661 and Creek 705 on fish habitat were all carried forward to residual effects assessment (**Table 5.3.9-33**).

Table 5.3.9-33: Summary of Potential Residual Effects of Changes in Flow after Mitigation

Potential Environmental Effect	Project Phase	Likelihood of Occurrence With Mitigation
Change in fish habitat quality and availability in Davidson Creek as a result of changes in flows	Construction/Operations/Closure/ Post-Closure	Likely
Change in fish habitat quality and availability in lower Chedakuz Creek as a result of changes in flows	Construction/Operations/Closure/ Post-Closure	Likely
Change in fish habitat quality and availability in Creek 661 as a result of changes in flows	Construction/Operations/Closure/Post-Closure	Likely
Change in fish habitat quality and availability in Creek 705 as a result of changes in flows	Construction/Operations/Closure/Post-Closure	Likely

5.3.9.3.2.2.3 Magnitude of Effects on Fish Habitat of Changes in Flow after Mitigation

To determine whether or not a residual change represents a significant adverse effect on fish habitat, a threshold for acceptable change must be defined. This was defined as a 10% reduction in total habitat availability over relevant stanzas for rainbow trout spawning and juvenile rearing and for kokanee spawning. This section assesses the degree to which changes in flow will fall below the 10% threshold.

The rationale for a reduction of 10% being not significant is based on the same assumptions applied to develop Davidson Creek IFN. Flow/habitat models represent theoretical habitat availability; when applied to a time series of flows, they assume that habitat availability is independent of conditions earlier in the time series. In reality, there is high variability in baseline flow conditions. Conditions experienced by fish are affected by the time series, in particular when poor conditions cause a habitat bottleneck. The population effects of this event (e.g., caused by unusually high or low flows) persist through the cohort of fish and reduce habitat productivity relative to the theoretical total indicated by the models. Given the range of baseline variability, no significant adverse effect to ecological function or biological populations is expected from reductions in total modelled habitat availability of 10% or less. As habitat availability varies naturally, effective habitat is always less than what is modelled by flow/habitat relationships. Therefore, 10% is a conservative estimate of the reduction in modelled productivity that does not result in ecological change. A change in modelled habitat availability up to 10% is not ecologically or biologically relevant. Because a 10% change in modelled habitat availability is likely to have an effect of less than 10% in fish population terms, a change of this magnitude is considered undetectable in fish population estimates.

Flow/habitat models are not available for winter conditions, because predictive hydraulic models are not accurate once depths and velocities are affected by ice cover, and because fish habitat preference data are not available for the winter. Under winter conditions, fish seek flow refugia in pools with sufficient dissolved oxygen to support their requirements. The availability of suitable winter habitats may be affected by changes in flow regimes, and water extraction during the winter has been identified as a management concern for BC streams (e.g., Faulkner et al., 2012). Potential effects on winter fish habitat were evaluated qualitatively with reference to anticipated winter low flows for each Project phase. The minimum monthly flow to occur within the winter stanza (1 December to 30 April) for each Project phase was compared to the minimum monthly baseline flow.

There is no explicit mechanism to determine a threshold for potential effects of winter flow reduction. A threshold of 10% reduction in flows was applied. This is likely to be highly conservative because a 10% change in winter flows likely results in much less than a 10% change in habitat availability, because fish use pool refuge habitat during the winter, and pool habitat is insensitive to changes in flow.

Potential effects on physical habitat were assessed by comparing Project conditions to available recommendations for flushing and channel forming flows available in the scientific literature.

Davidson Creek

With mitigation, all flow-related changes in rainbow trout habitat within Davidson Creek downstream of the TSF will be less than the 10% threshold (**Figure 5.3.9-6**). During construction, operations and closure, effects on kokanee spawning habitat will also be less than the 10% threshold. Reduced late-summer flows at post-closure will cause a 13% reduction in kokanee spawning habitat. The pre-Project watershed is largely restored at post-closure, with total drainage area increased by 3.3 km^2. However, the timing and volume of flows will be affected by the replacement of the natural watershed with residual facilities including the TSF pond and spillway (**Section 5.3.2**).

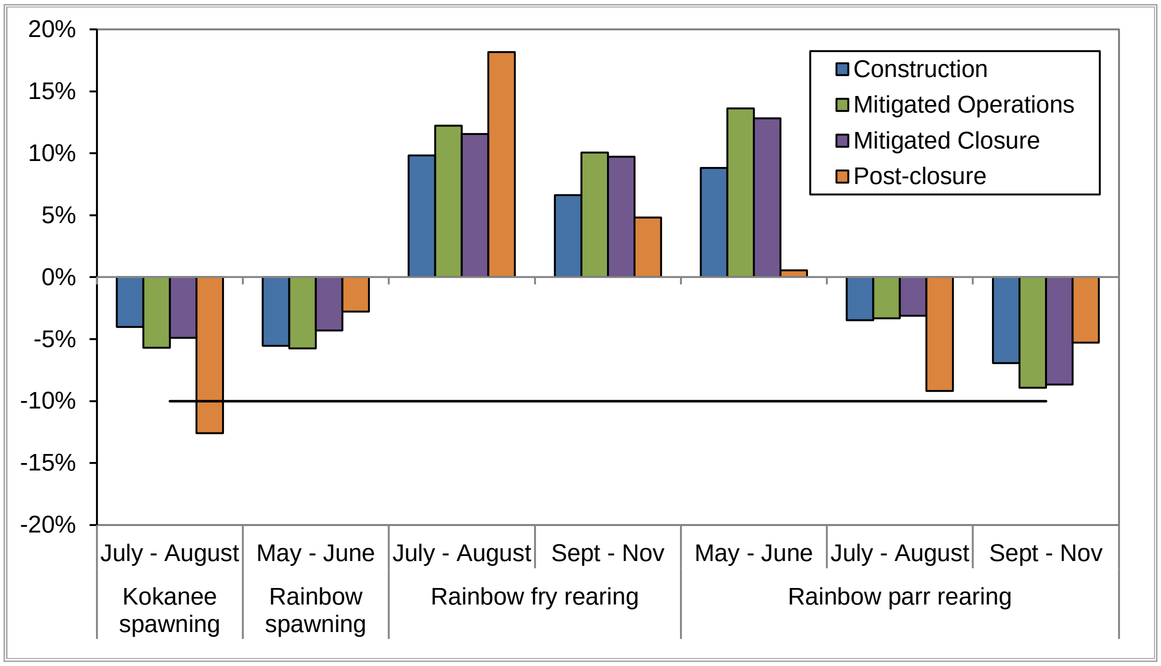


Figure 5.3.9-6: Summary of Residual Change in Total Habitat Area for Davidson Creek Downstream of TSF

Reductions in minimum winter flows during construction will range from 15% to 24% in Davidson Creek (not shown in **Figure 5.3.9-6**). Mitigation flows during operations and closure will maintain minimum winter flows within 10% of baseline. At post-closure, minimum monthly winter flows post-closure will be 14% lower than at baseline.

Reduced sediment transport from the upper watershed to the lower watershed, due to the TSF construction, has the potential to cause physical habitat changes in lower Davidson Creek. In addition, channel-forming flows will be curtailed during construction, operations, and closure. Physical habitat effects are not expected over the 35 year duration of construction, operations and closure. However, there is uncertainty with respect to long-term habitat effects in lower Davidson Creek at post-closure. Peak flows will be restored at post- closure (**Section 5.3.2**), but sediment supply dynamics for lower Davidson Creek are not well understood. Stream reaches in the LSA located downstream of other sediment traps (such as Chedakuz Creek downstream of Tatelkuz Lake) contain excellent spawning gravels. Monitoring will be required to determine if physical habitat effects occur in Davidson Creek downstream of the TSF.

Lower Chedakuz Creek

Residual effects on total habitat area of sections of in lower Chedakuz Creek were compared by Project phase to baseline conditions (**Figure 5.3.9-7**). Construction was not included in the comparison because effects are always less than for mitigated operations. With mitigation, all Project-related reductions in rainbow trout and kokanee habitat within Chedakuz Creek downstream of Tatelkuz Lake will be less than 5%.

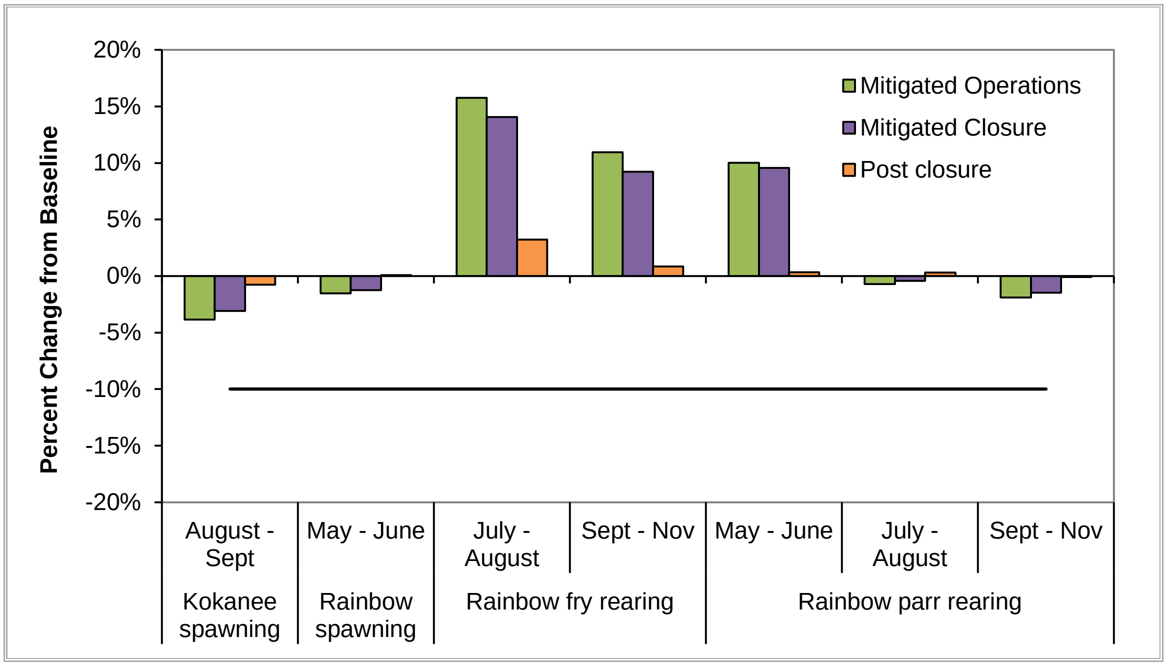


Figure 5.3.9-7: ***Summary of Residual Change in Total Habitat Area in Chedakuz Creek for Modelled Sections Downstream of Tatelkuz Lake***

During the winter, minimum monthly flows above Davidson Creek will be reduced by 17% during operations and 14% during closure. Below Davidson Creek, reductions will be 12% and 10%, respectively. Lower Chedakuz Creek is fed by Tatelkuz Lake water, so it is warmer than other streams in the LSA and generally remains ice-free during the winter. It is characterised by deep pool and glide habitats. Therefore, reductions in overwinter flows are not expected to cause adverse effects to fish habitat. Hydraulic model predictions of depths and velocities remain valid for ice-free conditions, although winter habitat preference data are not available. Based on these hydraulic models, winter flow reductions will reduce depths by an average of 3.0 cm upstream of Davidson Creek and 1.5 cm downstream. Changes of this magnitude will not affect the low-velocity winter refuge habitats used by fish.

Creek 661

Residual changes in total habitat area in Creek 661, for modelled sections downstream of Creek 505659, were compared by Project phase to baseline conditions (**Figure 5.3.9-8**). As with Davidson Creek and lower Chedakuz Creek, construction was not included in the comparison because effects are always less than for mitigated operations. All Project-related changes in aggregate rainbow trout and kokanee habitat will be less than the 10% threshold.

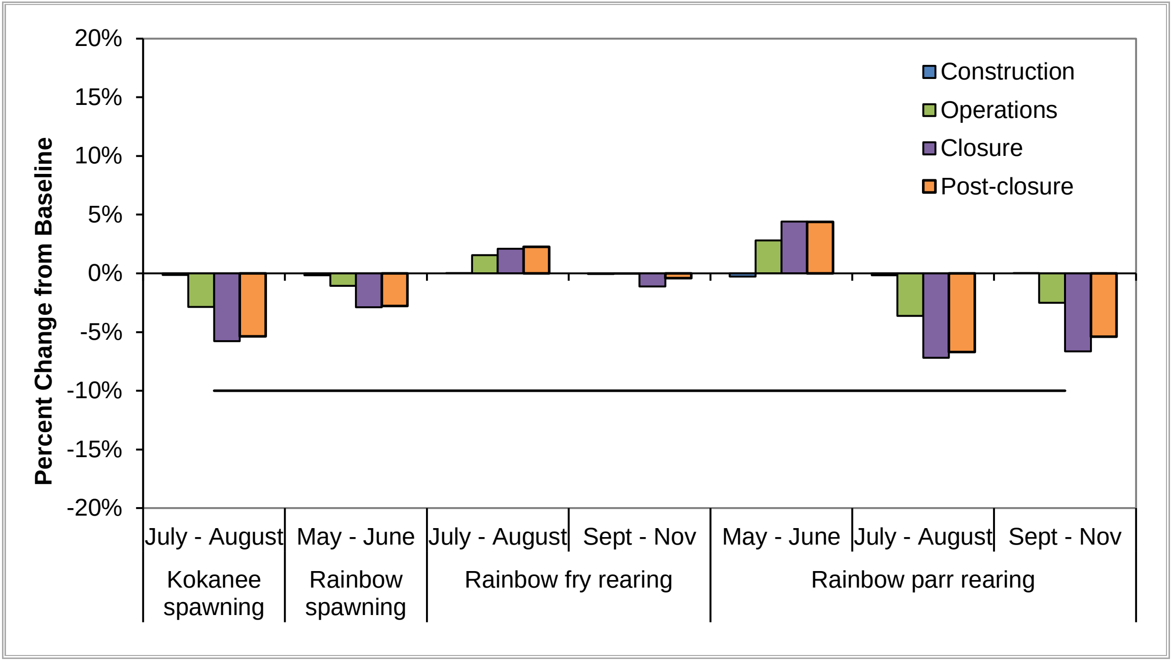


Figure 5.3.9-8: Summary of Residual Change in Total Habitat Area in Creek 661 Downstream of Creek 505659

Within the mainstem of Creek 661, the magnitude of change to overwinter flows will vary by Project phase and will be reduced with distance downstream of the confluence with Creek 505659. At the upstream extent, reductions in minimum winter flows will be 23%, 32% and 9% at operations, closure and post-closure, respectively. These changes reflect small differences in real flows (1 to 4 L/s), and overwintering habitat in the upper portions of the creek is poor. Hence, these flow reductions are not expected to affect overwintering habitat. Further downstream in Creek 661, the maximum reduction will be 3%. No ecological effects of changes in overwinter flows are anticipated in Creek 661 downstream of Creek 505659.

Due to the magnitude of flow changes in Creek 661, no physical effects are anticipated. Permanent changes in peak flows will occur due to the diversion of flows to the Davidson Creek Watershed. However, these changes will be small (maximum 9% reduction in peak flows at post-closure; **Section 5.3.2**) and are not expected to result in changes to physical habitat structure.

Creek 705

Residual changes in total habitat area for modelled sections in Creek 705 are compared between Project phases and baseline conditions in **Figure 5.3.9-9**. Only the operations phase is presented, because flow changes occur once flows in the diversion are established, and there are no Project-related changes thereafter. All modelled changes are less than the 10% threshold. Flow/habitat models were not constructed for stream sections immediately downstream of Lake 01538UEUT because these reaches may experience short-term changes in habitat quality as the physical channel responds to permanently increased flows. These changes will occur during high flow events, and may cause channel widening and bank erosion at some locations. Given the physical attributes of the existing channel, it is expected that the system will rapidly stabilise to accommodate increased flows, and that any effects to fish habitat in this section will be small.

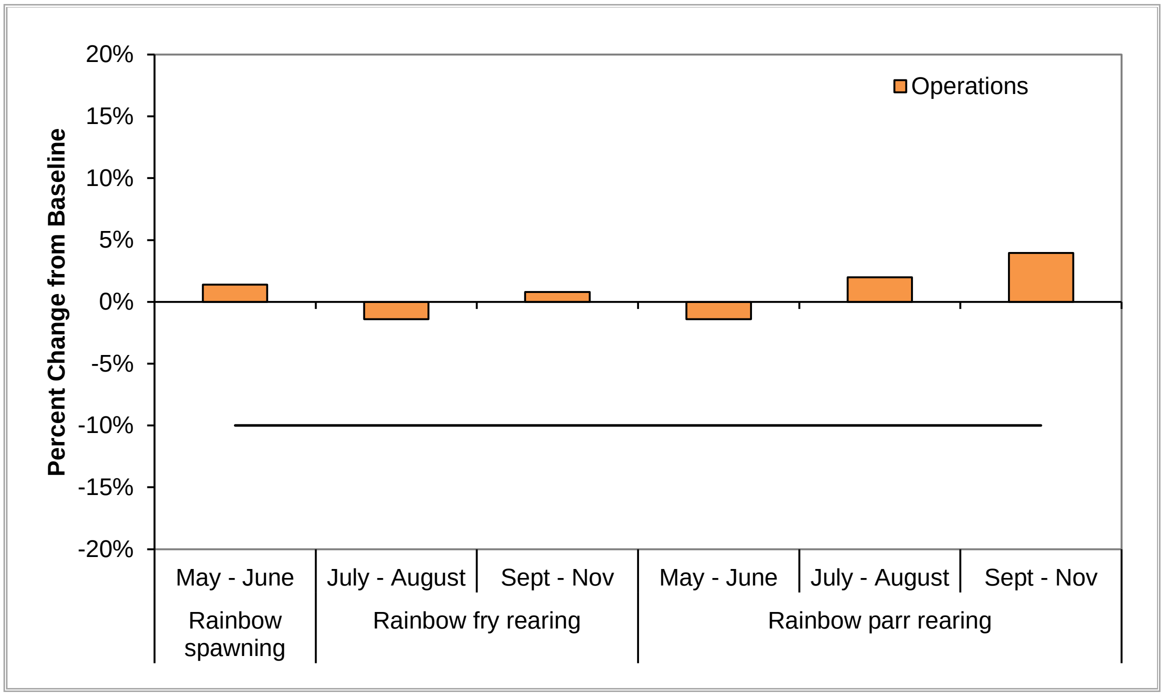


Figure 5.3.9-9: Summary of Residual Change in Total Habitat Area in Creek 705

Winter stanza flows in Creek 705 will increase by 3 L/s. This represents a three-fold increase over mean baseline minimum winter stanza flows at the outlet of Lake 01538UEUT (1 L/s), but the magnitude of the change will decrease with distance downstream. Given low winter flows and generally low overwintering habitat quality (**Section 5.1.2.6**), changes in winter flows in Creek 705 are not expected to result in adverse effects to fish habitat; increases may improve overwintering habitat.

