6. AQUATIC ECOLOGY

6.1 Introduction and Terms of Reference

Benga Mining Limited (Benga) conducted a fisheries and aquatic baseline assessment program (hereafter referred to as the aquatic ecology assessment) for the Grassy Mountain Coal Project (the Project) between 2014 and 2016. The following section provides an overview summary of the aquatic ecology assessment approach, objectives, methodologies, and findings from work conducted for the Project.

The Aquatic Ecology Effects Assessment is captured, in detail, within the updated Consultant Report #6 (CR#6). The scope, format and contents of the updated CR #6 are guided by:

- the Terms of Reference for the Environmental Impact Assessment Report prepared by the Alberta Energy Regulator (AER, Section 4.5); and
- the *Guidelines for the Preparation of an Environmental Impact Statement* prepared by the Canadian Environmental Assessment Agency (CEAA, Sections 6.1.5 and 6.3.1).

Section 4.5 of Terms of Reference from AER:

Section in Final Terms of Reference for Project (AER 2015)	
4.5	**Aquatic Ecology**
4.5.1	**Baseline Information**
[A]	Describe and map the fish, fish habitat and aquatic resources (e.g., aquatic and benthic invertebrates) of the lakes, rivers, ephemeral water bodies and other waters. Describe the species composition, distribution, relative abundance, movements and general life history parameters of fish resources. Also identify any species that are: a) Listed as "at Risk, May be at Risk and Sensitive" in the *General Status of Alberta Wild Species* (Alberta Environment and Sustainable Resource Development); b) Listed in Schedule 1 of the federal *Species at Risk Act*; c) Listed as "at risk" by COSEWIC; and d) Traditionally used species.
[B]	Describe and map existing critical or sensitive areas such as spawning, rearing, and over-wintering habitats, seasonal habitat use including migration and spawning routes.
[C]	Describe the current and potential use of the fish resources by Aboriginal, sport or commercial fisheries.

Section in Final Terms of Reference for Project (AER 2015)
[D] Describe and quantify the current extent of aquatic habitat fragmentation. **4.5.2 Impact Assessment** [A] Describe the potential impacts to fish and fish habitat, such as stream alterations and changes to substrate conditions on water quality or quantity, while considering: a) Fish tainting, survival of eggs and fry, chronic or acute health effects, and increased stress on fish populations from release of contaminants, sedimentation, flow alterations, and temperature and habitat changes; b) Potential impacts on riparian areas that could affect biological resources and productivity; c) The potential for increased fishing pressures in the region that could arise from the increased workforce and improved access resulting from the Project. Identify the implications on the fish resource and describe any potential mitigation strategies to minimize these impacts, including any plans to restrict employee and visitor access; d) Changes to benthic invertebrate communities that may affect food quality and availability for fish; and e) The potential for increased fragmentation of aquatic habitat. [B] Identify the key aquatic indicators that the proponent used to assess project impacts. Discuss the rationale for their selection. [C] Discuss the design, construction, and operational factors to be incorporated into the project to minimize impacts on fish and fish habitat and protect aquatic resources. Describe how any water intakes have been designed to avoid entrapment and entrainment of fish and provide information on the species of fish considered. [D] Identify plans proposed to offset any loss in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat. [E] Discuss the significance of any impacts on water quality and implications to aquatic resources (e.g., biota, biodiversity, and habitat) and related implications for First Nations' traditional and current use of these resources. [F] Describe the effects of any surface water withdrawals considered, including cumulative effects on fish and fish habitat.

Terms of Reference from CEAA Guidelines

Section in Final CEAA Terms of Reference for Project (CEAA 2015)
Project Setting and Baseline Conditions
6.1.5 Fish and Fish Habitat

Section in Final CEAA Terms of Reference for Project (CEAA 2015)
For potential affected surface waters:
a characterisation of fish populations on the basis of species and life stage, including information on the surveys carried out and the source of data available (e.g., location of sampling stations, catch methods, date of catches, species, catch-per-unit effort);
a description of primary and secondary productivity in affected water bodies, including a survey of benthic invertebrate communities with characterisation of seasonal variability;
a list of any fish or invertebrate species at risk that are known to be present;
a description of the habitat by homogeneous section, including the length of the section, width of the channel from the high water mark (bankful width), water depths, type of substrate (sediments), temperature, aquatic and riparian vegetation, and photos;
a description of natural obstacles (e.g., falls, beaver dams) or existing structures (e.g., water crossings) that hinder the free passage of fish; maps, at a suitable scale, indicating the surface area of potential or confirmed fish habitat for spawning, rearing, nursery, feeding, overwintering, migration routes, etc. where appropriate, this information should be linked to water depths (bathymetry) to identify the extent of a water body's littoral zone; and
the description and location of suitable habitats for fish species at risk that appear on federal and provincial lists and that are found or are likely to be found in the study area and in particular the westslope cutthroat trout in Gold Creek and Blairmore Creek drainages.
Predicted Effects on Valued Components
Based on the predicted changes to the environment identified in section 6.2, the proponent is to assess the environmental effects of the Project on the followings VCs:
6.3.1 Fish and Fish Habitat
the identification of any potential serious harm to fish, including the calculations of any potential habitat loss (temporary or permanent) in terms of surface areas (e.g., spawning grounds, fry-rearing areas, feeding), and in relation to watershed availability and significance. The assessment will include a consideration of:
the geomorphological changes and their effects on hydrodynamic conditions and fish habitats (e.g., modification of substrates, dynamic imbalance, silting of spawning beds);
the modifications of hydrological and hydrometric conditions on fish habitat and on the fish species' life cycle activities (e.g., reproduction, fry-rearing, movements);
potential impacts on riparian areas that could affect aquatic biological resources and productivity taking into account any anticipated modifications to fish habitat;
any potential imbalances in the food web in relation to baseline;
effects on primary and secondary productivity of water bodies, including a discussion of sensitive species in benthic invertebrate communities and how mine-related effects may affect fish food

