GRASSY MOUNTAIN COAL PROJECT: AQUATIC ECOLOGY EFFECTS ASSESSMENT ADDENDUM CONSULTANT REPORT #6

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MEMS 7779
VERSION 3

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LIST OF ACRONYMS

ACA	Alberta Conservation Association
AEP	Alberta Environment and Parks
AEPEA	Alberta Environmental Protection and Enhancement Act
AEMP	Aquatic Effects Monitoring Plan
AER	Alberta Energy Regulator
AESRD	Alberta Environment and Sustainable Resource Development
ARMP	Aquatic Resources Management Plan
AVI	Alberta Vegetation Inventory
AWS	Area weighted suitability
BC	British Columbia
BKTR	Brook trout
BMP	Best Management Practice
CHPP	Coal handling and preparation plant
CPR	Canadian Pacific Railroad
COSEWIC	Committee on the Status of Endangered Wildlife
CRA	Commercial, recreational or Aboriginal
CRDA	Central rock disposal area
DFO	Fisheries and Oceans Canada
EIA	Environmental Impact Assessment
ESP	Eastern sedimentation pond
FAA	Fisheries Act Authorization
FHAP	Fish Habitat Assessment Procedures
FWMIS	Fish and Wildlife Management Information System
HSC	Habitat suitability curves
IFA	Instream flow assessment
LWD	Large woody debris
LSA	Local study area
LSP	Loadout sedimentation pond
MAD	Mean annual discharge

MMD	Mean monthly discharge
MMER	Metal Mining Effluent Regulations
MOE	Ministry of Environment
NESP	Northeast sedimentation pond
NRDA	North rock disposal area
NWSP	Northwest surge pond
PAG	Potential acid generating rocks
PDC	Planned development case
PoE	Pathway of effects
PSSP	Plant site sediment pond
RFD	Reasonably foreseeable development
RNTR	Rainbow trout
RSA	Regional study area
RWP	Raw water pond
SARA	Species at Risk Act
SEFA	System for environmental flow assessment
SESP	Southeast surge pond
SIR	Supplemental information request
SRDA	South rock disposal area
SWSP	Southwest surge pond
TSS	Total suspended solids
VC	Valued component
WMP	Water Management Plan
WSP	West sedimentation pond
WSCT	Westslope cutthroat trout
YOY	Young of the year

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AMENDMENT RECORD

This report has been issued and amended as follows:

Issue	Description	Date	Approved by	
1	Grassy Mountain Coal Project – Aquatic Ecology Effects Assessment Addendum. Consultant Report #6 (Draft)	20170117		
2	Grassy Mountain Coal Project – Aquatic Ecology Effects Assessment Addendum. Consultant Report #6 (Draft)	20170118		
3	Grassy Mountain Coal Project – Aquatic Ecology Effects Assessment Addendum. Consultant Report #6 (Final)	20170125	<Original signed by>	<Original signed by>
			Martin Davies Project Director	Cory Bettles Project Manager

1.0 INTRODUCTION

1.1 OVERVIEW

This report comprises the aquatic ecology component of an Environmental Impact Assessment (EIA) for the proposed Benga Mining Limited (Benga) Grassy Mountain Coal Mine Project (the Project) in southwestern Alberta. The report was prepared by Hatfield Consultants Partnership (Hatfield) for Benga.

The environmental effects assessment for aquatic ecological resources for the proposed Project identifies linkages between Project activities and the environment to determine the residual effects of the project on fish and fish habitat. Residual effects (i.e., those effects that remain after the implementation of all mitigation actions) are placed in context of the cumulative effects of previous, existing, and future projects.

The scope, format and contents of the report were guided by the Terms of Reference (TOR) for the Environmental Impact Assessment Report prepared by the Alberta Energy Regulator (AER 2015) and the Guidelines for the Preparation of an Environmental Impact Statement prepared by the Canadian Environmental Assessment Agency (CEAA 2015) and include the following steps:

- Identify valued components (VCs) upon which the assessment will focus;
- Select appropriate assessment endpoints and measurement indicators for VCs;
- Define spatial and temporal boundaries and assessment cases used to evaluate the effects of the Project;
- Describe existing (Baseline Case) conditions relevant to the assessment of the Project;
- Conduct a pathways analysis to identify Project components or activities with a potential to create a residual effect;
- Conduct an Application Case assessment for each VC to predict residual effects of the Project and describe the incremental addition of the addition of the Project to the cumulative effect identified for the Baseline Case;
- Where residual effects from the Project are identified, conduct a Reasonably Foreseeable Planned Development Case (PDC) assessment for each VC to predict the cumulative effects of previous and existing projects and activities, the Project, and potential future projects that are considered reasonably foreseeable;
- Determine the significance of residual cumulative effects for the Application Case and PDC for VC assessment endpoints; and
- Identify monitoring and follow-up programs to address any identified uncertainty.