5.3.9.3.2.3 Potential Effects on Fish Habitat of Changes in Water Quality

5.3.9.3.2.3.1 Potential Effects

This section discusses the potential effects on water quality as a result of Project activities, and of the potential effects on other dimensions of fish habitat as a result of changes in water quality. The potential effects of changes in water temperature on fish habitat are discussed in **Section 5.3.9.3.2.4**.

During construction and operations, Project activities may change surface water quality (**Table 5.3.9-34**). These changes may result from: (1) surface and groundwater seepage from the TSF into Davidson Creek and Creek 661; (2) runoff from East or West NAG waste rock and overburden dumps into Creek 661; (3) changes in catchment areas of Project components; (4)

pumping of Tatelkuz Lake water via the FSS to the freshwater reservoir, which will then discharge into Davidson Creek; and (5) diversion of Lake 01682LNRS into the Creek 705 Watershed.

Table 5.3.9-34: Potential Effects on Fish Habitat of Changes in Water Quality at the Mine Site

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Change in water quality, including TSS, metals and nutrients, in Davidson Creek as a result of seepage from mine site and input of Tatelkuz Lake water via the FSS.	Construction/Operations/ Closure/Post-Closure	Likely
Change in water quality, including TSS, metals, and nutrients, in Creek 705 as a result of diversion of Lake 01682LNRS into the Creek 705 Watershed(1)	Construction/Operations/ Closure/Post-Closure	Likely
Change to periphyton density, biomass and taxonomic composition in Davidson Creek, Creek 705 and Creek 661 as a result of changes in water chemistry.	Construction/Operations/ Closure/Post-Closure	Likely
Change to BMI density, biomass and taxonomic composition in Davidson Creek, Creek 705 and Creek 661 as a result of changes in water chemistry.	Construction/Operations/ Closure/Post-Closure	Likely

Note: (1) Dute to minor differences in background water chemistry, not mine activities.

Mining will also result in the deposition of mine tailings into the portions of Davidson Creek within the TSF. During the transition from closure to post-closure phases, surface water quality in Davidson Creek may also change as water is discharged from the TSF into Davidson Creek.

Water quality in Davidson Creek, Creek 661 and Creek 705 may be affected by these activities. Changes in water quality can alter other aspects of fish habitat by altering the density, biomass or taxonomic composition of periphyton and BMI. The periphyton community is the primary photosynthetic community in streams and an important food source for BMI. In turn, BMI are an important food source for fish. Both periphyton and BMI can be indicators of stream ecological health, and are sensitive to changes in water quality.

5.3.9.3.2.3.2 Mitigation Measures

The single most important mitigation measure is the commitment that the mine site will be operated as a no-discharge facility, meaning all water that falls as rain or snow on the site will be captured and stored in the TSF (**Table 5.3.9-35**).

Table 5.3.9-35: Mitigation Measures to Avoid or Reduce Potential Effects on Fish Habitat of the Mine Site

Likely Environmental Effect	Project Phase	Mitigation Measure	Mitigation Success Rating
Change in water quality, including TSS, metals, and nutrients, in Davidson Creek as a result of seepage from the mine site.	Construction/Operations/ Closure/Post-Closure	No surface discharge during operations and closure. A seepage management system will ensure no surface discharge during operations and closure. Construction of sediment control ponds, erosion and sediment control measures, based on the Erosion and Sediment Control Plan, will be used to protect erodible soils and minimize erosion of soils within the mine site. ECD will capture downstream seepage and pump it back to the TSF. Treatment wetlands will be constructed downstream of the TSF during later Operations and Closure and will be used to polish water discharged from the TSF during Closure and Post-Closure.	High
Change in water quality in Davidson Creek as a result of Tatelkuz Lake water input via the FSS.	Construction/Operations/ Closure/Post-Closure	None because quality of Tatelkuz Lake water is sufficient to support all fish species in the LSA including the two indicator species.	High
Change in water quality, including TSS, metals and nutrients, in Creek 661 as a result of upstream mine site activities.	Construction/Operations/ Closure/Post-Closure	Redirection of flows into TSF. Construction of sediment control ponds, erosion and sediment control measures, based on the Erosion and Sediment Control Plan will be used to protect erodible soils and minimize erosion of soils within the mine site.	High
Change in water quality, including TSS, metals, and nutrients in Creek 705 as a result of diversion of Lake 01682LNRS into the Creek 705 watershed.	Construction/Operations/ Closure/Post-Closure	Area to be flooded by lake enlargement will be stripped of all vegetation and topsoil up to the high water line.	Moderate
Change to periphyton density, biomass and taxonomic composition in Davidson Creek, Creek 705 and Creek 661 as a result of change in water chemistry.	Construction/Operations/ Closure/Post-Closure	No surface discharge and a seepage management system will ensure negligible surface discharge during operations and closure. Construction of sediment control ponds, erosion and sediment control measures, based on the Erosion and Sediment Control Plan will be used to protect erodible soils and minimize erosion of soils within the mine site. ECD to capture downstream seepage and pump it back to the TSF.	High
Change to BMI density, biomass, and taxonomic composition in Davidson Creek, Creek 705 and Creek 661 as a result of change in water chemistry.	Construction/Operations/ Closure/Post-Closure	No surface discharge and a seepage management system will ensure negligible surface discharge during operations and closure. Construction of sediment control ponds, erosion and sediment control measures, based on the Erosion and Sediment Control Plan will be used to protect erodible soils and minimize erosion of soils within the mine site. ECD to capture and downstream seepage and pump it back to the TSF.	High

The objective of site water management designs are to provide sufficient water to support mill water requirements and to maintain PAG materials in the TSF in a subaqueous state, while mitigating environmental impacts to fish habitat upstream and downstream of the mine infrastructure.

During construction, potential export of sediment from the mine site to Davidson Creek will be mitigated with sediment control ponds. Major construction will require the use of coffer dams downstream of construction, as described in the Sediment and Erosion Control Plan (SECP) (**Section 12.2.1.18.4.1**). Wastewater treatment will include routing of wastewater to a rapid infiltration basis to avoid impacts to surface water streams.

During operations and closure, the Project will not have a direct surface water discharge to streams. Instead, discharge will be limited to a small amount of TSF seepage. Seepage management designs are intended to prevent surface water discharges to receiving environments during operations (i.e., zero surface discharge facility). Main design elements for the seepage management system include seepage collection ponds, a seepage collection trench, and the ECD below the TSF. Seepage from the Site D main dam of the TSF is anticipated to be 55 L/s. This will be captured by the ECD, located downstream in Davidson Creek, and will be pumped back to the TSF. Only 2 L/s of seepage will bypass this latter dam. This represents 96% efficiency at recovering seepage.

Water quality will be further managed through wetland development in the TSF during later operational and closure stages. Water management designs during the closure and post-closure periods will restore natural drainage patterns, where possible, to avoid or minimize potential effects to fish habitat from downstream flow changes. A wetland treatment area below the TSF, developed during the late closure and post-closure periods, will be used to support long-term water quality objectives for the protection of fish in Davidson Creek. **Appendix 2.6C** (Wetland Water Treatment) provides a conceptual design for the Blackwater treatment wetlands and summarizes case histories of natural and constructed wetlands that have been used successfully to treat mine water discharges. These case histories include metal mines located in BC (Silver Queen Mine), Yukon (Keno Hill Mining District), Minnesota (constructed wetland), Montana (constructed wetland), Colorado (constructed wetland) and Australia (Woodcutter's mine). Hence, they represent climatic conditions that are representative of the Blackwater area. Treatment wetlands are a natural version of passive bioreactors that use biochemical mechanisms to break down organic molecules and sequester heavy metals. **Appendix 2.6C** summarizes two case histories of bioreactors used for Canadian mines: Teck's Trail smelting operation and the Tulsequah Mine.

In the event that post-closure water quality in the TSF is not acceptable for discharge into Davidson Creek, even with treatment in constructed wetlands, then TSF water will be treated in a lime neutralization treatment plant to remove metals. In addition, fertilizer may be added to the pit lake to generate phytoplankton blooms that will take metals out of circulation. As they sink to the pit bottom, dead phytoplankton cells would accumulate metals on their surfaces and take the metals down to burial in sediments where they would be sequestered indefinitely. Fertilization is currently being used to extract and bury metals in the pit lake of the Island Copper Mine of northern Vancouver Island.

Flow augmentation of Davidson Creek with water from Tatelkuz Lake will continue until TSF seepage and supernatant are acceptable for discharge to Davidson Creek.

Closure water management of the reclaimed East NAG dump will include monitoring water in the diversion channel east of the dump, which, during operations will direct contact water to the TSF. Should this water prove acceptable for discharge to Creek 661 at closure, the diversion channel will be dismantled. Regulatory approval will be required to discharge this water to Creek 661.

TSS will be captured by sediment control ponds during construction and meet provincial permit requirements prior to pond discharge. During operations and closure site water will be captured and pumped back to the TSF. At post-closure only water filtered through the wetlands and water reservoir will be released into Davidson Creek.

The quality of water that will be pumped from Tatelkuz Lake to Davidson Creek is known to be suitable for all fish species in Davidson Creek, including the two indicator species – rainbow trout and kokanee – because Tatelkuz Lake is the primary residence lake for rainbow trout and kokanee in the LSA. Hence no mitigation is required for discharging water from Tatelkuz Lake into Davidson Creek.

Upon successful implementation of the mitigation measures outlined, there are no residual effects expected during construction, operations, closure or post-closure, with the exception of elevated concentrations of sulphate. All other parameters are predicted to meet BC and CCME water quality guidelines, except where background concentrations are naturally above these guidelines. While above the guidelines, they are well within background natural levels. Site-specific guidelines will be applied (**Section 5.3.3**).

During the post-closure phase sulphate is predicted to exceed water quality guidelines in Davidson Creek. This prediction is conservative because water quality modelling assumes no sulphate reduction in the water column of the TSF. However, there is substantial scientific evidence that sulphate reduction does occur if anoxic conditions are present (**Section 5.3.3**). In addition, natural sulphate reduction is expected to occur in the wetlands immediately downstream of the TSF. Therefore, actual sulphate concentrations at post-closure may be lower than are predicted by the conservative models used for this assessment.

Therefore, water quality guidelines will be met before discharge into Davidson Creek. Hence, the potential effect on fish habitat of changes in water quality was not carried forward into residual effects assessment.

In Creek 661, surface water quality effects are predicted to range from negligible (unmeasureable) to minor (not significant), because there will be no surface or groundwater connection to this water body from the Project components.

In Creek 705, surface water quality effects from the mine site are predicted to range from negligible (unmeasureable) to minor (not significant) because there will be no surface or groundwater connection to this water body from the mine site.

The only potential residual effect may occur as a result of the enlargement of Lake 01682LNRS. Enlargement of this lake, upstream of the Site C West dam, will create additional lake habitat to offset unavoidable losses of fish habitat that occur elsewhere on the Project, as described above and details in the FMOP. An increase in mercury concentration in aquatic plants and animals, including fish, may occur as a result of flooding soils in the lake enlargement plan, although this effect will be reduced by proposed mitigation measures, including clearing of vegetation and removal of soils during the construction of the new lake area. The potential effect of elevated mercury concentrations in Creek 705 was carried forward into residual effects assessment.

5.3.9.3.2.4 Potential Effects on Fish Habitat of Davidson Creek of Changes in Water Temperature

5.3.9.3.2.4.1 Potential Effects

Section 5.3.8.3.2.6 provides a detailed analysis of the potential changes in water temperature of Davidson Creek as a result of flow augmentation from Tatelkuz Lake. In brief, water quality modelling presented in **Section 5.3.3** showed that water pumped from depths between 8 and 12 m in Tatelkuz Lake will be generally warmer in winter and cooler in summer than water in Davidson Creek. Comparison of those predicted temperatures with mean observed temperatures in Davidson Creek from 2011 to 2013 show that the predicted temperatures for a 10 m intake depth are the closest match to observed temperatures. For all three depths, however, predicted winter temperatures in Davidson Creek during operations and closure will still be 2°C to 3°C higher than baseline temperatures.

At post-closure, water will no longer be pumped from Tatelkuz Lake, and Davidson Creek in-stream fish needs will be met by discharge and seepage from the TSF. Temperature of the discharged water will then be governed by the combined surface water temperature of the post-closure pit lake and the TSF. Water quality modelling showed that water temperatures in Davidson Creek during post-closure will be elevated compared to baseline because they will be largely driven by a volume of lake water (from the pit lake and the TSF) that will be larger than the smaller volume of the headwater Lake 01682LNRS that exists presently. As such, those temperatures will follow more closely the rainbow trout optima than they do at present. Maximum summer temperatures will not exceed the upper limit of the BC temperature criteria for rainbow trout.

Higher temperatures during winter will have little effect on periphyton and BMI because those communities are largely dormant at that time of the year. Lower temperatures during summer during operations and closure phases may reduce growth rates and possibly density and biomass (**Table 5.3.9-36**). Higher summer temperatures during post-closure may increase growth rates and possibly density and biomass. However, those changes in growth, density and biomass will remain within the range of natural variability because water temperatures will remain within the range of natural variability. Flushing flows during operations and closure will prevent the growth of algal mats.

Table 5.3.9-36: Potential Effects on Fish Habitat of Davidson Creek of Temperature Changes

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Change in water temperature in Davidson Creek as a result of Tatelkuz Lake water input.	Construction/Operations/ Closure	Likely
Change in water temperature in Davidson Creek as a result of discharge from TSF.	Post-Closure	Likely
Change to periphyton density, biomass and taxonomic composition as a result of water temperature changes.	Construction/Operations/ Closure/Post-Closure	Likely
Change to BMI density, biomass and taxonomic composition as a result of water temperature changes.	Construction/Operations/ Closure/Post-Closure	Likely

5.3.9.3.2.4.2 Mitigation Measures

During late construction (when the FSS will become operational), operations and closure, water temperature in Davidson Creek will be influenced by the temperature of water pumped from Tatelkuz Lake and discharged into the creek. The primary mitigation measure will be to pump water from an intake depth that will result in water temperatures in Davidson Creek that will be minimally different from baseline conditions.

The secondary mitigation measure will be the operation of the TFCS consisting of temperature and flow measurement devices and associated control logic feedback loops on the discharge pipeline. A reservoir bypass line will connect directly to the water supply pipeline to allow for direct discharge of the required IFN during reservoir maintenance. It can also be used to provide cooler water as required for fisheries in Davidson Creek.

The exact design of the TFCS and its ability to control temperature and flows is not clear at this point. Therefore, for the purpose of effects assessment, it was assumed that it will have no effect. This is a conservative assumption because it means that the magnitude of actual effects will be smaller than predicted.

The success of these two mitigation measures in reducing temperature change from baseline is classified as moderate due to the uncertainties involved in predicting water temperature (described in **Section 5.3.3**).

Once water enters Davidson Creek it will continue to be influenced by natural factors such as air temperature, solar heating and groundwater upwelling.

Table 5.3.9-37 lists the mitigation measures proposed to eliminate or minimize effects on fish habitat of the changes in water temperature in Davidson Creek.

Table 5.3.9-37: Mitigation Measures to Reduce Potential Effects on Fish Habitat of Changes in Water Temperature of Davidson Creek

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measure	Mitigation Success Rating
Change in water temperature in Davidson Creek as a result of Tatelkuz Lake water input	Construction/Operations/ Closure/Post-Closure	Intake pipes located at depth in Tatelkuz Lake that will produce temperatures in Davidson Creek most similar to baseline. Operation of TFCS.	Moderate
Change to periphyton density, biomass and taxonomic composition as a result of water temperature changes	Construction/Operations/ Closure/Post-Closure	Intake pipes located at depth in Tatelkuz Lake that will produce temperatures in Davidson Creek most similar to baseline. Operation of TFCS.	Moderate
Change to BMI density, biomass and taxonomic composition as a result of water temperature change	Construction/Operations/ Closure/Post-Closure	Intake pipes located at depth in Tatelkuz Lake that will produce temperatures in Davidson Creek most similar to baseline. Operation of TFCS.	Moderate

Since water temperatures in Davidson Creek during flow augmentation will be warmer in winter and cooler in summer and since water temperatures during post-closure will be elevated during summer these effects were carried forward to residual effects assessment.

5.3.9.3.3 Mine Access Road

5.3.9.3.3.1 Potential Effects on Fish Habitat

All five permanent streams crossed by the mine access road are either confirmed or assumed to be fish-bearing (**Table 5.3.9-13**). The four non-classified drainages do not support fish and, therefore, are not discussed further.

Potential effects of construction, operations, and closure of the new mine access road on fish habitat at the five permanent streams along its route were based on the DFO *Pathways of Effects for Cleaning or Maintenance of Bridges or Other Structures* (DFO, 2010a)*, Vegetation Clearing* (DFO, 2010b)*, Use of Industrial Equipment* (DFO, 2010c)*, Placement of Material or Structures in Water* (DFO, 2010d)*,* and *Grading* (DFO, 2010e). They include the following:

- Increased bank erosion and transport of sediment. This is possible due to clearing of vegetation and exposing soils along the stream and mobilizing sediments in the stream channel due to site preparation by heavy machinery. Sediment entering the stream at the crossing site may increase deposition of fine sediments in the channel substrates and increase TSS concentrations in the water;

- Deposition of soil or gravel from road surfaces into streams during road grading;
- Temporary or permanent loss of fish habitat where instream works or temporary ford crossings are required;
- Temporary or permanent loss of riparian vegetation. This has the potential to decrease cover for fish, decrease nutrient supply, increase bank erosion and increase stream temperatures; and
- Spills or leaks of deleterious substances from machinery, including fuel, oil, and grease.

(Note that this list of potential effects differs from the list shown for fish in **Section 5.3.8.3.3.1** because it does not include strictly fish-related potential effects such as barriers to upstream or downstream passage, direct mortality to fish, and effects to fish respiration and embryo survival.)

In the absence of mitigation measures, the proposed mine access road may result in permanent and temporary alteration of fish habitat at the five fish-bearing permanent stream crossings (**Table 5.3.9-38**). Since the access road will be used during closure and into post-closure, these effects apply to all phases of mine life.

Table 5.3.9-38: Potential Effects on Fish Habitat of the Mine Access Road without Mitigation

Potential Environmental Effect	Project Phase	Likelihood of Occurrence before Mitigation
Increased surface erosion from areas disturbed during construction and increased sediment transport from constructed gravel road surfaces	Construction/Operation/Closure	Likely
Deposition of soil or gravel from road surfaces into streams during road grading	Construction/Operation/Closure	Likely
Temporary/permanent loss of fish habitat during watercourse crossing construction	Construction/Operation/Closure	Likely
Alteration of stream substrates where riprap placement extends below the high water level	Construction/Operation/Closure	Unlikely
Confinement of the floodplain during high flows due to riprap placement on stream banks at crossing sites	Construction/Operation/Closure	Unlikely
Hardening of the riparian zone due to riprap installation	Construction/Operation/Closure	Likely
Decreased overstream cover due to disturbance to riparian vegetation	Construction/Operation/Closure	Likely
Decreased nutrient supply and increased stream water temperatures resulting from losses of overhanging riparian vegetation	Construction/Operation/Closure	Likely
Reduced growth and survival caused by spills or leakage of fuels or deleterious substances into streams.	Construction/Operation/Closure	Likely

5.3.9.3.3.2 Mitigation Measures

All proposed stream crossing techniques will follow guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012) (**Table 5.3.9-39**). Fish-bearing stream protection practices will be implemented during all phases of construction in accordance with Section 5 of that guidebook.