Section in Final CEAA Terms of Reference for Project (CEAA 2015)
sources;
the effects of changes to the aquatic environment on fish and their habitat, including;
the anticipated changes in the composition and characteristics of the populations of various fish species, including forage fish;
any modifications in migration or local movements (upstream and downstream migration, and lateral movements) following the construction and operation of works;
any reduction in fish populations as a result of potential overfishing due to increased access to the project area; and
any modifications and use of habitats by federally or provincially listed fish species (i.e. westslope cutthroat trout) including anticipated changes in water quantity and influence on the ability of fish to access spawning, nursery, rearing, food supply and migration habitat.
a discussion of how project construction timing correlates to key fisheries windows for fish species, and any potential impacts resulting from overlapping periods;
a discussion of how vibration caused by blasting may affect fish behaviour, such as spawning or migrations;
changes in concentrations of contaminants of concern in the aquatic ecosystem1;
changes to fish health resulting from increased contaminants of concern; and
a description, or conceptual model as appropriate, of how changes in water quantity in watercourses will influence the ability of fish to access spawning, nursery, rearing, food supply and migration habitat

6.1.1 Valued Component Selection & Assessment Areas

Valued components (VCs) represent components of the natural and human environments that are considered by the proponent, public, Aboriginal groups, scientists and other technical specialists, and government agencies involved the assessment process to have scientific, ecological, economic, social, cultural, archeological, historical, or other importance. Identification of VCs for an EIA help to concentrate the assessment on the issues that matter most, resulting in a comprehensive yet efficient, accessible, and focused assessment.

Candidate valued components are potential VCs that are evaluated, in part, using baseline data, to determine whether they should be carried forward as VCs for the Project's EIA. If multiple candidate

VCs are similarly affected by the Project and addressing both would result in redundancy, only one is carried forward to the EIA to avoid redundancy in the analysis.

A preliminary list of candidate aquatic ecology VCs was identified for the Project in consultation with regulators, fisheries professionals experienced with Gold Creek and Blairmore Creek watersheds, interested public and Aboriginal groups feedback. The baseline information presented in this report considers fisheries and aquatic resources broadly; however, it focuses primarily on one particular VC: westslope cutthroat trout (WSCT). A summary of candidate VCs is provided in Table 3.1 of CR #6.

WSCT are the primary aquatic ecology VC because of their provincial and federal status, their presence, distribution, and abundance in the local study area (LSA) and because they are the only native fish species within the LSA to be potentially affected through potential direct habitat loss and/or alteration (*i.e.*, changes in stream flow). An independent Aquatic/Fish Health VC was considered given the potential water quality-related effects throughout the life of the mine and included other fish species (non-native brook trout [*Salvelinus fontinalis*; BKTR] and rainbow trout [*Oncorhynchus mykiss*; RNTR]) and lower trophic organisms. Given the conservation sensitivities surrounding WSCT, non-native BKTR and RNTR were used as a surrogate to evaluate potential water quality-related effects to the health of WSCT in the LSA. "WSCT Health" was, thus, included in the WSCT VC and is discussed in this assessment but is predominantly addressed through the Surface Water Quality Assessment Report (CR #5).

The WSCT is the only native fish species documented in historical reports and supported by Project baseline surveys within both Blairmore and Gold Creek watersheds. Based on genetics and range distribution, distinct populations of WSCT are identified in Alberta and British Columbia (BC). This assessment involves the Alberta population of WSCT exclusively.

6.1.1.1 Westslope Cutthroat Trout: Alberta Population

The following sub-section is a general summary of Westslope Cutthroat Trout life-history in Alberta. For further details and reference to where the information was compiled, please see CR #6, Section 3.1.

Historically, WSCT inhabited most streams in southwestern Alberta from the alpine to the prairies. Currently genetically pure cutthroat trout occupy only a small fraction of the original WSCT distribution and occur as relatively small, disconnected populations. There are four general categories of human activities that have led to the decline in numbers of WSCT in western Canada over the past 125 years:

- introduction of non-native salmonids resulting in competition, replacement and hybridization. Hybridization is considered the greatest current threat to native WSCT populations;
- over-exploitation, beginning with the arrival of the Canadian Pacific Railroad (CPR) at the turn of the century;
- habitat damage and loss; and
- climate change could represent a significant challenge in the future for this cold-water dependent species.

In Alberta, WSCT spawning typically takes place between May and July depending on location, and usually occurs when water temperatures reach 10°C even as low as 6°C in high elevation populations. Incubation is also temperature dependent and its duration generally persists for six to seven weeks. Once the eggs hatch, alevins typically remain in the redd for an additional one to two weeks. Following emergence, fry migrate to low energy lateral habitats, which are areas with low water velocity and appropriate cover. In 2016, the onset of spawning commenced in early May and was concluded by early June, which is considered early given the atypical freshet flows (mid-April) experienced compared to average freshet timing and flows (June).

Larger juveniles move into pools where they establish social dominance based on size. Juveniles require large territories and the availability of suitable pool habitat is often a limiting factor in the species productivity even in dynamic streams. Juveniles preferred window of rearing stream temperature is between 4°C and 15°C.

Adult habitat for WSCT can be varied depending on the particular life history type. The resident life history type typically remains in their natal stream for their entire life. For fluvial (riverine) forms, slow pools formed by boulders or large woody debris (LWD) with fast adjacent water and plenty of cover (*e.g.*, undercut banks, instream structures) are needed. Given the obstructions limiting migration and potential niche shifts in Gold and Blairmore creeks, the fluvial and resident form are most likely present. As with juveniles, adult WSCT prefer rearing water temperatures between 4°C and 15°C.

Suitable overwintering habitat appears to be largely determined by local groundwater influx and absence of anchor ice. During winter months, fluvial adults will congregate in slow deep pools sheltered from high flows while juveniles often overwinter in cover provided by boulders and other large instream structures.