1.2 PROJECT LOCATION AND DESCRIPTION

The Project is to be located along the eastern edge of the Rocky Mountain foothills approximately 90 km southwest of Fort McLeod, Alberta, in the municipality of Crowsnest Pass (Figure 1.1). The Project is to be situated in the watersheds of Blairmore and Gold creeks, which are drainages in the Crowsnest River watershed, itself a major drainage in the Oldman River system. The Project is to be located in the Northern Continental Divide Ecoregion[1] and in the Rocky Mountains Front Range Physiographic Region[2]. Blairmore and Gold creek watersheds contain watercourses that DFO (2014) and Alberta Westslope Cutthroat Trout Recovery Team (2013) have designated as critical habitat for the Alberta population of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi)*. The estimated areas of disturbance by the Project are provided in Table 1.1.

Table 1.1 Summary of spatial extent of the primary Project components.

Project Component	Component Area (m^2)	Percentage of Project Footprint (%)
Coal Handling Processing Plant and Infrastructure	941,000	6.2
Coal Load-Out and Railway Loop	331,000	2.2
Construction Camp	19,000	0.1
Haul Road	3,000	<0.1
Powerline, Access and Conveyor RoW	152,000	1.0
Reclamation Material Storage	379,000	2.5
Surface Water Management Ponds and Ditches	746,000	4.9
Ultimate Rock Disposal Extent	5,899,000	38.8
Ultimate Pit Extent	6,324,000	41.6
Proposed Water Pipeline/Service Road Right of Way	15,000	0.1
Proposed Golf Course Development [1]	381,000	2.5
Proposed Helipad Access [1]	16,000	0.1
Total Mining Activities Reclamation Area	**14,810,000**	**97.4**
Total Non-Mining (Incidental) Area [1]	**397,000**	**2.6**
TOTALS[2]	**15,207,000**	**100**

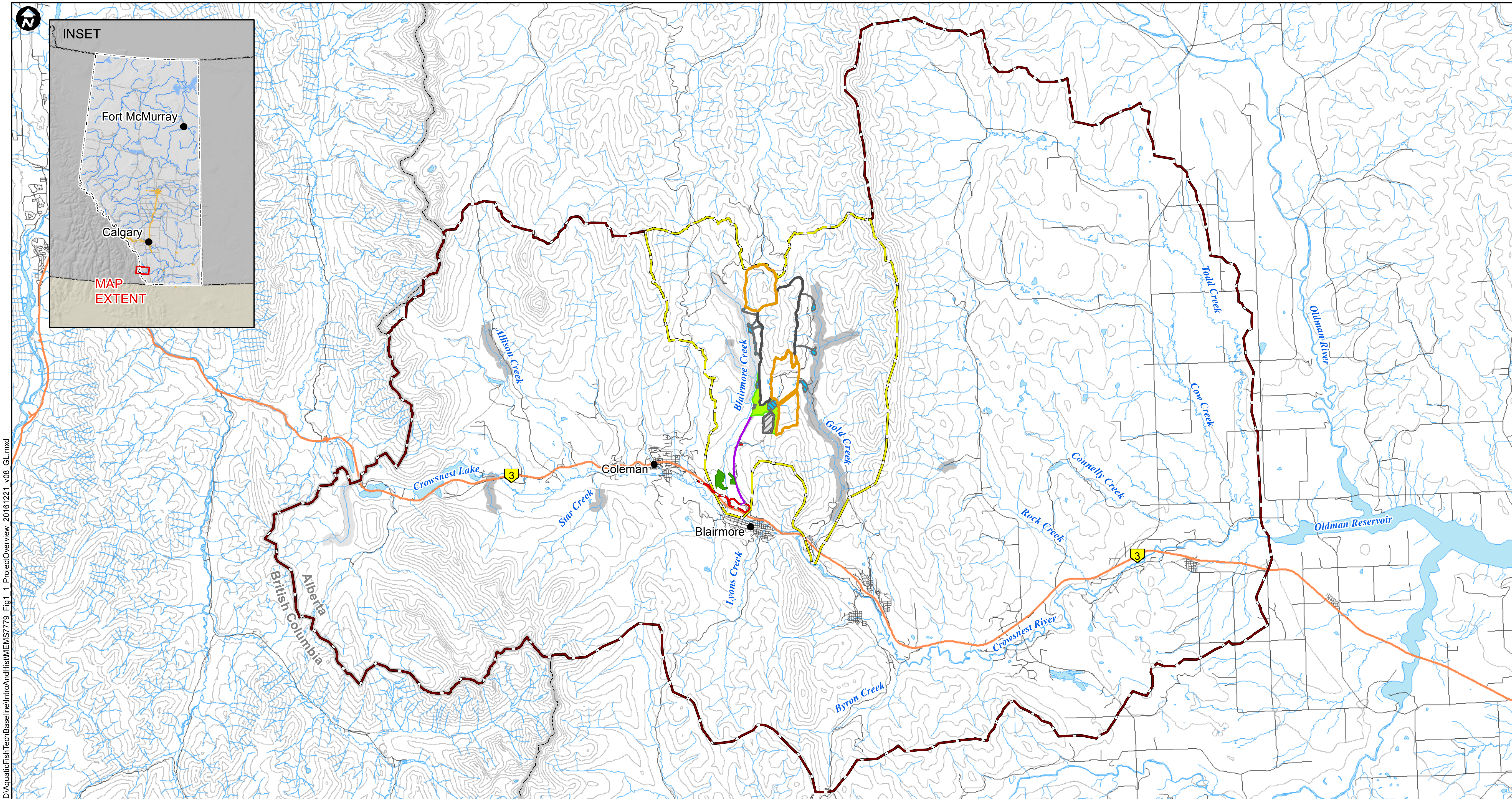
[1] Benga Reclamation Responsibility includes "incidental physical activities" identified by CEAA