Erosion control measures presented below will be implemented to protect erodible soils and minimize sediment inputs to streams. Additional erosion control measures detailed in the SECP section of the Construction Management Plan (**Section 12.2.1.18.4.1**) will also be employed.

Table 5.3.9-39: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish Habitat of the Mine Access Road

Likely Environmental Effect	Project Phase	Mitigation Measures	Mitigation Success Rating
Increased surface erosion from areas disturbed during construction and increased sediment transport from gravel road surfaces	Construction/Operations/ Closure	Erosion and sediment control measures (e.g., rip-rap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils.	High
Deposition of soil or gravel from road surfaces into streams during road grading	Construction/Operations/ Closure	Grader operators will follow guidelines to prevent sediment deposition.	High
Temporary loss of fish habitat during watercourse crossing construction	Construction/Operations/ Closure	Instream works will be avoided or minimized. Clear-span bridges requiring no instream construction will be installed on fish-bearing streams, if required. Machinery will be allowed to ford a stream on a one-time basis to construct stream crossing..	High
Alteration of stream substrates where riprap placement extends below the high water level	Construction/Operations/ Closure	Placement of rip-rap within the active channel will be avoided.	High
Confinement of the floodplain during high flows due to riprap placement on stream banks at crossing sites	Construction/Operations/ Closure	Placement of rip-rap within the active channel will be avoided.	High
Hardening of the riparian zone due to riprap installation	Construction/Operations/ Closure	Placement of rip-rap within the active channel will be avoided. Rip-rap placement will be limited to around bridge abutments Disturbance to vegetation in the riparian area will be minimized. Disturbed areas will be stabilized, vegetated, and/or seeded as soon as possible after construction.	High
Decreased over-stream cover due to disturbance to riparian vegetation	Construction/Operations/ Closure	Disturbance to riparian vegetation will be minimized. Disturbed areas will be stabilized, vegetated, and/or seeded as soon as possible after construction.	High
Decreased nutrient supply and increased stream water temperatures resulting from losses of overhanging riparian vegetation	Construction/Operations/ Closure	Disturbance to riparian vegetation will be minimized. Disturbed areas will be stabilized, vegetated, and/or seeded as soon as possible after construction.	High
Reduced growth and survival caused by spills or leakage of fuels or deleterious substances into streams	Construction/Operations/ Closure	An emergency spill response kit will be kept on-site during construction and closure. Fuels will be stored and refuelling will be conducted outside of riparian areas at all times. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

To minimize or eliminate each of these potential effects to fish habitat, the following mitigation measures will be implemented during the construction, operation, and closure of the stream crossings along the mine access road:

- Clear-span bridges will be constructed and maintained following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b), including:
    - Design and construct approaches to the water body such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.
    - Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures; and
    - Abutments of all clear-span bridges will be located above the high water levels of each stream;
- Cross drains will typically be placed in seepage zones and in areas of low elevation to minimize disruption to local drainage patterns;
- Bridge and culvert installation will be timed so that instream works will be completed within the BC MOE reduced risk timing window for rainbow trout (15 July to 15 April of the following year) for Region 7- Omineca (BC MOE, 2004). Culvert design will be contingent on the nature of the crossing;
- Machinery will be allowed one-time fording of a stream for purposes of constructing stream crossings; and
- Road surfaces will be monitored for increased erosion and sedimentation and repairs will be made if needed.

All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed mine access road. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat in the five permanent streams along the mine access road. Confidence in this assessment is high and, for this reason, potential effects of the mine access road on fish habitat were not carried forward to the residual effects assessment.

5.3.9.3.4 Freshwater Supply System

There are four potential classes of effects on fish habitat by the fresh water supply system (FSS) caused by the following:

- Physical footprint of the intake structure on the shoreline of Tatelkuz Lake;
- Changes in water surface elevation (WSE) of Tatelkuz Lake due to the volume of water pumped from Tatelkuz Lake;
- Stream crossings along the water pipeline corridor; and
- Physical footprint of the freshwater reservoir on the mine site.

This section assesses each class of potential effects, other than changes in stream flows, which were addressed previously in **Section 5.3.9.3.2.2**.

5.3.9.3.4.1 Potential Effects on Fish Habitat of the Tatelkuz Lake Intake Structure

5.3.9.3.4.1.1 Potential Effects

During the construction phase, potential effects on fish habitat may result from building the laydown area and the footprint of the pumping facility near the shoreline of Tatelkuz Lake (**Table 5.3.9-40**). Heavy machinery will be used during construction and there is the possibility of sediment erosion into the lake (DFO, 2010f). Riparian vegetation may be removed and shoreline banks may be disturbed by construction activities. These changes have the potential to affect shoreline fish habitat (DFO, 2012e).

Within the lake, there may be an effect on fish habitat caused by the two 610 mm intake pipes. Without mitigation the intake pipes may cause temporary or permanent alterations to fish habitat in Tatelkuz Lake, including changes to aquatic macrophytes, substrate composition and flow (DFO, 2010e).

Table 5.3.9-40: Potential Effects on Fish Habitat of the Tatelkuz Lake Inlet Structure

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Loss of riparian habitat from areas during construction, operation and closure	Construction/Operation/Closure	Likely
Change in sediment composition and erosion near inlet pipes	Construction/Operation/Closure	Likely
Change in access to littoral habitat including, decreased food supply, cover and structure for fish due to intake pipes	Construction/Operation/Closure	Likely
Increased levels of sedimentation during construction and decommissioning of pipe intake and housing structure	Construction/Closure	Likely
Change in flow around pipeline intake	Construction/Operation/Closure	Likely

5.3.9.3.4.1.2 Mitigation Measures

To minimize or eliminate the potential effects during construction and closure of the pump intake station, the following mitigation measures from *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b) will be implemented (**Table 5.3.9-41**):

- Where feasible, schedule work to avoid wet, windy and rainy periods that may increase erosion and sedimentation;
- Install effective erosion and sediment control measures before starting work to prevent sediment from entering Tatelkuz Lake;
- Implement measures for containing and stabilizing waste material from construction materials above the high water mark of nearby waterbodies;

- Conduct regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction;
- Repair erosion and sediment control measures and structures if damage occurs;
- Remove non-biodegradable erosion and sediment control materials once site is stabilized;
- Minimize the clearing of riparian vegetation;
- Minimize the removal of natural woody debris, rocks, sand or other materials from banks, the shoreline or the bed of the waterbody below the ordinary high water mark;
- Ensure machinery arrives on site in clean condition and is maintained free of fluid leaks, invasive species and noxious weeds;
- Whenever possible, operate machinery on land above the high water mark in a manner that minimizes disturbance to the banks and bed of the waterbody; and
- Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way to prevent any deleterious substances from entering the water.

Table 5.3.9-41: Mitigation Measures to Eliminate or Reduce Potential Effects on Fish Habitat of the Tatelkuz Lake Inlet Structure

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measures	Mitigation Success Rating
Loss of riparian habitat along the shoreline during construction, operations and closure	Construction/ Operation/ Closure	Minimize the clearing of riparian vegetation. Minimize the removal of woody debris, rocks or sand along the shoreline.	High
Change in sediment composition and erosion around intake pipe	Construction/ Operation/ Closure	Passive intake screen that admits water at a low, uniform velocity. Placement of intake away from critical littoral habitat.	High
Change in access to littoral habitat including, decreased food supply, cover and structure for fish due to intake pipes	Construction/ Operation/ Closure	Placement of intakes pipelines underground and intake screens in areas and depth where fish habitat concentrations are low. Placement of intake away from critical littoral habitat.	High
Increase sedimentation during construction of pipeline and housing structure	Construction	Installation of effective erosion and sediment control measures before work to prevent sediment from entering the lake.	High
Change in flow around pipe intake	Operation	Passive intake screen that admits water at a low, uniform velocity.	High

Design and maintenance of the intake pipes of Tatelkuz Lake will follow *Freshwater Intake End-of-pipe Fish Screen Guideline* (DFO, 1995), and the *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b). The design will include the following:

- Openings in the guides and seals will be less than opening criteria to make “Fish tight”;
- Screens on intake pipe will be located at a minimum 300 mm above the bottom of the lake to prevent entrainment of sediment or aquatic organisms;
- Structural support will be provided to the screen panels to prevent sagging and collapse of the screen;
- Screens will have manifolds installed in them to ensure even water velocity distribution across the screen surface. The ends of the structure will be made out of solid materials and the end of the manifold will be capped;
- Heavier cages will be fabricated out of bar or grating to protect the finer fish screen. Spacing of 150 mm between bars is typical;
- Provisions will be made for removal, inspection and cleaning of the screens;
- Regular maintenance and repair of the seals and screens will be carried out to prevent debris-fouling and impingement of fish; and
- Pumps will be shut down when fish screens are removed for inspection and cleaning.

Implementation of the appropriate mitigation measures described is anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat as a result of the Tatelkuz Lake Intake Structure footprint. Confidence in this assessment is high and, for this reason, potential effects of the mine access road on fish habitat were not carried forward to the residual effects assessment.

5.3.9.3.4.2 Potential Effects on Fish Habitat of Changes in Water Surface Elevation (WSE) of Tatelkuz Lake

5.3.9.3.4.2.1 Potential Effects

Drawdown of Tatelkuz Lake WSE may cause loss of littoral fish habitat used by fish for cover and forage and, possibly, spawning (**Table 5.3.9-42**). Drawdown may cause erosion and release of sediment into the water column. Other, related potential effects may include changes in the amount and composition of littoral aquatic vegetation, light penetration, nutrient concentrations, water temperatures, and DO concentrations.

These potential effects differ from those listed for the fish VC in **Table 5.3.9-31** because effects assessment in **Section 5.3.8** was focused on direct and indirect effects to fish, not fish habitat.

Table 5.3.9-42: Potential Effects on Fish Habitat of Tatelkuz Lake from Water Diversion

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation/Compensation
Loss of littoral habitat for rearing, foraging and, spawning fish by altering habitat structure or cover	Construction/Operation/ Closure	Likely
Increased sediment erosion into the lake during construction, lake drawdown and closure activities	Construction/Operation/ Closure	Likely
Changes in water temperature along the littoral zone from lake drawdown, leading to changes in physical, biological and chemical characteristics of water	Construction/Operation/ Closure	Likely
Changes in vegetation and nutrient supply in the littoral zone, leading to changes in food supply	Construction/Operation/ Closure	Likely

The magnitude, frequency and ultimate consequence of these potential effects depends on the magnitude and frequency of the drawdown. For hydroelectric reservoirs with annual drawdowns on the order of tens of metres, these potential effects will have strong impacts on the quantity and quality of fish habitat in the littoral zone, but for Tatelkuz lake, where annual drawdown will be on the order of tens of centimetres (as shown below), these potential effects will have much less impact on littoral zone fish habitat.

Due to the magnitude of withdrawals and modelling based on a detailed lake bathymetry, potential effects will only occur in the upper 1 m of the littoral zone. (The littoral zone is defined as the habitat within 6 m of the lake surface.) This means that effects to riparian habitat of Tatelkuz Lake of changes in water surface elevation are expected to be minimal.

Baseline studies of fish habitat in Tatelkuz Lake conducted in 2013 (**Section 5.1.2.6** and **Appendix 5.1.2.6B**) showed that the primary environmental drivers of littoral BMI communities in the lake are substrate type, algal cover, and the amount of submerged vegetation. BMI taxa were generally in higher abundance on fine substrate than on coarse substrate. Since fine substrate communities in the littoral zone occur in areas of low gradient, mostly at the northern and southern ends of the lake, it is expected they will be disproportionately exposed to reductions in WSE relative to coarse substrates. Some reduction in productive capacity of BMI may occur due to the reduction of wetted bottom area and change in availability of high productivity substrates.

To assess the potential effects on littoral habitat of water extraction from Tatelkuz Lake, the potential loss of littoral habitat was estimated for each phase of the Project for both an average year and a 1:50 dry year. The first step was to define the littoral habitat types. Tatelkuz Lake littoral habitat was classified into 11 types based on substrate composition and the presence and spatial extent of submergent and emergent vegetation (**Table 5.3.9-43**). Aquatic vegetation was important to include because it is used as cover for juvenile rainbow trout and kokanee in Tatelkuz Lake.

Table 5.3.9-43: Littoral Habitat Types in Tatelkuz Lake, July 2013

Habitat Code	Description
Gc-NV	Gravel-cobble-no vegetation
Cg-NV	Cobble-gravel-no vegetation
Cb-NV	Cobble-boulder-no vegetation
Bc-NV	Boulder-cobble-no vegetation
Fg-NV	Fines-gravel-no vegetation
Gf-EV	Gravel-fines-emergent vegetation
Fg-EV	Fines-gravel-emergent vegetation
Gf-SV	Gravel-fines-submergent vegetation
Fg-SV	Fines-gravel-submergent vegetation
Cb-SV	Cobble-boulder-submergent vegetation

Note: Gf = gravel dominant/fines subdominant; Gc = Gravel dominant/cobble subdominant; Cg = Cobble dominant/gravel subdominant; Cb = Cobble dominant/boulder subdominant; Bc = Boulder dominant/cobble subdominant; Fg = Fines dominant/gravel subdominant; NV = no vegetation; EV = emergent vegetation; SV = submergent vegetation

The second step was to map the amount of available littoral fish habitat based on a May 2013 bathymetric survey at a WSE of 927.6 m above sea level (masl). This WSE represents high water surface elevations that occur approximately 2% of the time. The maximum lake fluctuation is 2 m and the average lake fluctuation is 0.8 m annually. Therefore, the total amount of littoral habitat mapped will not be available in all years, and in any given year habitat availability changes as lake levels will vary as a function of natural inflows and outflows. Mapping of littoral habitat to 927.6 m permitted an assessment of changes in littoral habitat for a wide range of lake elevation scenarios.

Monthly lake WSE was modelled for the average and 1:50 dry year scenarios, and for the construction (year -2), operations (year +17), and closure (year +20) phases (**Section 5.3.2; Table 5.3.9-44; Figure 5.3.9-6, Figure 5.3.9-7**).

For the 1:50 dry year scenario, the lowest WSE in Tatelkuz Lake occurs September and the highest WSE occurs in May. The largest change from baseline conditions for a 1:50 dry year scenario occurs in the month of June and is a reduction of 0.11 m. This change in WSE is small relative to baseline mean annual (0.80 m) and maximum (2.0 m) fluctuations in lake levels.

Post-closure will result in a return to near baseline conditions because pumping of water from Tatelkuz Lake will cease and the diversion from the Creek 661 Watershed to the Davidson Creek Watershed will be insignificant in terms of the drainage area flowing in to Tatelkuz Lake.

Table 5.3.9-44: Estimated Tatelkuz Lake Water Surface Elevations (WSE) by Mine Phase

Mine Phase	Estimated Average WSE			Estimated 1:50 Dry Year WSE		
	Highest	**Lowest**	**Average**	**Highest**	**Lowest**	**Average**
Month	**May**	**January**	**Annual**	**May**	**September**	**Annual**
Baseline Elevation (masl)	927.37	926.93	927.07	926.93	926.76	926.85
Construction (Year -2) Elevation (masl)	927.37	926.93	927.07	926.93	926.76	926.85
Change from Baseline in cm	0.10	0.00	0.02	0.14	-0.01	0.02
% Change from Baseline Fluctuation	0%	0%	0%	0%	0%	0%
Operations (Year +17) Elevation (masl)	927.30	926.89	927.02	926.83	926.72	926.80
Change from Baseline in cm	-6.72	-3.61	-4.25	-10.15	-4.08	-5.5
% Change from Baseline Fluctuation	-5%	-18%	-3%	-8%	-12%	-4%
Month	**May**	**January**	**Annual**	**March**	**September**	**Annual**
Closure (Year +20) Elevation (masl)	927.30	926.90	927.03	926.84	926.73	926.80
Change from Baseline in cm	-6.67	-2.89	-3.88	-3.09	-3.27	-4.87
% Change from Baseline Fluctuation	-5%	-15%	-3%	-11%	-10%	-3%

Note: WSE = water surface elevation, cm = centimetre; % = percent; masl = metres above sea level.

The fluctuations in baseline WSE that are shown in **Figure 5.3.9-10** and **Figure 5.3.9-11** are based on natural variation in the absence of pumping. The third step in analysis was to factor in the amounts of water than will be pumped. Differences between baseline and operations/closure WSE show how much the FSS will withdraw to meet the mitigation flows defined for Davidson Creek in addition to the constant withdrawal of 33 L/s required for the mill during operations and to speed pit filling during closure. The Davidson Creek instream flow needs are as follows:

- Winter Stanza (December – March): 0.125 m^3/s (or 125 L/s);
- Freshet Stanza (May – June): 0.56 m^3/s (or 560 L/s);
- Rainbow Incubation Stanza (July – August): 0.15 m^3/s (or 150 L/s); and
- Kokanee Incubation Stanza (September – November): 0.115 m^3/s (or 115 L/s).