Westslope Cutthroat Trout are sensitive to changes in water temperature and are not typically found in waters where maximum stream temperature repeatedly exceeds 22°C. Their preferred temperature range is 9 to 12°C. More recent research has found that the upper incipient lethal temperature of

WSCT is 19.6°C, and a maximum daily temperature between 13°C and 15°C ensures suitable thermal temperature for WSCT, with optimum growth occurring at 13.6°C. Further research has found that 15°C is the upper range at which optimum growth for WSCT occurs.

Riparian vegetation is considered an essential element of WSCT habitat. Not only does it serve to stabilize stream banks, reduce predation and aid in maintaining low stream temperatures through reduced insolation, but the riparian input of terrestrial insects (macroinvertebrates) is often an important food source during the summer months.

Critical Habitat Designation

The Alberta Minister of Sustainable Resource Development supported the listing of WSCT as Threatened under Alberta's Wildlife Act in 2009. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of WSCT in Alberta and designated the Alberta population as Threatened. In 2013, the Alberta unit was listed as Threatened under Part 3 of Schedule 1 of SARA. This statute prohibits activities that harm aquatic species listed under the Act as threatened, endangered, or extirpated. SARA also prohibits activities that destroy any listed species' "critical habitat," as identified in federally adopted "Recovery Strategies" for listed threatened or endangered species.

In 2009, a joint federal/provincial recovery team was established for the WSCT to produce a recovery Strategy that would meet the needs of both Canada and Alberta. In 2014, the federal Recovery Strategy for WSCT (Alberta Population) was finalized (DFO 2014); this strategy forms the basis of action plans that will provide information on recovery measures to be taken by DFO and the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species.

"Critical habitat" for Alberta populations of WSCT is identified as all areas of bankfull waterbodies currently occupied by naturally occurring, pure-strain populations within the original WSCT distribution (as defined in Section 2.0 of the Alberta Recovery Plan). The bankfull level is the usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams) this refers to the "active channel bank-full level" which is often the 1:2 year flood flow return level.

The Recovery Plan identifies parts of four watercourses in the LSA, totaling approximately 16.5 km of watercourse, as critical habitat, each containing a population that has no evidence of recent or contemporary introgression as determined by genetic testing (*i.e.*, >0.99 pure on average). Three of these are in the Gold Creek watershed, including almost 14 km of the Gold Creek mainstem, while one is located on a tributary to Blairmore Creek (CR#6; Figure 3.1 and Table 3.3). Fish recovered in these designated critical habitats were determined to be 99% genetically-pure. Areas identified as critical habitat in these two watersheds are upstream of barriers that prevent immigration of other fish species and populations. In addition, the Recovery Plan identifies parts of two watercourses, totaling approximately 10 km in length, in the Blairmore Creek watershed as containing near-pure WSCT (CR #6; Figure 3.2 and Table 3.3). The majority of Blairmore Creek mainstem has been categorized as a "Conservation Population", which is a naturally self-sustaining population of native WSCT that is managed to preserve the unique ecological and behavioral traits of the sub-species and has the potential for recovery.

6.1.1.2 Assessment Areas

6.1.1.2.1 Spatial Boundaries

Local Study Area

The Local Study Area (LSA) for aquatic ecology, water quality, and hydrology encompasses areas where Project activities have the potential to effect fish or fish habitat. The LSA is comprised of Blairmore and Gold creek watersheds, given the Project footprint is located entirely within these two watersheds (CR #6; Figure 3.1).

Both Blairmore and Gold creek watersheds are located in the eastern slopes of the southern Canadian Rockies. With an area of 50 km^2 and 63 km^2, respectively, Blairmore and Gold creek watersheds contain watercourses and parts of watercourses identified as critical habitat for WSCT. Provincial and Federal governments have developed a recovery plan and strategy for WSCT. The Recovery Plan identifies parts of four watercourses in the LSA, totaling approximately 16.5 km of watercourse, as critical habitat. Three of these are in the Gold Creek watershed, including almost 14 km of the Gold Creek mainstem, while one is located on a tributary to Blairmore Creek (CR #6; Figure 3.1, Table 3.4). Fish recovered in these designated critical habitats were determined to be 99% genetically-pure. Areas identified as critical habitat in these two watersheds are upstream of barriers that prevent immigration of other non-native fish species. In addition, the Recovery Plan identifies parts of two watercourses containing near-pure WSCT, totaling approximately 10 km in length, in the Blairmore Creek watershed (CR #6; Figure 3.1, Table 3.4).

Regional Study Area

The Regional Study Area (RSA) for aquatic ecology, water quality, and hydrology includes the entire Crowsnest River watershed, to evaluate potential cumulative effects at the regional level (CR #6; Figure 1.1), and considers that Project effects have the potential to interact with other projects within the Crowsnest River watershed. Taken together, Blairmore and Gold creeks represent approximately 11% of the watershed area of the Crowsnest River.

The Recovery Plan identifies four parts of other watercourses in the RSA besides Gold Creek and Blairmore Creek, totaling approximately 7.2 km of watercourse, as critical habitat for WSCT and one watercourse in the RSA, approximately 1 km in length, as containing near-pure WSCT (CR #6; Figure 1.1, Table 3.5).

6.1.1.2.2 Temporal Boundaries

The temporal considerations for the aquatic ecology effects assessment are based on the Project description and schedule (Section C.1.3) and include unique conditions that may affect fish and aquatic resources. The Project mine life is approximately 24 years (2019 to 2043) excluding pre-mining (2017 to 2019) and closure (2034 to 2050).

6.2 Baseline Conditions

This section presents a summary of the setting and characterization of existing baseline conditions for fisheries and aquatics resources, fluvial geomorphology and hydrology that is relevant for the assessment of potential aquatic effects from the Project. For detailed methodology and results, please refer to CR#6; Section 4.1.1, Appendix A1: Section 3.0, Appendix A2: Section 2.0, Appendix A3: Section 3.0).