[2] Due to rounding of values, totals may not equal the sum of the individual values presented in the table.

The total expected footprint of the Project is approximately 15,207,000 m^2 or 14% of the combined area of Blairmore and Gold creek watersheds, and approximately 2% of the total area of the Crowsnest River watershed. Additional details of the mine plan for the Project area provided in Section C of the Application.

[1] http://www.ecozones.ca/english/zone/MontaneCordillera/ecoregions.html

[2] Pettapiece (1986), cited in http://www.ags.gov.ab.ca/publications/MAP/PDF/MAP_550.pdf



LEGEND

- Identified Westslope Cutthroat Trout Critical Habitat
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation
- Primary Highway
- Road
- 100m Contour
- Watercourse
- Waterbody
- Local Study Area
- Regional Study Area
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area
- Railway Loop

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

TITLE

OVERVIEW OF PROJECT LOCATION

NOTES

Data Sources: Government of Canada, Government of Alberta
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

Hatfield CONSULTANTS

PROJECT: 7779
DRAWN BY: SS / EDITED BY: GL
CHECKED BY: CB
DATE: December 21, 2016

FIGURE **1.1**

Document Path: K:\Data\Project\MEMS7779\A_MXD\AquaticFish\TechBaseline\IntroAndHist\MEMS7779_Fig1_1_ProjectOverview_20161221_v08_GL.mxd

2.0 SCOPE OF THE ASSESSMENT

This report addresses sections relevant to aquatic ecology and therefore includes information with respect to fish and fish habitat features specific to the Project. The concordance tables for this Aquatic Ecology Effects Assessment are provided in Table 2.1 and Table 2.2 respectively (Appendices 1 and 2 of the Application provide concordance tables for the complete AER Terms of Reference and complete CEAA Guidelines for the Preparation of an Environmental Impact Statement, respectively).

2.1 TERMS OF REFERENCE

The scope, format and contents of the final Aquatic Ecology Effects Assessment is being guided by the TOR for the EIA report prepared by the AER (AER 2015) and the Guidelines for the Preparation of an Environmental Impact Statement prepared by the Canadian Environmental Assessment Agency (CEAA 2015). The final Aquatic Ecology Effects Assessment report evaluates selected VCs by considering key measurement indicators and effect pathways in consideration of pertinent regulatory frameworks (e.g., *Fisheries Act*, *Species at Risk Act, Wildlife Act* etc.). The applicable TOR and guidelines for the baseline assessment of fish and fish habitat as specified by AER and CEAA are provided in Table 2.1 and Table 2.2 respectively.

Table 2.1 AER Terms of Reference sections applicable to this assessment.