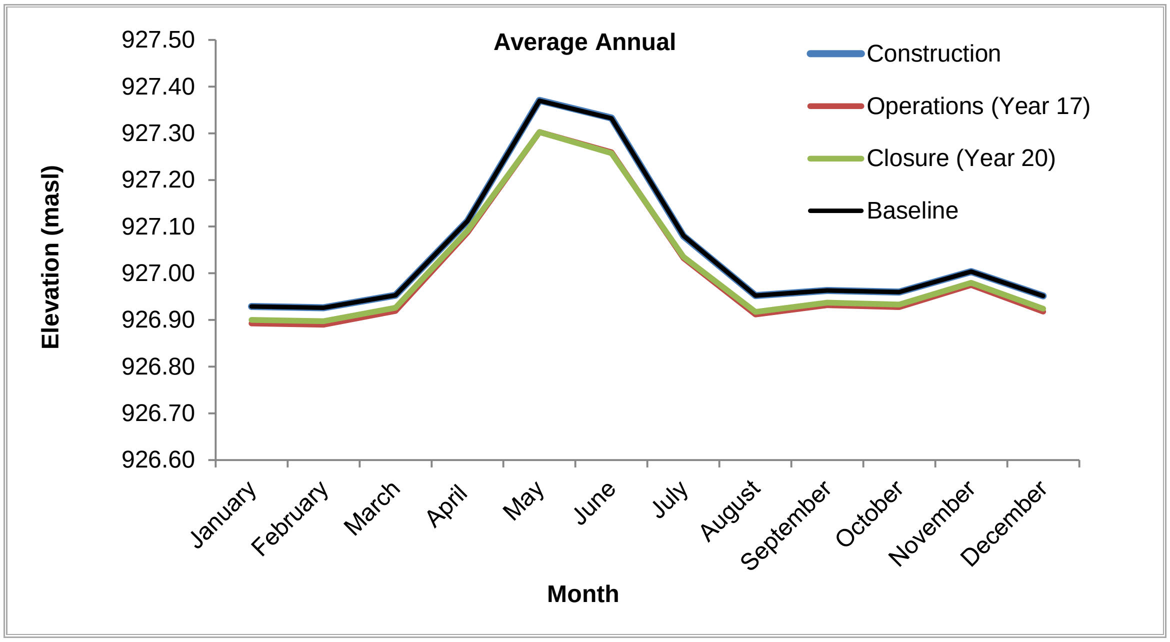


Figure 5.3.9-10: Mean Monthly Water Surface Elevations in Tatelkuz Lake

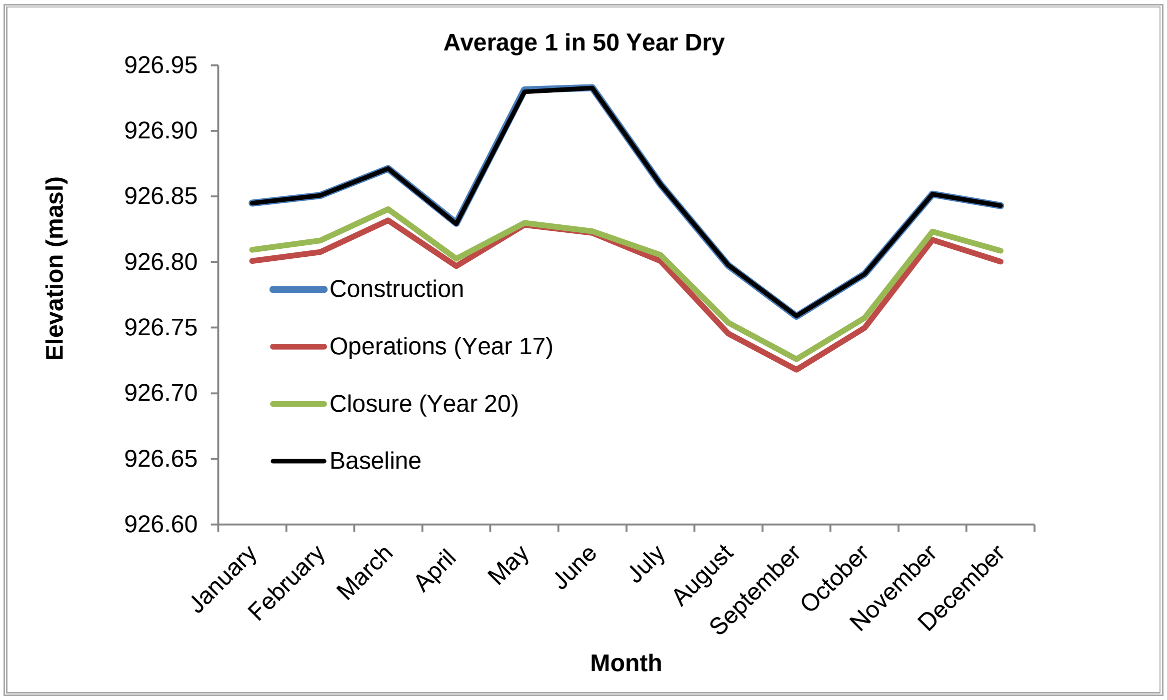


Figure 5.3.9-11: Estimated Average 1 in 50 Dry Year Water Surface Elevations in Tatelkuz Lake

This seasonal variance in water withdrawal means that the highest pumping rates will tend to occur during the same time period as the highest lake WSE.

To determine how much littoral habitat is available under each scenario and Project phase, monthly lake WSE were projected over the littoral lake bathymetry map in GIS to generate habitat area by habitat type. Areas were then separated by depth stratum (0 to 1 m, 1 to 2 m and 2 to 4 m). The first depth stratum (0 to 1 m) will have the greatest potential for change in littoral fish habitat because the predicted drawdown in the lake will not exceed 0.11 m in any phase or scenario. It is therefore assumed that there will be no impact to those depth strata deeper than 1 m.

Littoral habitat for each phase of the Project was summarized for each season and for each scenario below. The analysis assumed that vegetation does not change seasonally, because there are no data to determine otherwise.

During the construction phase, the aggregate modelled change in littoral habitat area compared to baseline conditions will be less than 0.01% loss in any month or scenario (**Table 5.3.9-45**). Considering each habitat class individually, the greatest change in littoral habitat will occur during the month of May, when lake WSE are at highest but water withdrawals are also largest (to provide flushing flows to Davidson Creek). Lake WSE during construction will be similar (<0.5% change) to baseline conditions for both the annual average scenario and the 1 in 50 year dry scenario.

Table 5.3.9-45: Seasonal Change in Littoral Habitat Area of Tatelkuz Lake in the 0 to 1 m Depth Stratum during Construction (Year -2)

	Winter (January)				Spring (May)				Summer (July)				Fall (October)			
Habitat Code	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline
Annual Average																
Bc-NV	0	0	0	0.0	3,696	1	3,709	0.3	675	0	674	-0.2	0	0	0	0.0
Bc-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cb-NV	47	0	47	0.0	9,181	4	9,207	0.3	1,943	1	1,940	-0.2	48	0	48	0.0
Cb-SV	0	0	0	0.0	352	0	353	0.3	72	0	72	-0.2	0	0	0	0.0
Cg-NV	72,869	28	72,869	0.0	64,158	26	64,159	0.0	68,379	26	68,382	0.0	71,945	27	71,942	0.0
Fg-EV	36,720	14	36,720	0.0	32,022	13	32,008	0.0	35,317	13	35,319	0.0	36,521	14	36,520	0.0
Fg-NV	83,593	32	83,594	0.0	68,218	27	68,166	-0.1	82,442	31	82,446	0.0	83,217	32	83,216	0.0
Fg-SV	13,477	5	13,477	0.0	5,407	2	5,387	-0.4	12,589	5	12,590	0.0	13,470	5	13,470	0.0
Gc-NV	30,800	12	30,798	0.0	41,748	17	41,763	0.0	36,900	14	36,898	0.0	32,977	13	32,985	0.0
Gf-EV	179	0	179	0.0	4,460	2	4,471	0.2	1,222	0	1,221	-0.1	199	0	199	0.0
Gf-NV	17,675	7	17,676	0.0	14,582	6	14,584	0.0	15,297	6	15,297	0.0	16,727	6	16,723	0.0
Gf-SV	7,362	3	7,362	0.0	6,991	3	6,989	0.0	7,300	3	7,300	0.0	7,348	3	7,348	0.0
Overall	262,721	100	262,721	0.0	250,815	100	250,795	0.0	262,135	100	262,138	0.0	262,453	100	262,452	0.0
1 in 50 Year Dry																
Bc-NV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Bc-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cb-NV	44	0	44	0.0	47	0	47	0.1	45	0	45	0.0	43	0	43	0.0
Cb-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cg-NV	75,300	29	75,300	0.0	72,838	28	72,798	-0.1	74,885	29	74,890	0.0	76,829	30	76,827	0.0
Fg-EV	34,224	13	34,223	0.0	36,717	14	36,712	0.0	35,098	13	35,090	0.0	28,453	11	28,462	0.0
Fg-NV	84,604	32	84,605	0.0	83,579	32	83,562	0.0	84,249	32	84,253	0.0	85,533	34	85,532	0.0
Fg-SV	13,431	5	13,431	0.0	13,477	5	13,477	0.0	13,447	5	13,447	0.0	13,337	5	13,337	0.0
Gc-NV	25,063	10	25,062	0.0	30,872	12	30,967	0.3	26,039	10	26,026	0.0	21,465	8	21,468	0.0

Habitat Code	Winter (January)				Spring (May)				Summer (July)				Fall (October)			
	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Construction Annual Total Area (m²)	Percent Change from Baseline
Gf-EV	130	0	130	0.0	180	0	181	0.5	138	0	138	-0.1	101	0	102	0.0
Gf-NV	20,249	8	20,249	0.0	17,643	7	17,602	-0.2	19,806	8	19,812	0.0	21,881	9	21,880	0.0
Gf-SV	7,301	3	7,300	0.0	7,362	3	7,361	0.0	7,336	3	7,335	0.0	7,039	3	7,039	0.0
Overall	260,346	100	260,345	0.0	262,715	100	262,706	0.0	261,042	100	261,036	0.0	254,681	100	254,690	0.0

Note: Gf = gravel dominant/fines subdominant; Gc = Gravel dominant/cobble subdominant; Cg = Cobble dominant/gravel subdominant; Cb = Cobble dominant/boulder subdominant; Bc = Boulder dominant/cobble subdominant; Fg = Fines dominant/gravel subdominant; NV = no vegetation; EV = emergent vegetation; SV = submergent vegetation

The aggregate change in littoral habitat during the operations phase will be less than 3% compared to baseline (**Table 5.3.9-46**). However, habitats containing boulders will be reduced in spring and summer months (>18% change). These habitats include Boulder-cobble no vegetation (Bc-NV), Boulder-cobble submergent vegetation (Bc-SV), Cobble-boulder no vegetation (Cb-NV) and cobble-gravel submergent vegetation (Cb-SV) and they are present in small quantities (<4% of total composition) near the edge of the shoreline. The gravel-dominated habitat class Gravel-fines emergent vegetation (Gf-EV) will be reduced (>10% change) compared to baseline conditions during all seasons in an average year. However, it accounts for less than 1.8% of all available habitat in the 0 to 1 m depth stratum. Other gravel-dominant and fines-subdominant habitat will still be available and there will be an increase in availability of Gravel-fines no vegetation (Gf-NV) habitat. Cobble, gravel and fines substrates do not seem to be limiting because more is available below the 0 to 1 m band. Because the total area of these habitat types is small, these larger percent changes in availability represent small changes in habitat area relative to the total present.

In the 1:50 dry year scenario there will be no boulder-dominant habitat available under baseline conditions and therefore no change in boulder habitat availability during any Project phase. The habitat classes with the largest reduction in area compared to baseline in the 1:50 dry year scenario will be Gf-EV and Fines-gravel emergent vegetation (Fg-EV). Both will be reduced by more than 10% for all seasons. However, Gf-EV habitat accounts for less than 0.07% of all available habitats. The Gravel-cobble no vegetation (Gc-NV) type accounts for approximately 10% of total available littoral habitat. Although there will be a reduction in the Gc-NV type, there will be a gain in the Cobble-gravel no vegetation (Cg-NV) type, which is composed of similar substrates.

During closure the aggregate change in littoral habitat compared to baseline conditions will be less than 2% (**Table 5.3.9-46**). Changes during closure will be similar to those during the operations phase. Boulder-dominant substrate types represent small areas of the total (<5% of the total composition) and will be reduced by approximately 50% when lake elevations are high in spring and summer. For the 1:50 dry year scenario, none of these boulder habitat types are available at baseline and the type will therefore not be affected by water withdrawals.

At post-closure, littoral habitat conditions in Tatelkuz Lake will return to baseline conditions because water will no longer be pumped to Davidson Creek, the mill site, or the mine pit. Changes in WSE over the course of the Project are not expected to affect the physical structure of the Tatelkuz Lake shoreline, so the post-Project conditions will mirror pre-Project conditions.

Finally, direct and indirect effects may also include reduction in the amount of fish habitat in lower Chedakuz Creek.

Table 5.3.9-46: Seasonal Change in Littoral Habitat Area of Tatelkuz Lake in the 0 to 1 m Depth Stratum during Operations (Year +17)

Habitat Code	Winter (January)				Spring (May)				Summer (July)				Fall (October)			
	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Operations Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Operations Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Operations Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Operations Annual Total Area (m²)	Percent Change from Baseline
Annual Avg.																
Bc-NV	0	0	0	0.0	3,696	1	2,915	-21.1	675	0	268	-60.3	0	0	0	0.0
Bc-SV	0	0	0	0.0	0	0	0	-27.4	0	0	0	-68.2	0	0	0	0.0
Cb-NV	47	0	46	-2.6	9,181	4	7,437	-19.0	1,943	1	809	-58.4	48	0	47	-2.3
Cb-SV	0	0	0	0.0	352	0	283	-19.4	72	0	29	-60.0	0	0	0	0.0
Cg-NV	72,869	28	73,923	1.4	64,158	26	64,462	0.5	68,379	26	69,705	1.9	71,945	27	72,898	1.3
Fg-EV	36,720	14	36,235	-1.3	32,022	13	32,874	2.7	35,317	13	35,862	1.5	36,521	14	36,723	0.6
Fg-NV	83,593	32	83,804	0.3	68,218	27	71,808	5.3	82,442	31	84,016	1.9	83,217	32	83,607	0.5
Fg-SV	13,477	5	13,468	-0.1	5,407	2	6,926	28.1	12,589	5	13,071	3.8	13,470	5	13,476	0.0
Gc-NV	30,800	12	28,305	-8.1	41,748	17	40,435	-3.1	36,900	14	36,293	-1.6	32,977	13	30,729	-6.8
Gf-EV	179	0	157	-12.2	4,460	2	3,716	-16.7	1,222	0	626	-48.8	199	0	178	-10.2
Gf-NV	17,675	7	18,780	6.3	14,582	6	14,611	0.2	15,297	6	15,492	1.3	16,727	6	17,706	5.9
Gf-SV	7,362	3	7,360	0.0	6,991	3	7,172	2.6	7,300	3	7,316	0.2	7,348	3	7,362	0.2
Overall	262,721	100	262,078	-0.2	250,815	100	252,639	0.7	262,135	100	263,488	0.5	262,453	100	262,728	0.1
1 in 50 Year Dry																
Bc-NV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Bc-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cb-NV	44	0	43	-2.7	47	0	44	-6.6	45	0	43	-3.6	43	0	42	-2.3
Cb-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cg-NV	75,300	29	76,555	1.7	72,838	28	75,772	4.0	74,885	29	76,552	2.2	76,829	30	77,881	1.4
Fg-EV	34,224	13	30,404	-11.2	36,717	14	33,071	-9.9	35,098	13	30,420	-13.3	28,453	11	23,149	-18.6
Fg-NV	84,604	32	85,439	1.0	83,579	32	85,012	1.7	84,249	32	85,437	1.4	85,533	34	85,258	-0.3
Fg-SV	13,431	5	13,357	-0.6	13,477	5	13,410	-0.5	13,447	5	13,357	-0.7	13,337	5	13,236	-0.8
Gc-NV	25,063	10	22,124	-11.7	30,872	12	23,950	-22.4	26,039	10	22,132	-15.0	21,465	8	18,796	-12.4

Habitat Code	Winter (January)				Spring (May)				Summer (July)				Fall (October)			
	Baseline Total Area (m^2)	Percent Substrate Composition	Estimated Operations Annual Total Area (m^2)	Percent Change from Baseline	Baseline Total Area (m^2)	Percent Substrate Composition	Estimated Operations Annual Total Area (m^2)	Percent Change from Baseline	Baseline Total Area (m^2)	Percent Substrate Composition	Estimated Operations Annual Total Area (m^2)	Percent Change from Baseline	Baseline Total Area (m^2)	Percent Substrate Composition	Estimated Operations Annual Total Area (m^2)	Percent Change from Baseline
Gf-EV	130	0	107	-18.0	180	0	121	-32.6	138	0	107	-22.8	101	0	82	-19.3
Gf-NV	20,249	8	21,581	6.6	17,643	7	20,752	17.6	19,806	8	21,578	8.9	21,881	9	23,096	5.6
Gf-SV	7,301	3	7,104	-2.7	7,362	3	7,253	-1.5	7,336	3	7,104	-3.2	7,039	3	6,715	-4.6
Overall	260,346	100	256,713	-1.4	262,715	100	259,386	-1.3	261,042	100	256,729	-1.7	254,681	100	248,255	-2.5

Note: Gf-gravel dominant/fines subdominant; Gc-Gravel dominant/cobble subdominant; Cg-Cobble dominant/gravel subdominant; Cb-Cobble dominant/boulder subdominant; Bc-Boulder dominant/cobble subdominant; Fg-Fines dominant/gravel subdominant; NV-no vegetation; EV-emergent vegetation; SV-submergent vegetation

Table 5.3.9-47: Seasonal Changes in Littoral Habitat Area of Tatelkuz Lake in the 0 to 1 m Depth Stratum during Closure (Year +20)

	Winter (January)				Spring (May)				Summer (July)				Fall (October)			
Habitat Code	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline
Annual Avg.																
Bc-NV	0	0	0	0.0	3,696	1	2,920	-21.0	675	0	291	-56.9	0	0	0	0.0
Bc-SV	0	0	0	0.0	0	0	0	-27.1	0	0	0	-64.8	0	0	0	0.0
Cb-NV	47	0	46	-2.1	9,181	4	7,450	-18.9	1,943	1	874	-55.0	48	0	47	-2.0
Cb-SV	0	0	0	0.0	352	0	284	-19.3	72	0	31	-56.6	0	0	0	0.0
Cg-NV	72,869	28	73,714	1.2	64,158	26	64,458	0.5	68,379	26	69,626	1.8	71,945	27	72,745	1.1
Fg-EV	36,720	14	36,340	-1.0	32,022	13	32,868	2.6	35,317	13	35,832	1.5	36,521	14	36,705	0.5
Fg-NV	83,593	32	83,768	0.2	68,218	27	71,782	5.2	82,442	31	83,932	1.8	83,217	32	83,540	0.4
Fg-SV	13,477	5	13,471	0.0	5,407	2	6,914	27.9	12,589	5	13,046	3.6	13,470	5	13,477	0.0
Gc-NV	30,800	12	28,802	-6.5	41,748	17	40,449	-3.1	36,900	14	36,331	-1.5	32,977	13	31,091	-5.7
Gf-EV	179	0	162	-9.8	4,460	2	3,722	-16.6	1,222	0	665	-45.6	199	0	182	-8.5
Gf-NV	17,675	7	18,559	5.0	14,582	6	14,610	0.2	15,297	6	15,482	1.2	16,727	6	17,547	4.9
Gf-SV	7,362	3	7,361	0.0	6,991	3	7,171	2.6	7,300	3	7,315	0.2	7,348	3	7,360	0.2
Overall	262,721	100	262,223	-0.2	250,815	100	252,627	0.7	262,135	100	263,425	0.5	262,453	100	262,695	0.1
1 in 50 Year Dry																
Bc-NV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Bc-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cb-NV	44	0	43	-2.2	47	0	44	-6.5	45	0	43	-3.3	43	0	42	-1.9
Cb-SV	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Cg-NV	75,300	29	76,309	1.3	72,838	28	75,728	4.0	74,885	29	76,422	2.1	76,829	30	77,726	1.2
Fg-EV	34,224	13	31,458	-8.1	36,717	14	33,183	-9.6	35,098	13	31,051	-11.5	28,453	11	24,235	-14.8
Fg-NV	84,604	32	85,314	0.8	83,579	32	84,977	1.7	84,249	32	85,380	1.3	85,533	34	85,318	-0.3
Fg-SV	13,431	5	13,373	-0.4	13,477	5	13,412	-0.5	13,447	5	13,366	-0.6	13,337	5	13,256	-0.6
Gc-NV	25,063	10	22,701	-9.4	30,872	12	24,054	-22.1	26,039	10	22,440	-13.8	21,465	8	19,291	-10.1

Habitat Code	Winter (January)				Spring (May)				Summer (July)				Fall (October)			
	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline	Baseline Total Area (m²)	Percent Substrate Composition	Estimated Closure Annual Total Area (m²)	Percent Change from Baseline
Gf-EV	130	0	111	-14.5	180	0	122	-32.2	138	0	109	-21.0	101	0	85	-15.9
Gf-NV	20,249	8	21,319	5.3	17,643	7	20,705	17.4	19,806	8	21,438	8.2	21,881	9	22,874	4.5
Gf-SV	7,301	3	7,151	-2.1	7,362	3	7,258	-1.4	7,336	3	7,129	-2.8	7,039	3	6,796	-3.5
Overall	260,346	100	257,779	-1.0	262,715	100	259,482	-1.2	261,042	100	257,379	-1.4	254,681	100	249,623	-2.0

Note: Gf-gravel dominant/fines subdominant; Gc-Gravel dominant/cobble subdominant; Cg-Cobble dominant/gravel subdominant; Cb-Cobble dominant/boulder subdominant; Bc-Boulder dominant/cobble subdominant; Fg-Fines dominant/gravel subdominant; NV-no vegetation; EV-emergent vegetation; SV-submergent vegetation

5.3.9.3.4.2.2 Mitigation Measures

A trade-off study was completed to select the water source which would result in the smallest potential Project effects (Knight Piésold, 2013a). Tatelkuz Lake was selected because the required withdrawal rates would result in the least effect on flows, lake volumes and associated environmental conditions.