6.2.1 Fisheries and Aquatics Baseline

Historical Information

Pertinent historical information was collected from the following publicly available resources:

- the FWMIS, accessed through an information request to Alberta Environment and Sustainable Resource Development (AESRD) and provided by AESRD (now referred to as AEP) in the form of a data report (AESRD 2013c) that included information on barriers to fish passage;
- information contained in the Recovery Plan prepared for the WSCT (Alberta Westslope Cutthroat Trout Recovery Team 2013, DFO 2014); and
- published reports from the ACA and available scientific literature.

Publicly available fisheries inventory and/or habitat assessment information for Gold Creek and Blairmore Creek watersheds is relatively limited. Sparse information was available through the FWMIS (*i.e.*, fish presence/absence, species distribution) and peer-reviewed publications or technical reports (*i.e.*, interspecific hybridization, Yau and Taylor 2014; population estimates, Blackburn 2011). WSCT, RNTR, WSCT x RNTR hybrids, and BKTR have been reported in Gold and Blairmore creeks.

The majority of fish captured upstream of the most southern barrier (*i.e.*, old water supply dam) on Gold Creek were BKTR (AESRD 2013c). The source of these non-native fish has been traced to deliberate stocking and is not a result of the barrier on Gold Creek being passable to fish.

Traditional Knowledge

Information was gathered during traditional knowledge and traditional land use surveys with members of interested Aboriginal groups conducted as part of Project preparation (Kanai Nation 2015, Piikanii Nation 2015, Siksika Nation 2015, Stoney Nakoda Nation 2015, Tsuut'ina Nation 2015, Métis Nation of Alberta and Pincher Creek Local 2016, and Métis Nation of British Columbia 2016, in Appendix 7c). There is an abundance of wildlife and plants in the traditional lands and waters that are valued by these groups. Overall most of the Aboriginal groups identified fish health as an important concern. Identifying potential impacts from the Project and applying appropriate mitigation, protection, restoration, and communicating about any spills are important. The Aboriginal groups will be involved in the on-going consultation throughout the Environmental Assessment.

Project-Specific Field Surveys (2014 to 2016)

The baseline conditions of the fish and fish habitat in Gold Creek and Blairmore Creek watersheds were characterized in the *Fisheries and Aquatics Technical Baseline Report* through multiple field-based sampling programs executed from 2014 to 2016 (CR#6, Appendix A1: Section 4.0). Sampling was completed in the LSA to describe habitat quantity, quality and use in potentially affected areas, potential fish distribution both spatially and temporally, and lower trophic dynamics. The level of detail for habitat assessment ranged from biophysical habitat surveys to detailed macrohabitat and mesohabitat characterization. Fish sampling was guided by standard protocol and designed to meet requirements of the Fisheries Research Licences (FRL 16-2611, 14-2724) and *Species at Risk Act* (SARA) Permit (16-PCAA-00026). Less invasive methods, such as snorkeling, were given preference over methods that have a higher potential to cause harm to fish, such as electrofishing, angling, and/or minnow trapping. Field-based surveys were driven primarily by seasonality and life history characteristics (*i.e.*, spawning, overwintering, and rearing).

Results illustrate that fish habitat in Gold and Blairmore creeks is fairly similar. Both watercourses are dominated by coarse substrate with fast-flowing pool-riffle, riffle and riffle-run-pool habitat units (>80% by area). Stream temperatures in Gold Creek tended to be cooler (5.4ºC) than Blairmore Creek (8.0 ºC), on average. The coldest average stream temperatures were observed at Caudron Creek (4.3ºC), a tributary to Gold Creek. WSCT is the only native species that has been detected within the LSA. Non-native rainbow trout (*Oncorhynchus mykiss*), rainbow trout x WSCT, and brook trout (*Salvelinus fontinalis*) are present in Gold Creek and Blairmore Creek, with the presence of barriers largely determining their distribution. Estimated fish density varies, with upper reaches of both Gold and Blairmore creeks containing a high density of smaller-sized fish and lower reaches containing lower densities, mostly of larger fish. Results from a mark-recapture survey estimated total sub-adult/adult fish populations in Gold and Blairmore creeks at 1,625 and 3,210, respectively. Levels of the 34 metals tested in collected fish tissues were all low, and mercury levels were below federal consumption guidelines. Density of macroinvertebrates ranged from 3,892 individuals/m^2 in the LSA to 14,302 individuals/m^2 in the RSA. Diversity and evenness were fairly high across all sites and community composition at all sites representing good water quality.

6.2.2 Fluvial Geomorphology

The methodology used to characterize the fluvial geomorphology in the LSA followed two main approaches: 1) Desktop analysis of land use changes, and 2) Field surveys of existing geomorphology on Gold and Blairmore creeks.

Recent land use within the LSA was characterized through a time series analysis of three years of aerial photographs. The objective of this exercise was to characterize both the recent (1982 and 1996) and current (2015) condition of the watershed. Both recent and current land use were characterized within the LSA using a modification of standard land use classification methods provided by BC Ministry of Environment (BC MOE 1986). Land use was classified for each year at a 1:20,000 scale. Classifications for all years were combined into two classes, perceived activity and no perceived activity. Using the combined classes, both area of change in land use and total area of land use over the period of analysis were calculated. The total area within the LSA classified to have perceived activity in any of the three years analyzed was 22.0 km^2, representing 19.3% of the total area of the LSA (113.8 km^2). Within the LSA, this activity is concentrated in valleys and on Grassy Mountain Ridge, an area of historical mining operations.

The assessment of the baseline geomorphology of Blairmore and Gold creeks was informed by field data collected within both watersheds on two separate site visits: May 14 – 18, 2016, and July 25 - 27, 2016. Both watercourses were assessed by walking continuous lengths of the channels. The field assessment methodology was designed to conform to guidelines for collection and analysis of fish habitat data for the purpose of assessing impacts associated with alteration of flow regimes and described in detail in Lewis *et al.* (2004) and Hatfield *et al.* (2007).