Section in Final AER Terms of Reference for Project (AER 2015)		Report Section
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);	a) to c): CR#6, Appendix A1, Section 2.2
	b) Listed in Schedule 1 of the federal *Species at Risk Act*;	
	c) Listed as "at risk" by COSEWIC; and	
	d) Traditionally used species.	d): CR#6, Section 4.1
[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.	CR#6, Appendix A1, Section 3.1
[C]	Describe the current and potential use of the fish resources by Aboriginal, sport or commercial fisheries.	CR#6 Sections 4.1, 4.2.1.2
[D]	Describe and quantify the current extent of aquatic habitat fragmentation.	CR#6 Appendix A1, Sections 3.1.1.3 and 4.1.1.3

Table 2.1 (Cont'd.)

Section in Final AER Terms of Reference for Project (AER 2015)		Report Section
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.	a) to b): CR#6, Section 4 c) CR#6, Section 4.2.1.2 d) CR#6, Section 4.2.2.2, and Appendix A1 e) CR#6, Section 4.2.3, and Appendix A1, Sections 3.1.1.3 and 4.1.1.3
[B]	Identify the key aquatic indicators that the proponent used to assess Project impacts. Discuss the rationale for their selection.	CR#6, Sections 3 and 4.2
[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.	CR#6, Sections 4 and 6
[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.	CR#6, Sections 4.3 and 6, Appendix A4
[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.	CR#6, Section 4, CR#5, Section 3.2.2
[F]	Describe the effects of any surface water withdrawals considered, including cumulative effects on fish and fish habitat.	CR#6, Section 4

Table 2.2 CEAA Terms of Reference sections applicable to this assessment.

Section in Final CEAA Terms of Reference for Project (CEAA 2015)	Report Section
Project Setting and Baseline Conditions	
6.1.5. Fish and Fish Habitat	
For potentially affected surface waters:	
▪ a characterization 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);	Appendix A1: Section 2 and 3.1.5
▪ a description of primary and secondary productivity in affected water bodies, including a survey of benthic invertebrate communities with characterization of seasonal variability;	Appendix A1: Section 3.2 and 4.2
▪ a list of any fish or invertebrate species at risk that are known to be present;	CR#6: Section 3.1 and 4.1
▪ a description of the habitat by homogeneous section, including the length of the section, width of the channel from the high water mark (bankfull width), water depths, type of substrate (sediments), temperature, aquatic and riparian vegetation, and photos;	CR#6: Section 4, Appendix A1: Section 3.1.1, 4.1.1, and Appendix A2
▪ 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	Appendix A1: Section 3.1.1 and 4.1.1, Figure 4.10 and 4.11. Appendix A3
▪ 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.	CR#6: Section 4, Appendix A1, Appendix A3
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:	CR#6: Section 4
o the geomorphological changes and their effects on hydrodynamic conditions and fish habitats (e.g., modification of substrates, dynamic imbalance, silting of spawning beds);	CR#6: Section 4 and Appendix A2
o the modifications of hydrological and hydrometric conditions on fish habitat and on the fish species' life cycle activities (e.g., reproduction, fry-rearing, movements);	CR#6: Section 4 and Appendix A3
o potential impacts on riparian areas that could affect aquatic biological resources and productivity taking into account any anticipated modifications to fish habitat;	CR#6: Section 4.2.3, 4.3.1, and 4.5
o any potential imbalances in the food web in relation to baseline; and	CR#6: Section 4, Appendix A1: Section 3.2 and 4.2
o 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 sources;	CR#6: Section 4, Appendix A1: Section 3.2 and 4.2

Table 2.2 (Cont'd.)

Section in Final CEAA Terms of Reference for Project (CEAA 2015)	Report Section
▪ the effects of changes to the aquatic environment on fish and their habitat, including:	
o the anticipated changes in the composition and characteristics of the populations of various fish species, including forage fish;	CR#6: Section 4
o any modifications in migration or local movements (upstream and downstream migration, and lateral movements) following the construction and operation of works;	CR#6: Section 4.2
o any reduction in fish populations as a result of potential overfishing due to increased access to the Project area; and	CR#6: Section 4.2.1.2
o 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.	CR#6: Section 4 and Appendix A3
▪ a discussion of how Project construction timing correlates to key fisheries windows for fish species, and any potential impacts resulting from overlapping periods;	CR#6: Section 4
▪ a discussion of how vibration caused by blasting may affect fish behaviour, such as spawning or migrations;	CR#6: Section 4.2.1.3 and 4.1.2.2
▪ changes in concentrations of contaminants of concern in the aquatic ecosystem[3];	CR#6: Section 4.2.1.1 and 4.2.2.4
▪ changes to fish health resulting from increased contaminants of concern; and	CR#6: Section 4.2.1.1 and 4.2.2.4
▪ 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.	CR#6: Section 4, and Appendix A3