The only mitigation measure that is proposed to limit potential effects of water extraction on fish habitat is to limit the volume of water that will be withdrawn should adverse effects on the littoral zone be anticipated (e.g., as a result of a forecasted dry year) or become apparent as a result of monitoring the lake WSE and littoral zone characteristics (**Table 5.3.9-48**). An annual time step for changes to pumping rate is proposed.

Table 5.3.9-48: Mitigation Measures to Eliminate Potential Effects to Fish Habitat due to Lower Water Surface Elevations (WSE) in Tatelkuz Lake

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measures	Mitigation Success Rating
Change in water temperature	Construction/Operation/ Closure	Limit withdrawal of water	Medium
Change in suitable rearing habitat for juvenile fish	Construction/Operation/ Closure	Limit withdrawal of water	Medium
Change in nutrient supply in the littoral zone	Construction/Operation/ Closure	Limit withdrawal of water	Medium
Erosion of banks	Construction/Operation/ Closure	Limit withdrawal of water	Medium

Because there are no water withdrawals from Tatelkuz Lake during construction and post-closure, there are, at most, negligible residual effects of the FSS on fish habitat in Tatelkuz Lake. Therefore, these two phases were not carried forward into the residual effects assessment.

During operations and closure phases, water will be withdrawn from Tatelkuz Lake to support water requirements for the process mill, flow augmentation of Davidson Creek, and filling of the open pit. Pumping from Tatelkuz Lake will cause changes in littoral habitat in the 0 m to 1 m depth stratum. These changes in Tatelkuz Lake littoral habitat are anticipated to be negligible in magnitude but they will be unavoidable and so they were carried forward into the residual effects assessment.

5.3.9.3.4.3 Potential Effects on Fish Habitat of the Freshwater Pipeline Corridor

5.3.9.3.4.3.1 Potential Effects

The freshwater pipeline will cross nine streams from Tatelkuz Lake to the freshwater reservoir on the mine site. Most of these crossings are pre-existing because the pipeline fill follow an existing road. In some cases, the streams will be crossed with existing bridges. In others, existing culverts will be upgraded to clear-span bridges. Trenching may be used for the smallest streams (e.g., PL-6).

Because the crossings will be done with existing bridges, new clear-span bridges or trenching, and there will be no directional drilling, the potential effects of construction, operations, and closure of the freshwater pipeline at the seven permanent watercourses along its route are based on DFO's *Pathways of Effects* advisory series (DFO, 2010a, 2010b, 2010c, 2010d, 2010e, 2010f, 2010g, 2010h). The freshwater pipeline will be removed upon closure, but the road crossings will remain as part of the FSR.

Potential effects on fish habitat of the water pipeline corridor may result from construction, operation and closure of activities at the eight stream crossings that are considered fish-bearing (**Section 5.3.8.3.1.4**). (The crossing classified as NVC will not be discussed further.) They include the following (**Table 5.3.9-49**):

- Increased erosion and transport of sediment. Disturbance to the banks from use of heavy equipment could lead to sediment entering the crossing sites and could contribute to increased sediment loads and siltation of downstream waterbodies;
- Temporary or permanent loss of riparian vegetation. Potential changes to fish habitat include loss of cover for fish, decreased nutrient supply, increased bank erosion and increased stream temperature; and
- Introduction of deleterious substances, such as oil and gas from machinery.

Table 5.3.9-49: Potential Effects on Fish Habitat of the Water Pipeline

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation/Offsetting
Change to riparian habitat during construction of crossings resulting in decreased nutrient supply and increased water temperatures	Construction/Operations/ Closure	Likely
Change to stream banks from heavy equipment and during construction	Construction/Operations/ Closure	Likely
Temporary/permanent loss of fish habitat under culverts and bridges or obstruction to fish passage	Construction/Operations/ Closure	Unlikely
Increased sedimentation during construction of bridges and trenches	Construction/Operations/ Closure	Likely
Spills or leakage of fuels or deleterious substances into streams	Construction/Operations/ Closure	Likely
Alteration of stream hydrology during construction of crossing	Construction/Operations/ Closure	Likely
Alteration of stream substrates during trenching	Construction/Operations/ Closure	Likely

These potential effects differ from those listed for the fish VC in **Table 5.3.9-48** because effects assessment in **Section 5.3.8** was focused on fish, not fish habitat.

At crossing PL-6 the pipeline will be trenched and run under the stream. Potential effects on fish habitat (DFO, 2010h) during construction are similar to those of bridge stream crossings and include:

- Change in sediment distribution. This may result in loss of spawning habitat by changing the bed substrates;
- Temporary or permanent loss of riparian habitat. This may lead to destabilization of banks in streams, loss of cover for fish, decreased nutrient supply and increased water temperature;
- Sediment mobilization once normal flows are resumed; and
- Alteration to stream hydrology.

The remaining two crossings (PL-5 and PL-7) will be located within the mine site footprint and so any loss of habitat due to their construction will be offset, as described in the FMOP (**Appendix 5.1.2.6C**).

5.3.9.3.4.3.2 Mitigation Measures

To minimize changes to fish habitat the pipeline will maximize the use of previously disturbed corridors. The water pipeline will parallel the road for a total of 13.3 km, of which 11.7 km will be upgrades to existing roads and 1.6 km will be new construction.

The culverts at crossings PL-3, PL-4 and PL-8 will be replaced with clear-span bridges. Bridges will also be built at crossings PL-1 and PL-2. The freshwater pipeline will cross these five locations attached to the bridges.

At crossing PL-6 the pipeline will be trenched and run under the stream.

To minimize or eliminate each of the potential effects the following mitigation measures will be implemented during construction and de-commissioning of the fresh water pipeline at the six permanent stream crossings (**Table 5.3.9-50**):

- Erosion and sediment control measures (e.g., rip-rap armouring, erosion control matting, and hydro seeding) will be used to protect erodible soils; and
- Abutments of all bridges will be located outside of the high water levels of each watercourse.

Table 5.3.9-50: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish due to Stream Crossings of the Water Pipeline

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measures	Mitigation Success Rating
Change to riparian habitat during construction of crossings resulting in decreased nutrient supply and increased water temperatures.	Construction/Operation/ Closure	Disturbance to riparian vegetation will be minimized. Disturbed areas will be stabilized, vegetated, and/or seeded as soon as possible after construction.	High
Change to stream banks from heavy equipment and during construction	Construction/Operation/ Closure	Placement of rip-rap within the active channel will be avoided. Disturbance to vegetation in the riparian area will be minimized. Disturbed areas will be stabilized, vegetated, and/or seeded as soon as possible after construction.	High
Temporary/permanent loss of fish habitat under culverts and bridges or obstruction to fish passage	Construction/Operation/ Closure	Placement of rip-rap within the active channel will be avoided or minimized.	High
Increased sedimentation during construction of bridges and trenches	Construction	Erosion and sediment control measures, including riprap armouring, erosion control matting, and hydro seeding, will be used to protect erodible soils.	High
Introduction of deleterious substances into streams	Construction /Closure	An emergency spill response kit will be kept on-site during construction. Fuels will be stored and refuelling will be conducted outside of riparian areas. Equipment and machinery will arrive clean and in good working condition, and will be maintained free of fluid leaks.	High
Alteration of channel configuration	Construction	Locate crossings as straight sections of stream, perpendicular to banks whenever possible. Trenching designed at appropriate depth to prevent pipeline exposure due to natural scouring of the stream bed.	High
Alteration of substrates during trenching	Construction	Make effort to backfill the trench so that the first layer excavated is the last to be replaced. Restore original streambed contours.	High

Clear-span bridges will be constructed and maintained following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a), including:

- Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation;
- Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures;
- Bridge and culvert installation will be timed so that instream works will be completed within the BC MOE reduced risk timing window for rainbow trout (15 July to 15 April of the following year) for Fish and Wildlife in Region 7- Omineca (BC MOE, 2004);
- If stream crossings fords are required for the movement of construction vehicles or equipment, these crossings will be carried out in accordance with the DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b), including:
    - Limiting machinery fording of any watercourse to a onetime event (i.e., over and back), and only if not alternative crossing method is available;
    - If repeated crossings are required or if the watercourse has steep of highly-erodible banks, construct a temporary crossing structure.

All of the mitigation measures proposed above are commonly and widely used around BC. Successful implementation of these mitigation measures will be highly effective at eliminating or, at most, leaving only negligible residual effects to fish habitat as a result of the construction of the pipeline crossings. Therefore, these potential effects on fish habitat were not carried forward to residual affects assessment.

5.3.9.3.4.4 Potential Effects on Fish Habitat of the Freshwater Reservoir

5.3.9.3.4.4.1 Potential Effects

Potential effects on fish habitat of the freshwater reservoir will occur during construction, operation and closure phases of the Project. During closure the reservoir will be replaced by a wetland, and during post-closure that wetland will be used as a passive water treatment facility for discharge from the TSF.

Potential effects on fish habitat during construction and operations are based on DFO *Pathways of Effects for Placement of Material or Structures in Water* (DFO, 2010d) and include the following (**Table 5.3.9-51**):

- Loss of fish habitat under the footprint of the reservoir;
- Increased TSS concentrations downstream of the reservoir caused by increased erosion of stream banks;
- Decreased riparian vegetation resulting in reduced channel stability and cover;

- Reduced density and biomass of periphyton and BMI due to increased TSS and decreased riparian zone cover;
- Increases in nutrient concentration in Davidson Creek due to discharge of Tatelkuz Lake water pumped via the FSS;
- Increases in density and biomass of periphyton and BMI due to increased nutrient concentrations from Tatelkuz Lake water introduced via the FSS; and
- Reduced growth and survival caused by spills or leaks of deleterious substances, including fuel, oil and grease, during construction and closure.

Table 5.3.9-51: Potential Effects on Fish Habitat of the Freshwater Reservoir

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Loss of stream habitat for spawning, rearing and foraging fish under the reservoir and upstream from reservoir	Construction	Likely
Increased sedimentation downstream from erosion during construction and de-commissioning of the dam	Construction/Closure	Likely
Reduced riparian cover	Construction/Closure	Likely
Reduced density and biomass of periphyton and BMI due to changes in TSS concentrations and riparian cover	Construction/Closure	Likely
Increase in nutrient concentrations in Davidson Creek due to discharge of Tatelkuz Lake water through the FSS	Construction/Operations/ Closure	Likely
Increased density and biomass of periphyton and BMI due to introduction of Tatelkuz Lake water from the FSS	Construction/Operations/ Closure	Likely
Spills or leakage of fuels or deleterious substances into streams	Construction/Operations/ Closure	Likely

These potential effects differ from those listed for the fish VC in **Table 5.3.9-40** because effects assessment in **Section 5.3.8** was focused on fish, not fish habitat.

5.3.9.3.4.4.2 Mitigation Measures

Loss of fish habitat in Davidson Creek and tributaries between the TSF and the dam is addressed in the FMOP (**Appendix 5.1.2.6C**).

To minimize or eliminate the potential effects the following mitigation measures will be carried out in accordance with DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b), including the following (**Table 5.3.9-52**):

- Erosion and sediment control measures (e.g., rip-rap armouring, erosion control matting and hydro seeding) will be used to protect erodible soils;
- Measures for containing and stabilizing waste material (e.g., construction waste and materials) above the high water mark of nearby waterbodies to prevent re-entry;
- Regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction;
- Repairs to erosion and sediment control measures and structures if damage occurs;
- Clearing of riparian vegetation should be kept to a minimum;
- Immediately stabilize banks disturbed by any activity associated with the project to prevent erosion and/or sedimentation, preferably through re-vegetation with native species suitable to the site;
- Ensure that machinery arrives on site in clean condition and is maintained free of fluid leaks, invasive species and noxious weeds;
- Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that minimizes disturbances to the banks and bed of the waterbody;
- Limit machinery fording of the watercourse to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, then construct a temporary crossing structure;
- Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water; and
- Remove all construction materials from site upon project completion.

There are no mitigation measures for the increase in nutrient concentrations expected from the discharge of Tatelkuz lake water into Davidson Creek via the FSS. These concentrations are known to be acceptable to fish because Tatelkuz Lake is the primary residence lake for rainbow trout and kokanee in the LSA. They may, however, increase the density and biomass of periphyton and BMI in Davidson Creek. Growth of periphyton mats will be stabilized by the implementation of annual flushing flows in Davidson Creek, as described by the Instream Flow Study (**Appendix 5.1.26D**). An increase in density of BMI will only improve the quantity of food available to fish in Davidson Creek.

Table 5.3.9-52: Mitigation Measures to Eliminate Potential Effects on Fish Habitat of the Freshwater Reservoir

Likely Environmental Effect	Project Phase	Mitigation/ Offsetting Measures	Mitigation Success Rating
Loss of fish habitat from creeks buried under the footprint of the reservoir	Construction	Offsets for loss of fish habitat upstream from the dam are described in the FMOP.	High
Increased sedimentation downstream from erosion during construction and de-commissioning of the dam	Construction/Closure	Erosion and sediment control measures (e.g., rip-rap armouring, erosion control matting and hydro seeding).	High
Reduced riparian cover	Construction/Closure	Minimize clearing of riparian vegetation and immediately stabilize banks disturbed by construction or decommissioning of the dam and reservoir.	High
Reduced density and biomass of periphyton and BMI due to changes in TSS concentrations and riparian cover	Construction/Closure	Erosion and sediment control measures, and minimize clearing of riparian vegetation and immediately stabilize banks.	High
Increase in nutrient concentrations in Davidson Creek due to discharge of Tatelkuz Lake water through the FSS	Construction/Operations/ Closure	None	NA
Increased density and biomass of periphyton and BMI due to introduction of Tatelkuz Lake water from the FSS	Construction/ Operations/Closure	Periphyton and BMI community density and biomass stabilized by flushing flows.	High
Spills or leakage of fuels or deleterious substances into streams	Construction/ Operations/Closure	An emergency spill response kit will be kept on-site during construction and closure. Fuels will be stored and refuelling will be conducted outside of riparian areas at all times. Ensure that machinery will arrive on site in a clean condition and that it is maintained free of fluid leaks.	High

Note: NA = not applicable.

The mitigation measures proposed above are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat downstream of the dam and freshwater reservoir during construction and offsetting. Therefore, these potential effects were not carried forward to residual affects assessment.

5.3.9.3.5 Airstrip and Airstrip Access Road

5.3.9.3.5.1 Potential Effects on Fish Habitat

The airstrip will be built on a site with no existing fish-bearing streams. Therefore, potential effects to fish habitat are limited to the airstrip access road and downstream receiving fish-bearing waters.

The airstrip access road crosses three streams that are tributaries of Turtle Creek (**Table 5.3.9-53**). However, only one of these streams – AA-002 – is fish-bearing. It is known to support rainbow trout. The other two crossings are on non-classified drainages that do not support fish or discernible fish habitat.

Table 5.3.9-53: Potential Effects on Fish Habitat of Stream Crossing AA-002 of the Airstrip Access Road

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Increased bank erosion and sedimentation from areas disturbed during construction and de-commissioning of stream crossings	Construction/Closure	Likely
Deposition of soil or gravel from road surfaces during road grading	Construction/Closure	Likely
Constriction of the floodplain due to stream crossing structure installations	Construction/Operations	Likely
Temporary or permanent loss of fish habitat during construction of stream crossings	Construction	Likely
Decreased cover and nutrient supply and increased sedimentation and water temperatures due to temporary or permanent loss of riparian vegetation	Construction/Closure	Likely
Spills or leakage of fuels or deleterious substances from machinery into streams	Construction/Closure	Likely

Potential effects to fish habitat at this fish-bearing stream could result from activities required to construct, operate, and close the airstrip access road and include (**Table 5.3.9-9**):

- Increased bank erosion and transport of sediment due to clearing of vegetation and exposing soils along the stream and mobilizing sediments in the stream channel due to site preparation by heavy machinery. Sediment entering the stream at the crossing site may increase deposition of fine sediments in the channel substrates and increase total suspended solid concentrations in the water;
- Deposition of soil or gravel from road surfaces into streams during road grading;
- Constriction of the natural floodplain near the crossing sites due to crossing structure installations. This has the potential to increase erosion of stream sediments at the

crossing site or in downstream stream reaches and increase water velocities at the crossing sites;

- Temporary or permanent loss of fish habitat where instream works or temporary ford crossings are required;
- Temporary or permanent loss of riparian vegetation. This has the potential to decrease cover for fish, decrease nutrient supply, increase bank erosion and increase stream temperatures; and
- Spills or leaks of deleterious substances from machinery, including fuel, oil, and grease.

5.3.9.3.5.2 Mitigation Measures

Due to the absence of streams at the airstrip site, construction of surface water control ditches and collection ponds is the only required mitigation measure specifically for protection of fish habitat at the airstrip site.

Fish-bearing stream protection practices will be implemented during all phases of construction and de-commissioning in accordance with Section 5 of the *Fish-Stream Crossing Guidebook* (BC MOF, 2012) (**Table 5.3.9-54**).

Erosion control measures will be implemented to protect erodible soils and minimize sediment inputs to streams. Additional erosion control measures detailed in the SECP section of the Construction Management Plan will also be employed (**Section 12.2.1.18.4.1**).