The majority of sediment in Gold Creek is organized in riffle-pool sequences. Cascade-pool, step-pool, and cascade-riffle-pool morphologies are also common reach types in Gold Creek, where cascade and cascade-riffle structures are more prevalent in upper reaches of the mainstem, giving way to plane bed morphologies as the sub-dominant reach type. Riffle-pool morphologies are generally less stable than step or cascade-pool reach types because of the higher percentage of finer material that can be more easily mobilized. Evidence of instability was observed in the form of two "blowout" zones where large volumes of fluvial material and LWD were deposited recently, causing channel bifurcations, avulsions, and are suspected to be responsible for disappearance of flow below the bed materials. Floodplain material cover is thin, and bank slopes are composed of bedrock or bedrock covered by thin alluvium.

The majority of sediment in Blairmore Creek is organized in cascade-riffle pool and bedrock-step pool morphologies. The upper three sections are predominantly cascade-riffle pool, with the channel flowing through floodplain deposits typically 1 to 2 m thick, through relatively confined steep-sloped narrow valleys. The section is heavily influenced by LWD and large boulders that have become positioned within the channel and are controlling flow and sediment transport, by slowing velocities and allowing deposition, particularly in bars, and upstream of LWD. These boulders and LWD structures contribute to the overall stability of the system. Lower Blairmore Creek is predominantly bedrock controlled, and as such, is generally considered to be highly stable, with the exception that slope failures may cause instability by introducing sediment and LWD. Large boulders were common in the channel. No avulsions were observed on Blairmore Creek along the length of assessed channel.

6.2.3 Hydrology

To characterize the hydrology in the LSA, three hydrometric gauges were installed along Gold Creek in support of the IFA for the Project (CR #6, Appendix A3) and the hydrology baseline study (CR #4). A mid-watershed gauge at GC-7/H01 operated from September 2013 to August 2014 and again from March to October 2016. Gauges further upstream at GC-11/H02 and GC-27/H03 both operated from May to October 2016. WSC have gauged flows at Gold Creek near Frank (GC-HWSC) since 1975, typically from April to November (8 months) each year.

Long-term synthetic daily flow data series extending from November 1975 to October 2016 (41-year period) were then developed for the three local gauges, based on the regression analysis between daily flows gauged concurrently between each local gauge and the WSC gauge. For characterizing hydrological conditions across each reach, required for the IFA analyses, the synthetic time series most appropriate to each reach was selected then adjusted empirically using the ratio of measured flows between gauge locations and appropriate reach-specific locations. The alternative approach of pro-rating the synthetic data based on reach drainage area characteristics was not used given the weak association between flows and drainage area outlined below (particularly around the Caudron Creek and Lille areas).

Three LSA hydrometric gauges were installed along Blairmore Creek. A lower-watershed gauge at BC-0/H01 and upper-watershed gauge at BC-15/H01 operated from September 2013 to August 2014 and again from March to October 2016. A mid-watershed gauge at BC-H02 operated from October 2013-August 2014 but was not re-commissioned in 2016. Similar to the process for Gold Creek, long-term synthetic daily flow data series extending from November 1975 to October 2016 (41-year period) were developed for these local gauges, based on the regression analysis between daily flows gauged concurrently between each local gauge and the WSC gauge on Crowsnest River at Frank. Correlations were slightly higher with this gauge than using the WSC gauge on Gold Creek near Frank. The synthetic time-series most appropriate to each reach was selected then adjusted empirically using the ratio of measured flows between gauge locations and appropriate reach-specific locations.

The hydrometric data indicate significant flow variability along the length of Gold Creek. Under normal baseline conditions, mean annual discharge (MAD) in the upper catchment increases from 0.047 m^3/s in Reach 9 near the headwaters to 0.068 m^3/s in Reach 8 above the confluence with Caudron Creek. In Reach 7 downstream of the Caudron Creek confluence, MAD increases approximately five-fold to 0.342 m^3/s, due to significant inflows from the Caudron Creek watershed, which is higher and wetter than Gold Creek. Streamflow data indicate that Reach 7 is a flow-losing reach, in which a small proportion (typically ~10%) of stream water is increasingly lost subsurface to the channel bed and bank sediments, which comprise the hyporheic zone. These losses become more considerable along Reach 6 (MAD 0.105 m^3/s), located close to a legacy mined area including the historic townsite of Lille. Downstream of Lille, Gold Creek begins to regain stream water from the hyporheic zone, then increases considerably at the confluence with Morin Creek watershed, with many physical similarities to those of Caudron Creek watershed. The estimated MAD in Reach 5 (downstream of Morin Creek) is 0.392 m^3/s. Flows then continue to accumulate during the remaining 6.5 km distance down to the confluence with the Crowsnest River in Frank. The MAD of Gold Creek near Frank estimated at the WSC gauge is 0.669 m^3/s.

Flows along the length of Blairmore Creek are spatially less complex than along Gold Creek. Under normal baseline conditions, MAD in the upper catchment increases from 0.110 m^3/s in Reach 5, to 0.175 m^3/s in Reach 4, to 0.208 m^3/s in Reach 3. The long-term MAD estimated at a local gauging station 2 km from the mouth (BC-0/H01) is 0.235 m^3/s.

6.3 Potential Impacts

6.3.1 Pathways of Effects Analysis

Interactions between the Project and fish and aquatic resources (*e.g.*, interactions between the Project components or activities and the measurement indicators) are identified through a pathways analysis that was exploited to focus the residual effects assessment. Potential pathways through which the Project could affect fish and aquatic resources were identified from several sources, including:

- a review of the Project description and collaborative scoping exercise of potential effects for the Project between expert fisheries/aquatic biologists and the engineering team;
- scientific knowledge and expertise with other coal mines; and
- engagement with Aboriginal groups, government, and the public.