2.2 GOVERNMENT REGULATION AND POLICY

The Aquatic Ecology Effects Assessment takes into consideration the following provincial and federal government laws, regulations, and standards:

- Alberta *Environmental Protection and Enhancement Act* (AEPEA, 2000), with associated regulations and amendments in force (current as of December 2014);
- Alberta *Water Act* (2000) with associated regulations and amendments in force particularly the Alberta Code of Practice for Watercourse Crossings (AESRD 2013a) and the Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body (AESRD 2013b);
- The Alberta *Wildlife Act* (2014) and Regulation;
- Environmental Quality Guidelines for Alberta Surface Waters (AESRD 2014);
- The federal *Fisheries Act (*1985), with associated regulations and amendments in force, current to August 2015 and last amended on 26 February 2015;

[3] The aquatic ecosystem includes those species assemblages that comprise the food chain through which contaminants of concern are known to bioaccumulate. This includes, but is not limited to, the following fish species: westslope cutthroat trout, rainbow trout, and mountain whitefish.

- Federal *Species at Risk Act* (SARA, 2002), including the Critical Habitat Protection Order for westslope cutthroat trout (*Oncorhynchus clarkii lewisi;* WSCT) Alberta population issued on November 20, 2015 under sections 58(4) and (5) of SARA, engaging section 58(1) of SARA.
- *Canadian Environmental Assessment Act* (2012); and
- *Canadian Environmental Protection Act* (1999).

The fish and fish habitat located within the study area are regulated and protected by two key federal statutes: the *Fisheries Act* and SARA.

2.2.1 *Fisheries Act*

The legislative authority for the management and conservation of fish and fish habitat in Canada is provided by the federal *Fisheries Act*. The *Fisheries Act* was updated in 2012, with revisions coming into effect in November 2013. Section 2(1) of the Fisheries Act defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." The main provision of the *Fisheries Act* regarding the protection of fish habitat is Section 35. Section 35(1) states that: "No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal (CRA) fishery, or to fish that support such a fishery." Section 35(2)(b) of the *Fisheries Act* includes provisions for exceptions to serious harm to fish by obtaining an authorization from the Minister of Fisheries and Oceans Canada. The Fisheries Protection Policy Statement (DFO 2013a) defines serious harm to fish as:

- The death of fish;
- Permanent alteration to fish habitat – an alteration of fish habitat of a spatial scale, duration, and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes;
- Destruction of fish habitat – an elimination of habitat of a spatial scale, duration, and intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.

The objective of the *Fisheries Act* and the supporting policy is to protect and manage fish habitats that support freshwater and marine fisheries associated with CRA fisheries. The assumption in this approach is that any reduction in the capacity of a habitat to support the life processes of fish will reduce fish production.

Section 36 of the *Fisheries Act* protects Canadian fish-bearing waters from releases of deleterious substances. The quality of effluent discharged from metal mines in Canada is regulated under the *Metal Mining Effluent Regulations (*MMER) under Sections 36 to 42 of the *Fisheries Act*. Coal mines do not currently fall under MMER, however their inclusion is under consideration. At this time, MMER provides best practice guidance for environmental effects planning. Mining operations that are not captured under the MMER (e.g., coal mines) are subject to subsection 36(3) of the *Fisheries Act*, prohibiting the deposit of deleterious substances in water frequented by fish.

2.2.2 Species at Risk Act

The purpose of the SARA is to prevent wildlife species from becoming extirpated or extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. When an EIA is carried out on a project that may affect a listed species or its critical habitat, the SARA requires that the potential adverse effects be identified. Critical habitat is the habitat necessary for the survival or recovery of a listed endangered, threatened or extirpated species in Schedule 1 of SARA. If the project is carried out, measures need to be taken to avoid or lessen and monitor those adverse effects. Such measures must be consistent with any applicable recovery strategies, action plans and management plans for those particular species.

Critical habitat is identified in Recovery Strategies, and posted on the Species at Risk Public Registry. Once the critical habitat is designated as final, it must be legally protected. This is often accomplished through the making of a critical habitat order, which triggers the prohibition against the destruction of any part of the critical habitat. The *Critical Habitat of the Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) Alberta Population Order* (the Order) was brought into effect under subsections 58(4) and (5) of the SARA on November 20, 2015 to satisfy the obligation to legally protect critical habitat by triggering the prohibition under subsection 58(1) of SARA against the destruction of any part of the species' critical habitat.