To minimize or eliminate each of these potential effects to fish habitat the following mitigation measures will be implemented during the construction, operation, and closure of the airstrip and access road (**Table 5.3.9-54**):

- A clear-span structure (e.g., bridge or open-bottom culvert) will be installed to replace the existing closed-bottom culvert at the single fish-bearing stream along the airstrip access road. This structure will be installed following guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012); and
- Abutments of the clear-span bridge will be located above the high water level;
- Crossing structure installation will be timed so that instream works will be completed within the BC MOE reduced risk timing window for rainbow trout of 15 July to 15 April of the following year in Region 7- Omineca (BC MOE, 2004);
- If temporary crossing structures are required for the movement of construction vehicles or equipment, then temporary single span bridges will be installed.
- Erosion and sediment control measures, including erosion control matting and hydro seeding, will be used to protect erodible soils around the stream crossings. Silt fencing will be used to limit sediment from reaching fish-bearing streams where required;

- If replacement of the existing watercourse crossing structures on the non-classified drainages is required, sufficiently sized and embedded corrugated steel pipe culverts will be installed; and
- Any maintenance activities required for the existing watercourse crossings will follow guidelines and mitigation measures set out in accordance with DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013a).

Table 5.3.9-54: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish Habitat due to the Airstrip and Airstrip Access Road

Environmental Effect	Project Phase	Mitigation Measure	Mitigation Success Rating
Increased bank erosion and sedimentation from areas disturbed during construction and de-commissioning of stream crossing	Construction/ Closure	Erosion and sediment control measures (e.g., erosion control matting and hydro seeding) will be used to protect erodible soils.	High
Deposition of soil or gravel from road surfaces during road grading	Operations	Grader operators will follow guidelines to prevent sediment deposition.	High
Constriction of the floodplain due to stream crossing structure	Construction/ Operations	Clear-span/open bottom structures requiring no instream construction will be installed at new crossings of fish-bearing streams, if required. Correctly sized and installed closed-bottom culverts will be used to replace any existing culverts on non-fish-bearing streams as necessary.	High
Temporary or permanent loss of fish habitat during construction of stream crossings	Construction	Instream works will be avoided or minimized. Machinery will be allowed to ford the stream on a one-time basis to construct stream crossings..	High
Decreased cover and nutrient supply and increased sedimentation and water temperatures due to temporary or permanent loss of riparian vegetation	Construction/ Closure	Disturbance to riparian vegetation will be limited to the areas immediately upstream and downstream of the existing road crossing. Disturbed areas will be stabilized, re-vegetated, and/or seeded as soon as possible after construction.	High
Spills or leakage of fuels or deleterious substances from machinery into streams	Construction/ Operations/ Closure	An emergency spill response kit will be kept on-site during construction and closure. Fuels will be stored off-site and all refuelling will be conducted outside of riparian and instream areas. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed airstrip access road. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat in the three streams along the access road route. Confidence in this assessment is high and, for this reason, potential effects on fish habitat of the airstrip and airstrip access road were not carried forward to the residual effects assessment.

5.3.9.3.6 Transmission Line

5.3.9.3.6.1 Potential Effects on Fish Habitat

Potential effects on fish habitat at stream crossings along the transmission line ROW and at existing and temporary access road stream crossings may occur during construction, operations, and closure phases. Specifically, potential effects to fish habitat along the transmission line ROW include (**Table 5.3.9-55**):

- Increased erosion and transport of sediment. This is possible due to clearing of riparian vegetation and exposure of soils along the creek banks and mobilization of sediments in the stream channels due to fording or site preparation by heavy machinery during temporary bridge installation or removal. Sediment entering the streams at the crossing sites may contribute to elevated total suspended solid concentrations and siltation of downstream water bodies;
- Deposition of soil or gravel from access road surfaces into streams during road grading;
- Temporary and/or permanent loss of fish habitat if instream works or temporary ford crossings are required or if closed-bottom crossing structures are installed in fish-bearing streams;
- Temporary or permanent loss of riparian vegetation. This has the potential to decrease cover for fish, decrease nutrient supply, increase bank erosion and increase stream temperatures; and
- Spills or leaks of deleterious substances, including fuel, oil, and grease leading to decreased fish health, growth, and/or survival.

These potential effects differ from those listed for the fish VC in **Table 5.3.9-44** because effects assessment in **Section 5.3.8** was focused on fish, not fish habitat.

Table 5.3.9-55: Potential Effects to Fish Habitat from the Transmission Line

Potential Environmental Effect	Project Phase	Likelihood of Occurrence Without Mitigation
Increased erosion and sedimentation from areas disturbed during construction and closure of temporary watercourse crossings	Construction/Closure	Likely
Deposition of soil or gravel from access road surfaces during road grading	Construction/Closure	Likely
Temporary/permanent loss of fish habitat due to instream works, watercourse crossing construction, and fording by heavy machinery	Construction/Closure	Likely
Decreased cover and nutrient inputs and increased sedimentation and water temperatures due to disturbance to riparian vegetation	Construction/Operations/ Closure	Likely
Spills or leakage of fuels or deleterious substances into watercourses	Construction/Closure	Likely

5.3.9.3.6.2 Mitigation Measures

Stream crossings will be constructed and maintained following guidelines and mitigation measures outlined in DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b) (**Table 5.3.9-56**).

Table 5.3.9-56: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish Habitat due to the Transmission Line

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measures	Mitigation Success Rating
Increased erosion and sedimentation from areas disturbed during construction and closure of temporary watercourse crossings	Construction/ Closure	Erosion and sediment control measures (e.g., erosion control matting, rip-rap, and hydro seeding) will be used to protect erodible soils. Silt fencing will be used to limit sediments reaching fish-bearing streams.	High
Deposition of soil or gravel from access road surfaces during road grading	Construction/ Closure	Grader operations will follow guidelines to prevent sediment deposition.	High
Temporary/permanent loss of fish habitat due to instream works, watercourse crossing installations, and fording by heavy machinery	Construction/ Closure	Instream works will be avoided or minimized. Clear-span bridges or requiring no instream construction will be installed at new stream crossings, if required. Machinery will be allowed to ford the stream on a one-time basis to construct stream crossings.	High
Decreased cover and nutrient inputs and increased sedimentation and water temperatures due to disturbance to riparian vegetation	Construction/ Operations/ Closure	Disturbance to riparian vegetation will be minimized within a 15 m-wide buffer strip around fish-bearing streams. Trees growing near the transmission line cable will be pruned or topped, while leaving the stumps and root wads in place. Disturbed areas will be stabilized, vegetated, and/or seeded with native species as soon as possible after disturbance.	High
Spills or leakage of fuels or deleterious substances into streams	Construction/ Closure	An emergency spill response kit will be kept on-site during all construction and closure activities near streams. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks. Fuels will be stored off-site and refuelling will be conducted outside of instream and riparian areas.	High

Erosion control measures presented below will be implemented to protect erodible soils and minimize sediment inputs to streams. Additional erosion control measures detailed in the SECP section of the Construction Management Plan will also be employed where applicable (**Section 12.2.1.18.4.1**).

To minimize or eliminate each of these potential effects to fish habitat, the following mitigation measures will be implemented during the construction, operation, and closure of the transmission line:

- Erosion and sediment control measures including erosion control matting and hydro seeding, will be used to protect erodible soils around all existing and new stream crossings. Rip-rap and other erosion and sediment control measures will be incorporated into all new temporary stream crossing designs where required. Silt fencing will be used to limit sediment from reaching fish-bearing streams where required;

- Existing stream crossings will be used to cross the Stellako and Nechako Rivers and the majority of other streams.
- Machinery will be allowed one-time fording to gain access to construct stream crossings. Temporary clear-span bridges with abutments above the high water mark may be installed at temporary stream crossings along new access roads, if required. All structures will be sized, installed and maintained following guidelines and mitigation measures outlined in BC MOF's *Fish-Stream Crossing Guidebook* (BC MOF, 2012) and DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b) including:
  - Approaches to the water body will be designed and constructed such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation; and
  - Access design will avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other areas that are inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- No structures will be constructed below the high water mark of any watercourse;
- Riparian vegetation at stream crossings and under the transmission line ROW will be managed in accordance with *Approved Work Practices for Managing Riparian Vegetation* (BC Hydro et al., 2003). This will include:
  - Retaining as much vegetation as possible within a 15 m-wide buffer around fish-bearing streams;
  - Pruning or topping trees growing near the transmission line cable, while leaving the stumps and root wads in place; and
  - Re-vegetating disturbed areas with native species as soon as possible after disturbance.

All of the mitigation measures proposed above are commonly and widely used around BC during transmission line construction, maintenance and closure, including construction, maintenance and closure of access roads. None of these measures are unique nor are they unsuitable for the streams to be crossed by the proposed transmission line or its access roads. For these reasons, all of these mitigation measures are anticipated to be highly effective for eliminating or, at most, leaving only negligible residual effects to fish habitat at streams crossed by the transmission line. Confidence in this assessment is high. For this reason, potential effects of the transmission line and its access roads on fish habitat were not carried forward to the residual effects assessment.

5.3.9.3.7 Kluskus FSR and Kluskus-Ootsa FSR

5.3.9.3.7.1 Potential Effects on Fish Habitat

Ditch construction, road surface grading, and bridge or culvert installation and maintenance may affect fish habitat at stream crossings along the existing Kluskus FSR, the existing Kluskus-Ootsa

FSR, and the re-aligned section of the Kluskus-Ootsa FSR. Specifically, potential effects to fish habitat at these stream crossings include (**Table 5.3.9-57**):

- Increased erosion and transport of sediment due to clearing of vegetation and exposure of soils along creeks and mobilization of sediments in stream channels due to fording or site preparation by heavy machinery. Sediment entering the streams at the crossing sites could contribute to increased sediment loads and siltation of downstream water bodies;
- Deposition of soil or gravel from road surfaces into streams during road grading;
- Temporary and/or permanent loss of fish habitat if instream works or temporary ford crossings are required or if closed-bottom crossing structures are installed in fish-bearing streams;
- Constriction of the natural floodplain near the crossing sites due to crossing structure installations. This has the potential to increase erosion of stream sediments at the crossing site or in downstream stream reaches and increase water velocities at the crossing sites; and
- Temporary or permanent loss of riparian vegetation. This has the potential to decrease cover for fish, decrease nutrient supply, increase bank erosion and increase stream temperatures.

Table 5.3.9-57: Potential Effects to Fish Habitat from Upgrading and Realigning the Kluskus and Kluskus-Ootsa FSRs

Potential Environmental Effect	Project Phase	Likelihood of Occurrence before Mitigation
Increased erosion from areas disturbed during construction and de-commissioning and increased sediment inputs	Construction/Closure	Likely
Deposition of soil or gravel from road surfaces into streams during road grading	Construction/Closure	Likely
Temporary/permanent loss of fish habitat due to instream works, watercourse crossing construction, and fording by heavy machinery	Construction/Closure	Likely
Constriction of the floodplain due to stream crossing structure installations	Construction/Operations	Likely
Decreased cover and nutrient inputs and increased sedimentation and water temperatures due to disturbance of riparian vegetation	Construction/Operations / Closure	Likely

5.3.9.3.7.2 Mitigation Measures

All proposed stream crossing techniques will follow guidelines set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012). Fish-bearing stream protection practices will be implemented during all phases of construction in accordance with Section 5 of that guidebook.

Erosion control measures will be implemented to protect erodible soils and minimize sediment inputs to streams. Additional erosion control measures detailed in the SECP section of the Construction Management Plan will also be employed where applicable (**Section 12.2.1.18.4.1**).

To minimize or eliminate each of these potential effects to fish habitat, the following mitigation measures will be implemented during the construction, operation, and closure of the Kluskus and Kluskus-Ootsa FSRs, including the realigned section of the Kluskus-Ootsa FSR (**Table 5.3.9-58**):

- An existing perched culvert located at site AE-013 on the section of the Kluskus-Ootsa FSR to be realigned will be removed. Installation of a new upstream crossing structure will eliminate a barrier to fish passage and improve fish access upstream of the existing culvert;
- Erosion and sediment control measures, including erosion control matting and hydro seeding, will be used to protect erodible soils around stream crossings. Riprap and other erosion and sediment control measures will be incorporated into stream crossing designs where required. Silt fencing will be used to limit sediment from reaching streams where required;
- Clear-span bridges with abutments above the high water mark or open-bottom culverts will be installed on fish-bearing streams. Further mitigation measures outlined in *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013b) will be followed during installation of these stream crossing structures, including:
  - Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation; and
  - Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Cross drains will be installed where required along the Kluskus and Kluskus-Ootsa FSRs. Typical locations for cross drainage culverts will be in natural seepage zones, low elevation areas, or near steep gradients to minimize disruption to local drainage patterns;
- Machinery will be allowed one-time fording to gain access to construct stream crossings. If temporary crossing structures are required for longer-term movement of construction vehicles or equipment, then temporary single-span bridges will be installed; and
- An emergency spill response kit will be kept on-site during construction, fuels will be stored off-site, all refuelling will be conducted outside of riparian and instream areas, and all machinery that arrives on site will be in a clean condition and maintained free of fluid leaks, so as to minimize spills or leaks of deleterious substances leading to decreased fish health, growth, and/or survival.

Table 5.3.9-58: Mitigation Measures to Eliminate or Reduce Potential Effects to Fish Habitat from the Kluskus and Kluskus-Ootsa FSRs

Likely Environmental Effect	Project Phase	Mitigation/ Enhancement Measures	Mitigation Success Rating
Increased erosion from areas disturbed during construction and increased sediment inputs	Construction/Closure	Erosion and sediment control measures (e.g., erosion control matting, riprap and hydro seeding) will be used to protect erodible soils. Silt fencing will be used to limit sediments reaching fish-bearing streams.	High
Deposition of soil or gravel from road surfaces into streams during road grading	Construction/Closure	Grader operators will follow guidelines to prevent sediment deposition.	High
Temporary/permanent loss of fish habitat due to instream works, watercourse crossing construction, and fording by heavy machinery	Construction/Closure	Instream works will be avoided or minimized. Clear-span/open-bottom structures requiring no instream construction will be installed at all new stream crossings. Machinery will be allowed to ford streams on a one-time basis to gain access to construct stream crossings. Temporary single span bridges may be used for temporary crossings, if required.	High
Constriction of the floodplain due to stream crossing structure installations	Construction/Operations	Clear-span/open bottom structures requiring no instream construction will be installed at all new stream crossings. Correctly sized and installed closed bottom culverts will be used to replace any existing culverts on non-fish-bearing streams as necessary	High
Decreased cover and nutrient inputs and increased sedimentation and water temperatures due to disturbance of riparian vegetation	Construction /Closure	Disturbance to riparian vegetation at all new fish-bearing stream crossings will be minimized by limiting clearing to the maximum area needed for crossing construction. Disturbed areas will be stabilized, vegetated, and/or seeded as soon as possible after construction.	High
Spills or leakage of fuels or deleterious substances into watercourses.	Construction/ Closure	An emergency spill response kit will be kept on-site during construction. Fuels will be stored off-site and all refuelling will be conducted outside of riparian and instream areas. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks.	High

All of the mitigation measures proposed above are commonly and widely used around BC during road construction. None of these measures are unique nor are they unsuitable for the streams to be crossed by the FSRs and the proposed realignment. For these reasons, all of these mitigation measures are anticipated to be effective for eliminating or leaving only negligible residual effects to fish habitat in permanent streams along the FSR routes. Confidence in this assessment is high. For this reason, potential effects of the FSRs on fish habitat were not carried forward to the residual effects assessment.

5.3.9.3.8 Summary of Potential Residual Effects

The analyses of this section identified eight potential residual effects on the fish habitat VC that cannot be eliminated through mitigation (**Table 5.3.9-59**).

Table 5.3.9-59: Residual Effects on Fish Habitat VC

Project Component	Potential Residual Effect
Mine site	• Loss of fish habitat under the mine site • Change in fish habitat quality and availability in Davidson Creek as a result of changes in flows • Change in fish habitat quality and availability in Creek 661 as a result of changes in flows • Change in fish habitat quality and availability in Creek 705 as a result of changes in flows • Mercury mobilization in Lake 01682LNRS
FSS	• Change in fish habitat quality and availability in lower Chedakuz Creek as a result of changes in flows • Changes in water temperature in Davidson Creek • Reduction in littoral fish habitat of Tatelkuz Lake
Mine access road	• None
Airstrip and airstrip access road	• None
Transmission line	• None
Kluskus FSR and Kluskus-Ootsa FSR	• None

5.3.9.3.9 Identification and Description of Potential Adverse Effects from Other Past, Present, and Certain or Reasonably Foreseeable Future Project or Activities

Table 4.3-11 shows the Summary Project Inclusion List developed for cumulative effects assessment. Of the 13 projects on that list, ten have potential to interact cumulatively with the fish habitat VC. A brief description of each of these projects, their location and timing relative to the Blackwater Project (to show potential spatial and temporal overlap), and their potential adverse effects to fish habitat are provided in **Table 5.3.9-60**.

Table 5.3.9-60: Potential Adverse Effects from Other Past, Present, and Certain or Reasonably Foreseeable Projects or Activities in the vicinity of the Blackwater Project

Project Name	Project Description	Location relative to Blackwater Project	Timing Relative to Blackwater Project	Potential Adverse Effect to Fish Habitat
Pacific Gas Looping Project	Natural gas transmission pipeline between Summit Lake, BC, and Kitimat, BC	Intersects transmission line LSA	Future	• Alteration of riparian habitat • Increased suspended sediment concentrations and deposition
Mining-existing	Surface molybdenum mine near Fraser Lake approximately 65 km west of Vanderhoof	Outside RSA	Ongoing	• Permanent alteration or destruction of fish habitat due to development of mine site components • Alteration of riparian habitat • Change in stream flows and water quality
Mining-exploration	Diamond drilling for sampling ore body at exploration sites, and reclamation of drill site and access trail upon completion of exploration activity	In LSA and RSA	Ongoing	• Alteration of instream and riparian habitats • Change in stream flows
Forestry	Cut block timber harvesting, road building, culvert replacement, and woodlot tenures	In LSA and RSA	Ongoing	• Alteration or removal of riparian vegetation • Increased suspended sediment concentrations and deposition • Permanent alteration or destruction of fish habitat due to fording of streams by heavy machinery
Hunting, trapping, and guide outfitting	Game hunting, maintenance of game trap lines, provision of guided fishing trips	In LSA and RSA	Ongoing	• Alteration or destruction of instream and riparian habitat due to recreational vehicles • Alteration of instream habitat due to sediment deposition
Fishing and hunting lodges	Commercial lodges providing cabin rentals, camping, fishing, boating, sightseeing, hiking, all-terrain vehicle use, horseback riding and other eco-tourism activities	In LSA and RSA	Ongoing	• Alteration or destruction of instream and riparian habitat due to recreational vehicles • Alteration of instream habitat due to sediment deposition
Recreation	All-terrain vehicle use, snowmobiling, hiking, camping, cross-country skiing, horseback riding, fishing, hunting, interpretive cultural heritage experiences, and eco-tourism	In LSA and RSA	Ongoing	• Alteration or destruction of instream and riparian by recreational vehicles • Alteration of instream habitat due to sediment deposition

Project Name	Project Description	Location relative to Blackwater Project	Timing Relative to Blackwater Project	Potential Adverse Effect to Fish Habitat
Agriculture	Rangeland tenures for raising cattle and horses; livestock ranching; commercial production of animals; soil-bound and greenhouse production of fruit, vegetable, cereal, seed, and forage crops	In LSA and RSA	Ongoing	• Changes in water quality due to nutrient enrichment from manure • Destruction of riparian habitats from livestock
Transportation	Two FSRs, a network of logging roads connecting timber harvesting tenures, mine access roads, and exploration access trails	In LSA and RSA	Ongoing	• Permanent alteration or destruction of fish habitat due to road and watercourse crossing construction • Alteration of habitat from sediment deposition and erosion due to road maintenance
Crown-land tenures	Agriculture, environment, institutional, quarrying, residential, wells, points of diversion (POD)	In LSA and RSA	Ongoing	• Change in water quality due to nutrient enrichment from manure • Alteration or destruction of fish habitat due to road and watercourse crossing construction • Alteration of habitat from sediment deposition and bank erosion

5.3.9.4 Residual Effects and their Significance

This section assesses the significance of those eight residual effects on the fish habitat VC considering context, magnitude, geographic extent, duration, reversibility, frequency. The likelihood of each residual effect is assessed and significance is assigned. The level of confidence and risk in the determination of significance and its likelihood are discussed. Rating criteria are defined in **Section 4.3.5** and summarized in **Table 5.3.9-61**.