The pathways analysis approach adopted herein is similar to that used by DFO, which applies Pathways of Effects (PoE) diagrams. This method has also been used on other aquatic environmental assessments specific to proposed coal mines and the DFO PoE diagrams are used to describe development proposals in terms of the activities that are involved, the type of cause-effect relationships that are likely to exist, and the mechanisms by which stressors ultimately lead to the effects on the aquatic environment. Each cause-and-effect relationship displayed in DFO PoE diagrams is represented as a line (or pathway), connecting the activity to a potential stressor, and the stressor to some effect on a fish or aquatic resource. Each pathway represents a conceivable opportunity where mitigation can be applied to reduce or eliminate the potential effect. When mitigation cannot be applied, or is unable to eliminate a potential effect, the remaining outcome (*i.e.*, effect) is referred to as a residual effect.

6.3.1.1 Pathways with no Linkage

Changes to Surface Water, Sediment Quality from Release of Spills or Hazardous Substances

The release of spills from hazardous substances (*e.g.*, fuel and oil) during Project construction, operations, reclamation, and closure has the potential to change surface water and/or aquatic sediment quality. This, in turn, can directly and/or indirectly adversely affect WSCT and its habitat. Generally, spills are preventable and local in nature and would be promptly reported and responded to with appropriate spill-response actions outlined in the Project Environmental Management Plan (*e.g.*, Hazardous Material Spill Response Procedure). Implementation of environmental design features and mitigation actions are expected to reduce the likelihood and extent of a hazardous spill and leaks on-site and along transportation corridors, thus result in no detectable changes in surface water or sediment quality in local watercourses relative to baseline conditions. Thus, this pathway was determined to have no linkage to effects on WSCT.

Changes in Recreational Access to Fish Bearing Reaches of Gold and Blairmore Creeks

Improved access and increased workforce in the area as a result of the Project could increase fishing pressure and fish harvest in local fish-bearing watercourses. This could result in a decreased abundance of sportfish if fishing pressure and/or fish harvest were not appropriately managed. Benga will work closely with AEP (the government resource agency mandated to manage provincial fisheries resources) to ensure fisheries resources in the LSA do not become over-exploited as a result of increased sportfishing. Public access will not be permitted within the Project mining footprint which includes haul roads or other access routes. Implementation of the above-mentioned mitigation and management actions is expected to effectively manage and reduce the likelihood and extent of recreational access to Gold and Blairmore creeks thus result in no detectable changes in WSCT relative abundance due to increased angling pressure relative to baseline conditions. Thus, this pathway was determined to have no linkage to effects on WSCT.

Blasting Activities Potentially Causing Direct Mortality of Westslope Cutthroat Trout

The Project intends to use explosives in the process of mining and this has the potential for creating instantaneous pressure changes (*i.e.*, overpressure) greater than 100 kPa (14.5 psi) in the swim bladder of a fish Wright and Hopky (1998). In addition, vibrations from the detonation of explosives may cause damage to incubating eggs. As well, blasts generate both seismic and surface waves (Rayleigh waves). Benga is committed to developing and using a blasting regime that will meet the blasting guidelines contained in Wright and Hopky (1998). Implementation of mitigation actions is expected to effectively manage and reduce the likelihood and extent of direct mortality to WSCT that inhabit both Gold and Blairmore creek watersheds. Thus, no detectable changes in WSCT relative abundance due to blasting activities, proportional to baseline conditions, is expected. Thus, this pathway was determined to have no linkage to effects on WSCT.

6.3.1.2 Secondary Effect Pathways

Changes in Water Temperature

Stream temperatures could be modified by the loss of runoff (flow), redirection, storage, or pumping of mine-influenced (treated) or clean water; by all activities associated with site preparation, waste rock placement, the implementation of the site Water Management Plan (WMP), or potentially due to heating or cooling of mine-treated water through a water treatment plant (if deemed necessary). Changes to stream temperatures could affect the thermal regime within Gold or Blairmore creeks such that water temperatures could fall outside of the thresholds tolerated by WSCT, ultimately affecting habitat quantity and suitability. Project effects on creek water temperature were modelled using the System for Environmental Flow Assessment (SEFA) program (CR#6, Appendix A3). Based on the findings from the predictive water temperature modeling assessment the likelihood and extent of stream temperatures to be altered that will potentially affect key WSCT bioperiods is considered negligible. Therefore, no detectable residual effects on fish habitat due to modifications in stream temperature are predicted throughout mine life (construction, operations, reclamation, closure phases).

Changes in Westslope Cutthroat Trout Food Supply

The food supply for WSCT within the aquatic ecology LSA will be altered by the following:

- changes to aquatic and/or riparian habitat of Gold and Blairmore creeks due to Project footprint; and
- changes to hydrology causing alteration in aquatic habitat of Gold and Blairmore creeks associated with site water management activities within the LSA.

The loss of habitat to mainstem Gold and Blairmore creeks and associated affected tributaries subsequently has the potential to alter the distribution, biomass, movement, and downstream drift of aquatic (and terrestrial) invertebrates. Although the tributary habitat losses that will occur as a result of the Project will affect tributary macroinvertebrate communities and may alter the biomass of invertebrate drift in localized areas of both Gold and Blairmore creeks, the contribution of the affected areas relative to the total invertebrate biomass within each mainstem watercourse is small in comparison to the total invertebrate supply of biomass supplied from all reaches and/or other tributaries based on drainage area. This pathway is considered a secondary linkage and is expected to not have a significant effect on WSCT and its habitat.

Changes to Sediment Supply and Transport Mechanisms

Site preparation, surface water management and erosion control, open pit development and/or waste rock placement activities can alter sediment supply, transport (*e.g.*, bedload movement), and basin sediment yield, which, in turn, can affect WSCT habitat quantity and suitability. Based on the findings from the fluvial geomorphology assessment (CR#6, Appendix A2: Sections 3.0 and 4.0), the likelihood and extent of physical habitat to be altered in terms of quantity and suitability is considered negligible. Thus, no detectable residual effects to fish habitat, due to modifications in fluvial geomorphological processes (*e.g.*, sediment mobility, bed load movement), proportional to baseline conditions, are expected throughout the mine life (construction, operations, reclamation, closure phases).