For an activity to be authorized that would otherwise be prohibited under SARA, the Minister of Fisheries and Oceans Canada (DFO) must be of the opinion that one of the following conditions is met:

- the activity is scientific research relating to the conservation of the species and is conducted by qualified persons;
- the activity benefits the species or is required to enhance its chance of survival in the wild; or
- affecting the species is incidental to carrying out the activity (i.e. is not the purpose of the activity).

Additionally, the Minister must be of the opinion that all three of the following conditions are met:

- all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted;
- all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat (or the residences) of its individuals; and
- the activity will not jeopardize the survival or recovery of the species.

Activities that are prohibited under sections 32, 33, and 58(1) of SARA, but meet the conditions that are described above, an approval can be granted by DFO. The approval can take the form of a SARA Permit, or a *Fisheries Act* Authorization that contains conditions for the protection of aquatic species at risk.

2.3 REGULATOR INPUT

The aquatic ecology study design for the Project was augmented in 2016 in response to fisheries- and aquatic-specific supplemental information requests (SIRs) received from AER, the Canadian Environmental

Assessment Agency (CEAA), and DFO based on their review of the November 2015 submission of Benga's Grassy Mountain Project EIA report (letters dated January 25 and March 21, 2016, respectively). The study design was developed to reasonably address identified information requests and/or data gaps as well as provide sufficient detail to meet provincial and federal fish research license (FRL) application requirements for actively sampling a federally listed Species at Risk. The 2016 study design was finalized based on the outcome of subsequent meetings with the same regulators as well as Alberta Environment and Parks (AEP). The study design was approved in July 2016 as well as amended and further approved in October 2016.

2.4 INFORMATION SOURCES USED IN THE EFFECTS ASSESSMENT

Information sources used to support the scoping and implementation of the aquatic ecology effects assessment included:

- Project Description and Mine Plans (Benga 2015);
- 2016 Fisheries and Aquatics Scope of Work for the Grassy Mountain Project (Hatfield 2016a);
- Fisheries and Aquatics Technical Baseline Report (Appendix A1);
- Fluvial Geomorphology Assessment of Blairmore Creek and Gold Creek (Appendix A2);
- Instream Flow Assessment (IFA), including the Water Temperature Assessment (Appendix A3);
- Preliminary Habitat Offsetting Plan (Appendix A4);
- Hydrology Baseline and Effects Assessment (Consultant Report #4);
- Water and Load Balance Model (Appendix 10B);
- Water Quality Management (Appendix 10C);
- Vegetation Baseline and Effects Assessment (Consultant Report #8);
- Stepping Back from the Water: A Beneficial Management Practices Guide for New Development Near Water Bodies in Alberta's Settled Region (AESRD 2012);
- The Fish and Wildlife Management Information System (FWMIS), accessed through an information request to Alberta Environment and Sustainable Resource Development (AESRD) and provided by AESRD in the form of a data report (AESRD 2013c) that included information on barriers to fish passage;
- The Status of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Alberta (AESRD and ACA 2006) which describes WSCT habitat, conservation biology, and species distribution;
- Information contained in the recovery plans prepared for the WSCT (Alberta Westslope Cutthroat Trout Recovery Team 2013, DFO 2014);

- Published reports from the ACA and other referenced academic research, reports, and grey literature;
- Information gathered during traditional knowledge and traditional land use surveys with members of Project identified Aboriginal groups conducted as part of Project preparation (Kanai Nation 2015, Piikanii Nation 2015, Tsuut'ina Nation 2015, Siksika Nation 2015, Stoney Nakoda Nation 2015, Métis Nation of Alberta Region 3 and Pincher Creek Local 1880 2016, and C. Gall, personal communication);
- Primary and secondary sources used in the development and selection of species-specific Habitat Suitability Criteria (HSC) curves for WSCT; and
- Maps, aerial photodocumentation, and ortho-rectified images of the study areas and Project footprint.

3.0 ASSESSMENT APPROACH

3.1 VALUED COMPONENTS

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" (BC EAO 2013). 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 (BC EAO 2013).

A preliminary list of candidate VCs (Table 3.1) 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).

Table 3.1 Summary of candidate valued components.

Candidate Valued Component(s)	Recovered in FWMIS Database	Traditional Use[4]	Captured in Baseline Field Studies	Status of Special Concern[5]
Fish				
Westslope Cutthroat Trout	√	√	√	√
Fish Health				
Brook Trout (surrogate for WSCT)	√	√	√	
Rainbow Trout (surrogate for other fish species)	√	√	√	
Macroinvertebrates	√	√	√	
Periphyton	√	√	√	
Aquatic Sediment	√	√	√	

WSCT are the primary fish VC because of their provincial and federal status and 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). The Fish Health VC was included to consider potential water quality-related effects throughout the life of the mine and includes 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* (Hatfield 2016b).