Once the evaluation of significance is determined, the level of confidence in the prediction is considered. Level of confidence can be high, moderate, or low and describes the certainty of the predicted outcome, allowing the decision-maker to evaluate risk. Uncertainty can be addressed through follow-up or monitoring programs.

Table 5.3.9-61: Rating Criteria to Assess Significance of Residual Effects to Fish Habitat

Rating Criteria	Description
Context	
Low	• VC has high resilience to stress, no listed species
Medium	• VC has medium resilience to stress; blue-listed species
High	• VC has low resilience to stress; red-listed species.
Magnitude	
Negligible	• No detectable change from baseline
Low	• Differs from mean baseline values, but is within range of natural variation, and below a guideline or threshold
Medium	• Differs from mean baseline values, approaches limits of natural variation, but is below or equal to a guideline or threshold
High	• Differs from mean baseline values, is outside range of natural variation, and beyond a guideline or threshold
Geographic Extent	
Point	• Organism level; linear scale <5 m; confined to one stream reach in the LSA
Site-Specific	• Effects confined to the Project site
Local	• Effect is confined to the LSA; local population; linear scale <100 m
Regional	• Effect is confined to the RSA; multiple populations or species
Duration	
Short-term	• Less than two years (construction)
Medium-term	• From 2 to less than 17 years (operations)
Long-term	• From 17 to less than 35 years (closure)
Chronic (permanent)	• From 36 years and beyond (post-closure)
Reversibility	
Yes	• Effect is reversible over one to a few life cycles after the impact ceases
No	• Effect is not reversible over the time scales listed
Frequency	
Once	• Effect occurs on one occasion
Intermittent	• Effect occurs several times
Continuous	• Effect occurs continuously
Likelihood	
Low	• Low likelihood a residual effect will occur
Moderate	• Moderate likelihood a residual effect will occur
High	• High likelihood a residual effect will occur
Significance	
Not significant (negligible)	• Effects are point-like or local in geographic extent, with a low context rating, and a negligible magnitude, short-term, reversible, and with a low frequency (once or intermittent)
Not significant (minor)	• Effects are local in geographic extent, with a low magnitude, and low context rating, short-term to chronic, reversible, and with a low frequency (once or intermittent)
Not significant (moderate)	• Effects are local to regional in geographic extent, and medium in magnitude, medium context rating, medium-term to chronic, reversible, and occur at all frequencies
Significant	• Effects occur to VCs with a medium to high context, high magnitude, regional in geographic extent, long-term to chronic, non-reversible, and occur at all frequencies.

Note: m = metre; m^2 = square metre; % = percent; VC = Valued Component.

The level of confidence associated with a determination of significance and likelihood is typically based on professional judgement and knowledge of the sources and nature of uncertainty as compounded through all steps in the effects assessment. Confidence and risk are evaluated for each residual effect prediction and each cumulative effect prediction. When there is a low confidence in residual effect prediction the necessity of additional risk analysis may be proposed (**Table 5.3.9-62**).

Table 5.3.9-62: Confidence

Level	Description
High	All of the following must be met: • VC is well understood • Project-VC interaction is well understood • Mitigation has been proven effective
Moderate	• VC understood in similar ecosystems and effects documented in the larger regional area or in the literature • Mitigation proven effective elsewhere
Low	• VC is not well understood • Project-VC interaction is not well understood • Mitigation has not been proven effective

5.3.9.4.1 Loss of Fish Habitat on the Mine Site

Fish habitat under the mine footprint and upstream of it will be unavoidably and permanently altered or lost during construction, operations, closure and post-closure phases. Therefore, the magnitude of the effect is high in all phases (**Table 5.3.9-63**).

Context is low because there are no listed ecosystems or blue-listed or red-listed aquatic species in either Davidson Creek or Creek 661. Brassy minnow, a blue-listed species, is the only listed fish species in the LSA, but it is present in Tatelkuz Lake, not Davidson Creek. The Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet that is blue-listed in BC, has been found in Lake 01682LNRS, but not in Davidson Creek. (See **Section 5.3.8.4.3** for more details.)

Geographic extent is local because the effect is confined to the upper reaches of Davidson Creek and Creek 661.

Duration extends throughout all phases; therefore, it is short-term during construction, medium-term during operations, long-term during closure and chronic in post-closure.

The effect is irreversible, and the frequency is continuous.

Table 5.3.9-63: Significance of Residual Effects on Fish Habitat of the Mine Site Footprint

Categories for Significance Determination	Project Phase			
	Construction	Operations	Closure	Post-Closure
Context	Low	Low	Low	Low
Magnitude	High	High	High	High
Geographic Extent	Local	Local	Local	Local
Duration	Short-term	Medium-term	Long-term	Permanent
Reversibility	No	No	No	No
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	Moderate	Moderate	Moderate	Moderate
Significance Determination	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)
Statement of the level of Confidence for Significance	High	High	High	High

These losses of fish habitat will be offset with fish habitat restoration, enhancement, and creation. These measures are described in detail in the FMOP (**Appendix 5.1.2.6C**). Two overwintering and rearing ponds will be constructed near the mid-reaches of Davidson Creek. Because that will not replace the entire amount of fish habitat that will be lost in Davidson Creek, additional fish habitat will be created elsewhere in the LSA, the RSA and in the larger region to offset this loss.

This effect is assessed as not significant (minor) for rainbow trout, largely because the lost habitat will be replaced by new fish habitat, as described by the FMOP. (There are no kokanee on the mine site.)

The likelihood of this determination is high because the FMOP is based on proven concepts that have been used successfully in other offsetting plans for mines in BC. Confidence in this assessment is high.

The residual effect on fish habitat due to development of the mine site was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

5.3.9.4.2 Changes in Stream Flows and Stream Habitat

The assessment of potential flow-related residual effects on fish habitat considered the extent, magnitude, and duration of anticipated flow changes using flow/habitat models and flow time series, winter flow statistics, and freshet flow data.

5.3.9.4.2.1 Davidson Creek

Changes to the flow regime in Davidson Creek are a design feature of the Project and are certain to occur. The potential effects of these changes on rainbow trout and kokanee are assessed as not significant (moderate) for construction, operations closure, and post-closure (**Section 5.3.9.3.2.2.3; Table 5.3.9-64**).

Table 5.3.9-64: Significance of Residual Effect on Fish Habitat in Davidson Creek of Flows Downstream of the Mine Site

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	Medium	Low	Low	Medium
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate
Kokanee				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Medium
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

Context is low because there are no listed ecosystems or blue-listed or red-listed aquatic species in either Davidson Creek or Creek 661. Brassy minnow, a blue-listed species, is the only listed fish species in the LSA, but it is present in Tatelkuz Lake, not Davidson Creek. The Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet that is blue-listed in BC, has been found in Lake 01682LNRS, but not in Davidson Creek. (See **Section 5.3.8.4.3** for more details.)

Also, rainbow trout and kokanee are resilient to modest changes in flow and the resulting effects to habitat, as shown by their wide geographic distribution in the LSA, and because natural flows exhibit high variability.

For construction, habitat changes will be less than the 10% threshold, but magnitude is assessed as medium because winter minimum flows will change by more than 10% from baseline. For operations and closure, magnitude is low because all changes are less than the 10% threshold and winter minimum flows are within 10% of baseline. For post-closure, magnitude is medium because there will be a 13% change in kokanee spawning habitat availability and because minimum winter flows will be reduced by 14%.

Geographic extent is local, because the effect is confined to the LSA.

Duration varies by phase.

Reversibility is not applicable to construction, operations and closure phases. At post-closure, flows will return to near baseline conditions, although there is some uncertainty with respect to gravel supply and overwintering flows.

Frequency is continuous, at least during construction, operations and closure phases.

Likelihood of effect is high because it is certain that flows will change in Davidson Creek downstream of the Project.

The assessment of non-significance was qualified as moderate because effects are local, with low or medium magnitude and context, are short to long-term, and occur continuously.

The residual effect on fish habitat in Davidson Creek of changes in flows was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

Confidence in this assessment is moderate because the magnitude of effects is based on two separate models, one for flows (the watershed model) and another for flow/habitat effects (the instream flow model). Confidence in the flow model is high (**Section 5.3.2**). The flow/habitat modelling approach is well-established, internationally applied, and site-specific components are based on Provincial standards. However, fish response to flow changes in Davidson Creek has not been empirically tested, and some scientific uncertainty remains. The moderate rating also reflects some uncertainty with respect to effects of changes in post-closure winter flows and gravel supply.

Monitoring of flows during the construction, operations and closure phases will be required to validate habitat model predictions and to assess whether adverse effects may occur at post-closure. Because potential effects occur at post-closure, 35 years of physical and biological monitoring data will be available to determine if a biological effect is expected, and to determine any required action.

Engineering options to help naturalize flow timing and volume at post-closure include:

- Reducing the residual TSF pond surface area to reduce evaporation; and
- Reducing seepage losses from the post-closure TSF spillway.

These engineering alternatives would be designed such that the post-closure flow regime mimics the baseline regime to the maximum extent possible. The Project design includes staged closure of the TSF, with the Site C TSF cell closed before the Site D cell (**Section 2.2**). This approach ensures that engineering alternatives to naturalize flows to the maximum possible extent are well understood by the time the Site D TSF cell is closed. Monitoring will also clarify the sediment-supply regime for the lower watershed. Therefore, it is likely that the magnitude of post-closure effects can be reduced to low.

5.3.9.4.2.2 Lower Chedakuz Creek

Due to the low magnitude of flow changes in lower Chedakuz Creek no physical effects on fish habitat are anticipated. Changes in peak flows will be negligible (**Section 5.3.2**). Changes are certain to occur to the flow regime in Chedakuz Creek. There were assessed as not significant (moderate) for construction, operations, closure and post-closure phases (**Section 5.3.9.3.2.2.3**; **Table 5.3.9-65**).

The residual effect on fish habitat in lower Chedakuz Creek as a result of changes in flows was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

Monitoring will be conducted to assess the accuracy of this assessment, to determine whether adverse effects to fish habitat occur as a result of the Project, and, if so, implement mitigation.

Table 5.3.9-65: Significance of Residual Effect on Fish Habitat in Lower Chedakuz Creek Downstream of Tatelkuz Lake

Categories for Significance Determination	**Project Phase**			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate
Kokanee				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

5.3.9.4.2.3 Creek 661

Changes to the flow regime in Creek 661 are certain to occur and are assessed as not significant (moderate) (**Section 5.3.9.3.2.2.3**; **Table 5.3.9-66**).

Table 5.3.9-66: Significance of Residual Effect on Fish Habitat in Creek 661 Downstream of Creek 505659

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate
Kokanee				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

Flow/habitat models were not developed for headwater sections of Creek 661 (upstream of the confluence with Creek 505659). Instead, potential effects were assessed based on flow changes.

For the upper portion of Creek 661, changes in flows will be low in magnitude, and the largest changes in proportional terms will occur during the winter. The section does not provide overwintering habitat, so no effect is anticipated. Potential effects are assessed as not significant (moderate) for construction, operations and closure (**Table 5.3.9-67**). Flows will be restored to baseline conditions at post-closure, so potential effects were assessed as not significant (moderate).

Table 5.3.9-67: Significance of Residual Effect on Fish Habitat of Flow Changes in Creek 661 Upstream of Creek 505659

Categories for Significance Determination	**Project Phase**			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Negligible
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (negligible)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	High

For Creek 505659, flow changes will occur for all Project phases (**Table 5.3.9-68**). Mean annual reductions will be 28%, 48% and 47% for operations, closure and post-closure, respectively. The duration of post-closure changes will be permanent, and will persist due to diversion of flows to the Davidson Creek drainage.

Table 5.3.9-68: Significance of Residual Effect on Fish Habitat of Flows in Creek 505659

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	High	High	High	High
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	N/A	N/A	N/A	No
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Included in Offsetting Plan	100% of habitat	100% of habitat	100% of habitat	100% of habitat
Significance Determination Considering Offsetting	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)
Statement of the level of Confidence for Significance	High	High	High	High

Changes in minimum overwintering flows will be small (i.e., 1 to 2 L/s) and represent a 13% reduction from baseline at post-closure. (This stream section provides overwintering habitat.) Due to the magnitude of effects, particularly at post-closure, the assessment conservatively assumes that all fish habitat downstream of the Project in Creek 505659 will be lost. The magnitude of effect is therefore high, and the effect is not reversible; 100% of the habitat in Creek 505659 is included in the FMOP (**Appendix 5.1.2.6C**) as a Project effect requiring offsetting measures.

This approach is conservative because habitat in the stream section will remain and fish will continue to use it, despite changes in flow. Because 100% of the habitat that will be potentially lost is included in offsetting requirements for the Project, and because proposed offsetting measures are based on proven concepts with high confidence in success, the potential effect is assessed as not significant.

In summary, the residual effect on fish habitat in Creek 661 as a result of changes in flows was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

5.3.9.4.2.4 Creek 705

Changes to the flow regime in Creek 705 are certain to occur and are assessed as not significant (moderate) for construction, operations, closure and post-closure phases (**Section 5.3.9.3.2.2.3**; **Table 5.3.9-69**).

Table 5.3.9-69: Significance of Residual Effect on Fish Habitat in Creek 705

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Rainbow Trout				
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short	Medium	Long	Permanent
Reversibility	No	No	No	No
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)	Not Significant (moderate)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

The residual effect on fish habitat in Creek 705 as a result of changes in flows was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

5.3.9.4.3 Mercury Mobilization in Lake 01682LNRS

Mercury concentrations in the aquatic ecosystem of Lake 01682LNRS may increase over the mine life as a result of enlarging the lake. (Kokanee are not present in the Creek 705 Watershed.) Once the soil is flooded, bacteria in the soil will begin to methylate total mercury stored in the soil, and methylmercury will then be taken up by aquatic plants and BMI and eventually by rainbow trout. Eventually, mercury concentrations will return to baseline concentrations – a process that typically takes 30 to 40 years (Azimuth, 2012).

The context of this residual effect is medium because specimens of the blue-listed Rocky Mountain Capshell have been found in Lake 01682LNRS (**Table 5.3.9-70**).

Magnitude is low because mercury and methylmercury concentrations are expected to increase in tissues of aquatic plants and animals, and to bioaccumulate in animals of higher trophic levels such as rainbow trout, but they are not expected to reach concentrations that could significantly affect any aspect of growth, survival or reproduction for any organism (Azimuth, 2012). The main scientific and social concern regarding mercury in aquatic ecosystems has always been for the health of humans, particularly pregnant women, who may consistently consume large quantities of fish from such reservoirs over a long time period.

Table 5.3.9-70: Significance of Residual Effects on Rainbow Trout from Elevated Methylmercury in Lake 01682LNRS

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Context	Medium	Medium	Medium	Medium
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Short-term	Medium-term	Medium-term	Medium-term
Reversibility	Yes	Yes	Yes	Yes
Frequency	Continuous	Continuous	Continuous	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)	Not Significant (minor)
Statement of the level of Confidence for Significance	Moderate	Moderate	Moderate	Moderate

Long-term human consumption of rainbow trout from lakes 01682LNRS and 01538UEUT is an unlikely scenario because until the mine site is abandoned (i.e., the *Mines Act* permit is closed) the mine site will be off limits to the general public. Lakes 01682LNRS and 01538UEUT and Davidson Creek upstream of the mine access road will not be accessible for any food fishing. That will be at least 18 years after mine closure or about 35 years total from mine opening.

The geographic extent is local because it is restricted to the two headwater lakes (01682LNRS and 01538UEUT) and the mainstem of Creek 705.

Typically, the period of elevated mercury concentrations in a new reservoir lasts for 30 to 40 years (Azimuth, 2012). This period corresponds to the Project life span. Hence, duration is predicted to be short-term during construction and medium term through operations, closure and post-closure.

The effect is reversible because mercury concentrations are expected to fall back to baseline concentrations early in the post-closure period.

This potential residual effect is predicted to be not significant (minor) because it is low in magnitude, local in extent, medium-term in duration, and reversible.

The likelihood of this residual effect occurring is high, but confidence in this assessment is moderate. Although the phenomenon of mercury mobilization in new reservoirs is global, and has been observed in the hydroelectric reservoirs of Quebec, Manitoba and BC, it remains difficult to reliably predict the increase in mercury concentrations (Azimuth, 2012).

The residual effect on fish habitat of mobilization of mercury in Lake 01682LNRS was carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

5.3.9.4.4 Changes in Water Temperature in Davidson Creek

The potential residual effect of changes in water temperature on fish habitat in Davidson Creek will occur during operations, closure and post-closure phases. During operations and closure water temperature is predicted to increase in the winter and decrease in the summer as a result of flow augmentation from water pumped from Tatelkuz Lake. Upon post-closure water temperatures are predicted to return to baseline in winter but remain elevated during the other three seasons.

Higher temperatures during winter will have little effect on periphyton and BMI because they are largely dormant at that time of the year. Lower temperatures during summer may reduce growth rates and possibly density and biomass, but the change will fall within the range of natural variability. (**Section 5.3.8** includes a more detailed assessment of potential effects on fish of changes in water temperature.)

Context for this assessment was rated low because there are no listed ecosystems or aquatic species in Davidson Creek (**Table 5.3.9-71**).

Table 5.3.9-71: Significance of Residual Effects of Water Temperature on Fish Habitat in Davidson Creek

Categories for Significance Determination	Project Phase			
	Construction	**Operations**	**Closure**	**Post-Closure**
Context	Low	Low	Low	Low
Magnitude	Low	Low	Low	Low
Geographic Extent	Local	Local	Local	Local
Duration	Chronic	Chronic	Chronic	Chronic
Reversibility	No	No	No	No
Frequency	Once	Intermittent	Intermittent	Continuous
Likelihood Determination	High	High	High	High
Significance Determination	Not significant (minor)	Not significant (minor)	Not significant (minor)	Not significant (minor)
Statement of the level of Confidence for Significance	High	High	High	High

Magnitude is also rated as low because predicted water temperatures will fall within the natural range of variation.

Geographic extent is local because it is limited to Reaches 1 to 6 of middle and lower Davidson Creek.