Changes to Water Quality Affecting the Health of Westslope Cutthroat Trout

Surface water runoff, surface-groundwater interactions, and discharge of mine-influenced water can alter surface water quality, which can affect WSCT habitat quantity and suitability or potentially cause direct changes in relative abundance (*i.e.* acute mortality). Based on the Surface Water Quality Assessment Report (CR #5), the pathway between water quality and WSCT health is classified as a secondary linkage. Given the proposed mitigation and monitoring measures, no significant effects are expected to WSCT health.

Calcite Precipitation

Calcite precipitation can affect WSCT habitat quantity or suitability. Baseline water chemistry in Gold and Blairmore creeks has been determined to contain calcium and carbonate at concentrations yielding calcite saturation indices of 0.6, where 0 indicates the theoretical level at which calcite would precipitate. The natural waters appear to have no capacity to prevent calcite precipitation in streams by dilution and management of the potential for calcite precipitation needs to be considered for the Project (Appendix A, Appendix 10B). The presence of calcite precipitate was not observed in either Gold or Blairmore creeks during characterization of baseline conditions of fish and fish habitat (CR#6: Section 4.2.2.5). Thus, the potential for calcite formation to precipitate to the extent where it could affect fish or fish habitat is currently considered low. A monitoring plan, was part of the WMP, will include monitoring key habitats for precipitation and treatment measures (*e.g.*, aeration and/or dilution) if calcite precipitation is observed.

6.3.2 Application Case: Overview of the Primary Pathway Aquatic Effects

The primary impacts of mine development on fish resources are almost always mediated through effects to their habitat. These effects include alteration to sediment deposition and scour processes in streams, stream crossings (roads, pipelines, and powerlines), stream diversions, changes to stream flows, effluent discharge, and complete habitat loss under the project footprint. In particular, the effects of waste rock storage areas, and project footprint components (CR#6, Table 1.1) typically require more robust assessment, as they are likely to pose the most significant risks to fish and fish habitat. Fish populations respond to perturbations in numerous ways, including increased stress, disease, mortality and decreased growth, inability to reproduce, survival, recruitment, and production. The assessment of potential aquatic effects for this project is driven by the bullets listed in the AER and CEAA Terms of References summarized in CR#6, Table 2.1 and Table 2.2).

The core components of the aquatic effects assessment focuses on the potential direct habitat losses to select watercourses as a result of the project footprint, alterations to stream flow in select tributaries and mainstem watercourses, effluent discharge (*i.e.*, potential changes in water quality) and how these project activities interact with the WSCT VC.

The following subsections provides an overview of the potential effects that have been assessed for the Project. Interactions between the Project and aquatic ecological resources were identified through a pathways analysis that was then used to direct the residual effects assessment for aquatic ecology components. Several effects pathways were evaluated. Three pathways were determined to be a no linkage effect pathway and five were determined to be secondary pathways. The two primary effect pathways that could affect the maintenance of self-sustaining and overall productivity of WSCT populations in the LSA were advanced to the Application Case.

6.3.2.1 Primary Effect Pathways

Changes to Tributary and Mainstem Aquatic and/or Riparian Habitat

The construction and operations can directly affect aquatic and riparian habitats through habitat loss. Such losses can be short-term or long-term depending on the duration of the effects at the site. For aquatic habitat, short-term losses are associated with temporary removal or modification of permanently or seasonally wetted parts of the stream channel that can be mitigated post-construction. After mitigation measures are applied to this pathway, the following habitat changes remain:

- medium and high value riparian habitat on fish-bearing watercourses; and
- aquatic habitat affected by pit extraction and ponds.

Although appropriate mitigation measures will be used, the pit excavation and pond development will result in permanent loss of WSCT aquatic habitat in GCT10 and GCT11 (758 m^2) and riparian habitat in Blairmore Creek, Gold Creek, GCT10 and GCT11 (19,270 m^2). The habitat losses will be offset and exceeded by gains in habitat attained through the implementation of an Offsetting Plan (CR #6: Appendix A4) required as a component of a *Fisheries Act Authorization* (FAA).

Changes to Hydrology in Gold and Blairmore Creeks Potentially Affecting Westslope Cutthroat Trout Habitat

Open pit development, resource extraction, and water management activities may change the hydrology in both Gold Creek and Blairmore Creek watersheds, which can affect WSCT habitat quantity, habitat suitability, and/or connectivity between habitats. Water management is a key aspect of the Project from the initial site disturbance through to final reclamation; consequently, water management planning for the protection of the aquatic environment has been a main consideration and priority throughout the development of the mine plan (Section C.5.3). Once all water management features are fully implemented, it is anticipated that predicted flow (runoff) will be reduced variably at different locations (nodes) within the Gold Creek watershed (CR #4: Section 5.2). The IFA (CR#6: Appendix A3) conducted for the Project considered potential flow changes on fish habitat associated specifically with WSCT during construction, operations, reclamation, and closure phases of the Project. About 530 m^2 of functional habitat (*i.e.*, spawning/incubation, adult holding, juvenile rearing, overwintering) in Gold Creek are predicted to be altered as a result in changes to the Gold Creek hydrological regime (CR#6, Table 5.1).

6.4 Cumulative Effects Assessment

Residual effects on aquatic ecological resources resulting from the primary pathways identified for the Project were assessed for the Application Case (CR#6: Section 4.3). In this section identified residual effects are further evaluated to assess their potential to interact with other reasonably foreseeable developments (RFD), where effects may overlap spatially and temporally with those of the Project. The projects that were considered in the PDC were aligned with those considered in the Surface Water Quality Effects Assessment (CR #5: Section 2.5) which included:

- Teck Coal Limited's, Elkview Baldy Ridge Extension and Michel Creek Coking Coal Project;
- Crown's four timber operations;
- ATCO's Castle Rock Ridge to Chapel Rock Transmission Project, and
- Alberta Transportation's Highway 3 Realignment Project.