Table 3.2 Valued components for the Aquatic Ecology Effects Assessment.

Valued Component	Rationale for Selection
Westslope Cutthroat Trout	The only native fish species documented in Blairmore and Gold Creek watersheds and its tributaries, and also distributed throughout the Crowsnest River watershed. The Alberta population of WSCT is listed in Schedule 1, part 3 of the *Species at Risk Act* (SARA) as a "*Threatened"* species; listed as Threatened as identified by the Alberta *Wildlife Act* WSCT inhabiting Blairmore Creek mainstem identified as a "Core Population", just below "Core Population" status due to hybridization levels being slightly less than 99%, but is a naturally self-sustaining population; WSCT inhabiting Gold Creek are deemed *Threatened* as per SARA Valued by local Aboriginal groups An important and highly sought after sportfish that is angled recreationally Species of socio-economic importance Susceptible to habitat perturbation, including changes in water quality, hydrology, and hydrogeology that could alter health of productivity of the species

[4] Information gathered during traditional knowledge and traditional land use surveys with members of Aboriginal Groups conducted as part of Project preparation (Kanai Nation 2015, Piikanii Nation 2015, Tsuut'ina Nation 2015, Siksika Nation 2015, Stoney Nakoda Nation 2015, Métis Nation of Alberta Region 3 and Pincher Creek Local 1880 2016, and C. Gall, personal communication) suggest no particular fish species are more important for traditional uses than others and therefore all fish species found in the LSA are denoted as traditional use species.

[5] from http://www.registrelep-sararegistry.gc.ca/species/schedules_e.cfm?id=1, http://www.cosewic.gc.ca/eng/sct3/index_e.cfm#3, and http://aep.alberta.ca/fish-wildlife/species-at-risk/documents/SpeciesAssessed-Endangered-Jul18-2014.pdf

Because the Project has the potential to cause effects on fish habitat in Blairmore Creek and Gold Creek including several local tributary streams in each watershed, fish and fish habitat in these watercourses are expected to be vulnerable to Project effects. 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.

3.1.1 Westslope Cutthroat Trout: Alberta Population

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 (Alberta Westslope Cutthroat Trout Recovery Team 2013).

In Alberta, WSCT spawning typically takes place between May and July depending on location, and usually occurs when water temperatures reach 10°C (Nelson and Paetz 1992) (6°C in high elevation populations; S. Humphries pers. comm. in DFO [2014]). 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 (Nelson and Paetz 1992; Scott and Crossman 1973). 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 (Appendix A1), 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 (ASRD and ACA 2006). Juveniles require large territories and the availability of suitable pool habitat is often a limiting factor in the species productivity even in dynamic streams (Schmetterling 2001). Juveniles preferred window of rearing stream temperature is between 4°C and 15°C (DFO 2014).

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 (DFO 2014).

Suitable overwintering habitat appears to be largely determined by local groundwater influx and absence of anchor ice (Brown and Mackay 1995a). 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 (Behnke and Zarn 1976). Their preferred temperature range is 9 to 12°C (Alberta Westslope Cutthroat Trout Recovery Team 2013). More recent work by Bear et al. (2007) found 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. Bear et al. (2007) 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 (Reeves et al. 1997), but the riparian input of terrestrial insects (macroinvertebrates) is often an important food source during the summer months (Behnke 1992).

3.1.2 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.

Blairmore and Gold Creek watersheds contain watercourses and parts of watercourses identified as *critical habitat* for WSCT. In November 2015, DFO issued a formal habitat protection order under the SARA for the designated areas identified in the Gold Creek watershed. In addition, the province of Alberta (Alberta Westslope Cutthroat Trout Recovery Team 2013) and Canada (DFO 2014) developed a recovery plan (strategy) for WSCT (these two documents will be collectively referred to as "the Recovery Plan" in this report). The Recovery Plan was developed with the primary objective: "*To protect and maintain the existing ≥0.99 pure populations at self-sustaining levels and re-establish additional pure populations to self-sustaining levels, within the species historical range in Alberta."* (Alberta Westslope Cutthroat Trout Recovery Team 2013).