Changes to water temperature are irreversible because summer water temperatures will be permanently elevated in the post-closure phase, although temperatures during that phase will still fall within the range of natural variation.

Frequency is continuous because flow augmentation will be continuous through operations and closure, and discharge from the TSF will be continuous during post-closure.

This potential residual effect is predicted to be not significant (minor) because it is low in magnitude and local in extent, even though it is chronic in duration and irreversible.

The likelihood of temperature change in Davidson Creek as a result of Project activities is high, but confidence in this assessment is moderate because of limitations in the data and in the model used to predict water temperatures in all phases.

The residual effect on fish habitat in Davidson Creek of changes in water temperature is carried forward into cumulative effects assessment because it was assigned a significance rating higher than “not significant (negligible)” (**Section 4.3.6**).

5.3.9.4.5 Reduction in Littoral Fish Habitat of Tatelkuz Lake

Reduction in WSE of Tatelkuz Lake is expected to have residual effects on the area and composition of littoral habitat in the 0 to 1 m depth stratum during operations and closure. Changes in composition of littoral habitat types from baseline conditions could potentially result in changes to water temperature, nutrients and erosion within the littoral zone.

Overall changes in area of fish habitat during operations compared to baseline are estimated to be small – less than 1% during an average year and less than 2.5% during a 1:50 dry year. Changes during closure are similar to operations: less than 1% change during an average year and less than 2% change during a 1:50 dry year (**Table 5.3.9-71**).

In addition, WSE fluctuate naturally, thereby regularly exposing shoreline substrates. Water temperature should not be affected because the lake is large and the littoral habitat accounts for a small portion of the lake temperature. Nutrient supply should not be affected because algae and vegetation will still exist in the littoral zone and are adaptable to small changes in lake levels. Also, substrates dominated by fines, which were identified in baseline investigations as important for BMI, account for a large portion (approximately 50%) of the substrate composition and exhibit very small changes caused by to Project water withdrawals.

Effects are restricted to operations and closure phases because pumping of Tatelkuz Lake water to the freshwater reservoir will begin during the construction phase and will end at the end of closure.

Table 5.3.9-72: Magnitude of Residual Effect on Littoral Habitat in Tatelkuz Lake

Project Phase	Scenario	Winter (January) (% Change)	Spring (May) (% Change)	Summer (July) (% Change)	Fall (October) (% Change)
Operations	Average	-0.2	0.7	0.5	0.1
	1:50 dry year	-1.4	-1.3	-1.7	-2.5
Closure	Average	-0.2	0.7	0.5	0.1
	1:50 dry year	-1.0	-1.2	-1.4	-2.0

Note: % = percent, negative value indicates a reduction from baseline conditions, positive value indicates an increase from baseline conditions.

Context is assessed as low because of the absence of any ecosystems of special conservation concern in the lake (**Table 5.3.9-73**).

The magnitude of change is negligible to low, because some months will differ from mean baseline values, but will remain within range of natural variation. On average, WSE of the lake fluctuates 0.8 m over a year, but the greatest change estimated to be caused by pumping 0.11 m from baseline conditions or 14% of the baseline range.

Table 5.3.9-73: Significance of Residual Effect on Littoral Habitat in Tatelkuz Lake

Categories for Significance Determination	Rating	
	Operations	Closure
Context	Low	Low
Magnitude	Negligible	Negligible
Geographic Extent	Local	Local
Duration	Medium-term	Long-term
Reversibility	Yes	Yes
Frequency	Continuous	Continuous
Likelihood Determination	High	High
Significance Determination	Not significant (negligible)	Not significant (negligible)
Statement of the level of Confidence for Significance	High	High

Geographic extent of the effect is local because it is confined to the littoral zone of Tatelkuz Lake.

Duration of the residual effects in Tatelkuz Lake is of medium-term (2 to <17 years) during operations and long-term (>17 to <35 years) during closure.

All potential residual effects are reversible. Upon closure, once the pit is filled and excess water is flowing to the TSF, pumping will cease and the FSS will be dismantled. The WSE of Tatelkuz Lake will return to baseline conditions. Vegetation communities will return to baseline conditions.

The frequency of the potential residual effect is continuous because pumping of water from Tatelkuz Lake to the freshwater reservoir will continue throughout mine life, ceasing only at the end of the closure phase.

This residual effect is assessed as not significant. A “negligible” qualifier is attached because the magnitude of the residual effect is assessed as negligible.

The likelihood of this residual effect is high. Sources of uncertainty are:

- Gaps in baseline quantification of littoral habitat include consideration of woody debris, and riparian vegetation. Woody debris and overhanging vegetation can enhance habitat by providing refuge and spawning habitat to fishes (Gaeta et al., 2013), and food and nutrient inputs;
- Modelling estimates have error. Estimated changes may be higher or lower than predicted by the model. However the model is conservative and takes into account 1 in 50 year dry scenario; and
- Some rare habitat types with small areas that are seasonally wetted could be more important to fish than previously estimated.

Confidence in this assessment is high because the overall change from baseline conditions does not exceed 5%. Also, the estimated lake elevation levels are within natural elevation fluctuations. Studies of droughts suggest that adverse effects to littoral habitat occur when lake elevations drop 1 m or more for extended periods of time (e.g., Matthews et al., 2003; Gaeta et al., 2014). The estimated reductions to lake elevations will not be greater than 0.11 m for any month in Tatelkuz Lake.

The residual effect on fish habitat in the littoral zone of Tatelkuz Lake is not carried forward into cumulative effects assessment because it was assigned a rating of “not significant (negligible)” (**Section 4.4.6**).

5.3.9.5 Cumulative Effects

Potential cumulative effects on fish habitat must be considered when Project-related potential residual effects on fish habitat overlap temporally or spatially with known or likely residual effects from past, present, or reasonably foreseeable projects. This section determines the need for assessing cumulative effects; assesses potential cumulative effects; and, if applicable, assesses cumulative effects and evaluate these effects using the same criteria and steps as noted in **Section 5.3.9.4** above. Potential cumulative effects on fish habitat were assessed within the Project aquatic cumulative effect study area (CESA) which is the same as the aquatic RSA.

5.3.9.5.1 Rationale for Assessing Cumulative Effects

Of the eight potential residual effects on fish habitat, none were assessed as significant in **Section 5.3.9.4**. One (changes in WSE of Tatelkuz Lake) was characterized as “not significant (negligible)” and was not carried forward to cumulative effects assessment (**Table 5.3.9-74**). Of the remaining seven, four were characterized as moderate and three were characterized as minor. The remaining seven were carried forward to cumulative effects assessment.

Table 5.3.9-74: Project-Related Residual Effects on the Fish Habitat VC: Rationale for Carrying Forward into the CEA

Project Component	Project Phase	Residual Effect	Rationale	Carried Forward in Cumulative Effects Assessment
Mine site	C, O, D/C, P	Loss of fish and fish habitat on the mine site	Fish habitat under the mine footprint will be permanently lost. This effect was assessed as “not significant (minor)” for rainbow trout, because the lost habitat will be replaced by new fish habitat in offset measures.	Yes
Mine site	C, O, D/C, P	Change in fish habitat quality and availability in Davidson Creek	Flow will be reduced due to development of mine site, but flow augmentation from Tatelkuz Lake will restore fish habitat close to baseline levels. This effect was assessed as “not significant (moderate)” because the effects are local, with low or medium magnitude and context, are short to long-term, and occur continuously	Yes
FSS	C, O, D/C, P	Change in fish habitat quality and availability in lower Chedakuz Creek	Flow will be reduced due to reduction in flows of Creek 661 and due to pumping of water from Tatelkuz Lake. This effect was assessed as “not significant (moderate)” because the magnitude of the effect is low and pumping of Tatelkuz Lake water will stop at closure.	Yes
Mine site	C, O, D/C, P	Change in fish habitat quality and availability in Creek 661	Flow will be reduced due to diversion of headwaters into the mine site. Changes will be low in magnitude for Creek 661 and its tributary Creek 505659. This effect was assessed as “not significant (moderate)” because of its low magnitude.	Yes
Mine site	C, O, D/C, P	Change in fish habitat quality and availability in Creek 705	Flow will increase due to diversion of Lake 01682LNRS into Lake 01538UEUT. This effect was assessed as “not significant (moderate)” because of the low magnitude of the effect on the Creek 705 mainstem.	Yes
Mine site	C, O, D/C, P	Mercury mobilization in Lake 01682LNRS	Mercury concentrations in plants and animals of Lake 01682LNRS and Lake 01538UEUT may increase as a result of mobilization of mercury from flooded soils in the enlarged of Lake 01682LNRS. This effect was assessed as “not significant (minor)” because mercury concentrations will not reach concentrations that would affect the health of plants or animals, nor will humans be affected because access to Lake 01682LNRS and Lake 01538UEUT will be restricted during mine life. Eventually, mercury concentrations will fall to baseline levels in the post-closure phase approximately 30-40 years after lake enlargement.	Yes
Mine site	O, D/C, P	Changes in water temperature in Davidson Creek	During flow augmentation, water temperature in Davidson Creek is predicted to increase in the winter and decrease in the summer because water will be pumped from below the epilimnion of Tatelkuz Lake. Upon post-closure, water temperatures are predicted to return to baseline in winter but remain elevated during the other three seasons. This effect was assessed as “not significant (minor)” because it is low in magnitude and local in extent and because the modified temperature regime is just as likely to produce positive effects on aquatic ecosystem as negative effects.	Yes

Project Component	Project Phase	Residual Effect	Rationale	Carried Forward in Cumulative Effects Assessment
FSS	O, D/C	Changes in WSE of Tatelkuz Lake	Changes in WSE caused by pumping water to the mine site will affect the 0 to 1 m depth stratum of the littoral zone. This effect was assessed as "not significant (negligible)" because the predicted change in habitat units (<3%) is within the range of natural variation and is so small that it is unlikely it can be measured. The effect is temporary and reversible once pumping stops and the end of the closure phase.	No

Note: C = construction; O = operations; D/C = decommissioning and closure; P = post-closure.

5.3.9.5.2 Potential Cumulative Effects

This section determines the need for assessing cumulative effects; assesses potential cumulative effects; and, If applicable, assesses cumulative effects and evaluate these effects using the same criteria and steps as noted in **Section 5.3.9.5** above.

To be classified as potential cumulative effects, the residual effects classified as "not significant (minor)" and "not significant (moderate)" (**Table 5.3.9-74**) have to interact with other projects or activities in the CESA as a result of spatial or temporal overlap. **Table 4.3-11** shows the Summary Project Inclusion List developed for cumulative effects assessment. Of the 13 items on that list, ten have potential relevance to the fish habitat VC, as follows:

- Pacific Gas Looping Project;
- Mining – existing;
- Mining – exploration;
- Forestry – logging;
- Hunting, trapping and guide outfitting;
- Fishing and hunting lodges;
- Recreation;
- Agriculture;
- Transportation; and
- Crown land tenures.

Table 5.3.9-75 shows that there are no interactions between the five indicators of the fish habitat VC (surface water flow, surface water quality (including water temperature), sediment quality, ecological health, and riparian habitat) and the seven residual effects for the projects and activities listed above. **Section 5.3.8.5.2** describes in detail why there are no interactions for the fish VC. That analysis is identical for the fish habitat VC. Hence, cumulative effects assessment for fish habitat did not proceed further.

Table 5.3.9-75: *Project-Related Residual Effects on Fish Habitat VC – Rationale for Carrying Forward into Cumulative Effects Assessment*

Indicator	Project Phase	Potential Residual Effect	Pacific Gas Looping Project	Mining – existing	Mining – exploration	Forestry – logging	Hunting, Trapping and Guide Outfitting	Hunting and Fishing Lodges	Recreation	Agriculture	Transportation	Crown land tenures	Inclusion in CEA?
Surface water flow	C, O, D/C, P	Loss of fish habitat on mine site	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in lower Chedakuz Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 661	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 705	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Mercury mobilization in Lake 01682LNRS	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
Surface water quality	C, O, D/C, P	Loss of fish habitat on mine site	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in lower Chedakuz Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 661	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 705	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Mercury mobilization in Lake 01682LNRS	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
Sediment quality	C, O, D/C, P	Loss of fish habitat on mine site	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in lower Chedakuz Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 661	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No

Indicator	Project Phase	Potential Residual Effect	Pacific Gas Looping Project	Mining – existing	Mining – exploration	Forestry – logging	Hunting, Trapping and Guide Outfitting	Hunting and Fishing Lodges	Recreation	Agriculture	Transportation	Crown land tenures	Inclusion in CEA?
		Change in flows in Creek 705	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Mercury mobilization in Lake 01682LNRS	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
Ecological health	C, O, D/C, P	Loss of fish habitat on mine site	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in lower Chedakuz Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 661	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 705	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Mercury mobilization in Lake 01682LNRS	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
Riparian habitat	C, O, D/C, P	Loss of fish habitat on mine site	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in lower Chedakuz Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 661	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in flows in Creek 705	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Mercury mobilization in Lake 01682LNRS	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No
		Change in water temperature in Davidson Creek	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	No

Note: C = construction, O = operation, D/C = decommissioning/closure, P = post-closure, and NI = no interaction.

5.3.9.6 Limitations

This section presents assumptions and limitations relative to the assessment of Project effects and the assessment of cumulative effects. Limitations to the assessments described in this section are primarily technical in origin. **Section 5.3.8.1.3.4** describes in detail the technical limitations – they will not be repeated here. Technical limitations specific to the fish habitat VC are the assumptions required for the models used to predict fish habitat quantity and quality, and stream flows and temperatures.

5.3.9.7 Conclusion

This section provides a conclusion regarding the significance of residual effects and cumulative effects if applicable. Potential effects of Project activities on fish habitat within the LSA were assessed after the application of mitigation measures. Eight residual effects were identified that could not be completely mitigated:

- Loss of fish habitat on the mine site due to construction of Project facilities. This was assessed as not significant (minor) for rainbow trout (there are no kokanee on the mine site) because these losses of fish habitat will be offset with habitat restoration, enhancement, and creation, as described in the FMOP (**Appendix 5.1.2.6C**);
- Changes in stream flows and fish habitat in Davidson Creek as a result of capture of flows in the upper watershed in the TSF. This was assessed as not significant (moderate) for all phases of the Project because the mitigated flow regime provided via the FSS will maintain at least 90% of baseline fish habitat;
- Changes in stream flows and fish habitat in Creek 661 as a result of capture of headwaters in the upper watershed on the mine site. This was assessed as not significant (moderate) for all phases of the Project because the changed flows will maintain at least 90% of baseline fish habitat;
- Changes in stream flows and fish habitat in lower Chedakuz Creek as a result of construction of Project facilities. This was assessed as not significant (moderate) for all phases of the Project because the changed flows will maintain at least 90% of baseline fish habitat;
- Changes in stream flows and fish habitat in Creek 705 as a result of diversion of Lake 01682LNRS into Lake 01538UEUT. This was assessed as not significant (moderate) for all phases of the Project because the changed flows will maintain at least 90% of baseline fish habitat;
- Mobilization of mercury in Lake 01682LNRS due to flooding of the lake perimeter. This was assessed as not significant (minor) because it is low in magnitude, local in extent, medium-term in duration, and reversible;
- Changes in water temperature in Davidson Creek as a result of flow augmentation of Davidson Creek by water pumped from depths between 8 m and 12 m in Tatelkuz Lake.

This was assessed as not significant (minor) because it is low in magnitude and local in extent, even though it is chronic in duration and irreversible; and

- Reduction in littoral fish habitat of Tatelkuz Lake due to water pumped to the mine site. This was assessed as not significant (negligible) for both rainbow trout and kokanee because the effect is of negligible magnitude, local, reversible, but continuous during the pumping period.

The residual effects assessed as “not significant (minor)” and “not significant (moderate)” were compared to activities expected to occur in the aquatics RSA in the future. No spatial or temporal overlaps were found, hence cumulative effects assessment stopped at that point.

5.3.9.8 Follow-Up Monitoring

Scientific uncertainty associated with these assessments of Project effects on the fish habitat VC will be addressed through the Aquatic Effects Monitoring Program (AEMP), which is described in detail in **Sections 13.3.2 to 13.3.6** of the Application. The purpose of the AEMP is to test predictions of the EA regarding potential Project effects on water flows, water quality, sediment quality, fish and fish habitat during operations, closure and early post-closure phases. The AEMP will integrate all monitoring of aquatic resources into a single program, thereby providing a single instrument for regulatory review of aquatic effects. The AEMP is a preliminary version that will be developed into final versions by New Gold in consultation with regulatory agencies and taking into account public and Aboriginal concerns.

Section 13.3.2 through **Section 13.3.6** describe preliminary AEMP components for surface water flow, surface water quality, sediment quality, groundwater flow, and groundwater quality. **Section 13.3.3** includes discussion of regulatory triggers for further study or adaptive management and mitigative action for exceedances in water quality guidelines. Any exceedance of parameters not periodically exceeded in the baseline data will be investigated and mitigative action taken if appropriate; for instance, a spike in TSS may cause exceedances due solely to that cause which may be easily correctable. Increasing trends that suggest guidelines or objectives are being approached on a sustained basis will be a trigger for investigation of cause and management changes to address.

As much as possible, sampling sites, sampling methodology, sampling frequency and sample sizes will follow those used for baseline studies so that the monitoring data and baseline data can be compared directly.

Monitoring of flows will be required during all phases of mine life to validate habitat model predictions and to assess whether adverse effects may occur at post-closure. Before potential effects occur at post-closure, 35 years of physical and biological monitoring data will be available to determine if a biological effect is expected, and to determine any required action. As with the fish components of the AEMP, the fish habitat components will also follow sampling sites, sampling methodology, sampling frequency and sample sizes used for baseline studies so that the monitoring data and baseline data can be compared directly. Fish habitat components of the AEMP (**Section 13.3.9.2**) may include the following:

- Stream flows and water temperatures in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured continuously at the same locations as in 2011, 2012 and 2013. Temperature data loggers will be attached to all hydrology stations;
- Stream habitat quality (e.g., water depth and velocity, substrate composition, stream bank erosion, etc.) at sites in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured once per year in the low-flow period of mid-summer;
- Stream periphyton and benthic macroinvertebrate (BMI) sampling at sites in Davidson Creek, Creek 661, lower Chedakuz Creek, and Creek 705, measured once per year in mid- August – the time of maximum density, biomass and taxonomic diversity;
- Vertical profiles of temperature, conductivity and dissolved oxygen measured from Tatelkuz Lake, Lake 01682LNRS, and Lake 01538UEUT on a quarterly basis (as part of current water quality sampling protocol);
- Water surface elevation of Tatelkuz Lake measured using continuously logging instruments;
- Littoral zone fish habitat quantity and quality in Tatelkuz Lake, measured at transects around the lake once per year in the low-flow period mid-summer. This survey may be conducted for an initial period of 3 years. Thereafter, frequency may be relaxed to every second year or fifth year or stopped; and
- Lake phytoplankton, zooplankton and BMI sampling in Tatelkuz Lake, Lake 01682LNRS, and Lake 01538UEUT, once per year in mid-August – the time of maximum density, biomass and taxonomic diversity.