Of the proposed projects forming the PDC:

- The proposed Michel Creek Coal Mine by Teck Coal Ltd. is not located in the Crowsnest River drainage and any effects of this project would likely be *via* changes in air quality.
- Future timber operations on Crown Land are likely to proceed at the same rate as they are currently.
- It is assumed that Alberta Transportation's re-alignment of Highway No. 3 will be done in an environmentally-sustainable manner and not adversely affect the water quality or aquatic resources of the Crowsnest River.

Two designatable units for the WSCT species were formalized in November 2006, consisting of one population in British Columbia and one population in Alberta. This determination was made on the basis of the marked difference in conservation status and distinctive ecozones inhabited by the two groups, and the lack of current dispersal opportunities between them (separated by the Rocky Mountains). Thus, there is no potential for this Project to overlap with those in BC (Teck Projects) and no cumulative effects expected.

Critical Habitat for WSCT that has been identified within the RSA for the Project includes Allison Creek, Star Creek, Girardi Creek, an unnamed tributary to the Crowsnest River, and an unnamed tributary to Rock Creek (CR#6:Figure 1.1, Table 3.4). Allison Creek, Star Creek and the unnamed tributary to the Crowsnest River are all located upstream of both Gold and Blairmore creeks and Rock Creek is located at least 10 kilometers downstream of the Project. Given that no potential residual effects (primarily to do with changes in hydrology) are anticipated within the RSA (*i.e.*, the Crowsnest River), the interaction of this Project with other WSCT designated critical habitats or RFDs that may influence these other critical habitats is not expected.

6.5 Mitigation and Monitoring

Follow-up programs are used to verify the predictions of environmental effects made during the EIA of the Project and to confirm whether mitigation measures have achieved the desired outcomes. A follow-up program is essential in identifying whether mitigation or monitoring methodologies need to be modified or adapted as the Project proceeds in order to continue to be effective and to address previously unanticipated adverse environmental effects.

The EA process identified WSCT as the aquatic ecology VC. Residual effects were predicted, which require monitoring to confirm the effectiveness/performance of mitigation applied to remove or counterbalance the effects. The effectiveness of the mitigation measures and determination of significance will be confirmed though the development and implementation of follow-up programs. Three separate aquatic monitoring programs with fish components will be required for this Project:

- Aquatic Resources Management Plan (ARMP);
- Aquatic Effects Monitoring Program (AEMP); and
- *Fisheries Act Authorization* (FAA) compliance and effectiveness monitoring plan.

These programs will be developed based on regulatory requirements associated with federal and provincial legislation including the federal SARA and *Fisheries Act* as well as provincial *Wildlife Act*. They will be based on BMPs and the current scientific literature.

Benga is committed to achieving continual improvement in environmental performance. The development and implementation of all monitoring and mitigation (including offsetting) identified for the Project and housed in the monitoring and follow up programs will be tracked in relevant management plans. As site conditions and monitoring dictate, or as new technology emerges, we will adaptively manage our site practices and monitoring program to meet the defined objectives. For some programs this would involve regular evaluation of predictive models; which would be clearly defined in each applicable management plan.

6.6 Summary

Valued components were identified based on an understanding of the Project, issues identified though consultation, requirements set-out in the Terms of Reference, and professional experience with other mining projects. The VC selected for this assessment was WSCT and the assessment endpoint was the maintenance of self-sustaining and ongoing productivity of WSCT populations.

Interactions between the Project and aquatic ecological resources were identified through a pathways analysis that was then used to direct the residual effects assessment for aquatic ecology components. Several effects pathways were evaluated. Three pathways were determined to be a no linkage effect pathway and five were determined to be secondary pathways. The two primary effect pathways that could affect the maintenance of self-sustaining and overall productivity of WSCT populations in the LSA were advanced to the Application Case (Table E.6.6-1). These pathways were:

- permanent loss of tributary and mainstem aquatic and/or riparian habitat in Gold and Blairmore creeks as a result of the Project footprint; and
- changes to hydrology in Gold and Blairmore creeks affecting WSCT habitat.

Overall, it is estimated that the Project will result in a loss of 758 m^2 of aquatic habitat and 18,868 m^2 of riparian habitat in Gold Creek watershed as a result of the Project footprint. The aquatic habitat losses are strictly from tributaries to Gold Creek mainstem. Additionally, 530 m^2 of functional habitat (*i.e.*, spawning/incubation, adult holding, juvenile rearing, overwintering) in Gold Creek is predicted to be altered as a result in changes to the Gold Creek hydrological regime. The Project will result in a loss of 402 m^2 of riparian habitat on Blairmore Creek. No losses of direct fish habitat, as a result of the Project footprint, are expected for Blairmore Creek and associated tributaries as all tributaries are non-fish bearing.

Table E.6.6-1 Summary of Impacts on Westslope Cutthroat Trout

VC Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact	Geographical Extent of Impact[1]	Duration of Impact[2]	Frequency of Impact[3]	Ability for Recovery[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability Occurrence – Ecological Context[8]	Significance
9. Changes to tributary and mainstem Aquatic and/or Riparian Habitat											
Physical footprint of surface water management infrastructure and open pits will cause the permanent change to WSCT habitat.	Yes	Application	Local	Long	Continuous	Reversible Long Term	Moderate	Positive (with application of Mitigation and Offsetting)	Moderate	High	Not Significant
10. Change in hydrology in Gold and Blairmore creeks affecting WSCT habitat.											
Changes in hydrology causing alteration in WSCT aquatic habitat of Gold and Blairmore creeks.	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Positive (with application of Mitigation and Offsetting)	Moderate	High	Not Significant
			Regional	Short	Continuous	Reversible Short Term	Low	Neutral	High	High	Not Significant

1 Local, Regional, Provincial, National, Global
2 Short, Long, Extended, Residual
3 Continuous, Isolated, Periodic, Occasional, Accidental, Seasonal
4 Reversible in short term, Reversible in long term, Irreversible – rare
5 No Impact, Low Impact, Moderate Impact, High Impact
6 Neutral, Positive, Negative
7 Low, Moderate, High
8 Low, Medium, High
9 Significant, In-significant