The Recovery Plan identifies parts of four watercourses in the LSA (total 16.5km in the LSA) 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)"[6]. 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 (Table 3.3, Figure 3.1). Fish recovered in these designated critical habitats were determined to be 99% genetically-pure (Alberta Westslope Cutthroat Trout Recovery Team 2013, DFO 2014)[7]. 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 (Table 3.3, Figure 3.1). Blairmore Creek mainstem (above known migration obstructions) has not been included in the critical habitat designation given evidence of introgression with non-native RNTR and not meeting the ≥0.99 pure criteria. Thus, the majority of Blairmore Creek mainstem has been categorized as a "Conservation Population" (Alberta Westslope Cutthroat Trout Recovery Team 2013), 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.

Table 3.3 Watercourses in the Local Study Area designated as critical habitat (greater than 99% genetically pure) and near-pure (95% to 99% genetically pure) westslope cutthroat trout.

Watercourse	Length of Watercourse (km)
Critical Habitat (>99% genetically pure)	
Gold Creek mainstem	13.95
Caudron Creek in Gold Creek Watershed	2.05
Morin Creek in Gold Creek Watershed	0.026
BCT04 in Blairmore Creek Watershed	0.026
Near-Pure (95% to 99% genetically pure)	
Blairmore Creek mainstem	7.74
BCT04 in Blairmore Creek watershed	2.19

6 Page 33 of Alberta Westslope Cutthroat Trout Recovery Team (2013)

7 Westslope cutthroat trout can only be reliably identified using genetic testing and the Recovery Plan considers a population to be genetically pure if the average genetic purity of a sample of fish from a creek is greater than 0.99.

Table 3.4 Other watercourses in the Regional Study Area designated as critical habitat (greater than 99% genetically pure) and near-pure (95% to 99% genetically pure) westslope cutthroat trout.

Watercourse	Length of Watercourse (km)
Critical Habitat (>99% genetically pure)	
Star Creek	1.28
Allison Creek	3.11
Girardi Creek	2.03
Rock Creek	0.77
Near-Pure (95% to 99% genetically pure)	
Island Creek	1.11

3.1.3 Assessment Endpoints & Measurement Indicators

Assessment endpoints are qualitative expressions used to assess significance of residual effects on VCs and to represent the key properties of a VC that should be protected for use by future generations. The assessment endpoint for the Aquatic Ecology Effects Assessment is the maintenance of self-sustaining and ongoing productivity of WSCT populations in Gold Creek and Blairmore Creek watersheds (Table 3.5).

Table 3.5 Assessment endpoints and measurement indicators.

Valued Component	Assessment Endpoint	Measurement Indicators
Westslope Cutthroat Trout	The maintenance or enhancement of: ▪ self-sustaining WSCT populations ▪ ongoing productivity of WSCT populations	WSCT habitat quantity & suitability Survival & reproduction of WSCT Relative abundance and distribution of WSCT

Measurement indicators represent properties of the environment and VC that, when changed, could result or contribute to an effect on that VC. The measurement indicators are collectively used to assess the overall influence of the Project on the assessment endpoint and, generally, become the basis for discussions of uncertainty of effects as well as the variables that may be used in monitoring programs to confirm assessment predictions. Measurement indicators provide the primary factors for discussing the uncertainty of effects on VCs, and subsequently represent key variables included in identified monitoring programs.

3.2 ASSESSMENT BOUNDARIES

3.2.1 Spatial Boundaries

3.2.1.1 Local Study Area

The Project is situated in the watersheds of Blairmore Creek (50 km²) and Gold Creek (63 km²), major drainages in the Crowsnest River watershed. Combined together, Blairmore and Gold creeks represent approximately 11% of the watershed area of the Crowsnest River. Both systems are part of the Oldman

River watershed, which flows into the Saskatchewan River, ultimately discharging into Lake Winnipeg. The aquatic LSA was selected based on the Project footprint, boundaries of local watersheds and the spatial extent of potential immediate direct and indirect effects of the Project on hydrogeology, surface water hydrology, water quality, and fisheries and aquatic resources (Figure 3.1). The LSA was also defined as the conservative downstream limit of potential fish and fish habitat that may be influenced by the Project with a focus on the critical habitat defined in the WSCT provincial and federal Recovery Plans (Alberta Westslope Cutthroat Trout Recovery Team 2013, DFO 2014) assigned to Gold Creek and Blairmore Creek.

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 (Figure 3.1, Table 3.3). Fish recovered in these designated critical habitats were determined to be 99% genetically-pure (Alberta Westslope Trout Recovery Team 2013, DFO 2014)[8]. 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, totaling approximately 10 km in length, in the Blairmore Creek watershed as containing near-pure westslope cutthroat trout (Figure 3.1, Table 3.3).

3.2.1.2 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 (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 one (1) km in length, as containing near-pure WSCT (Figure 1.1, Table 3.4).

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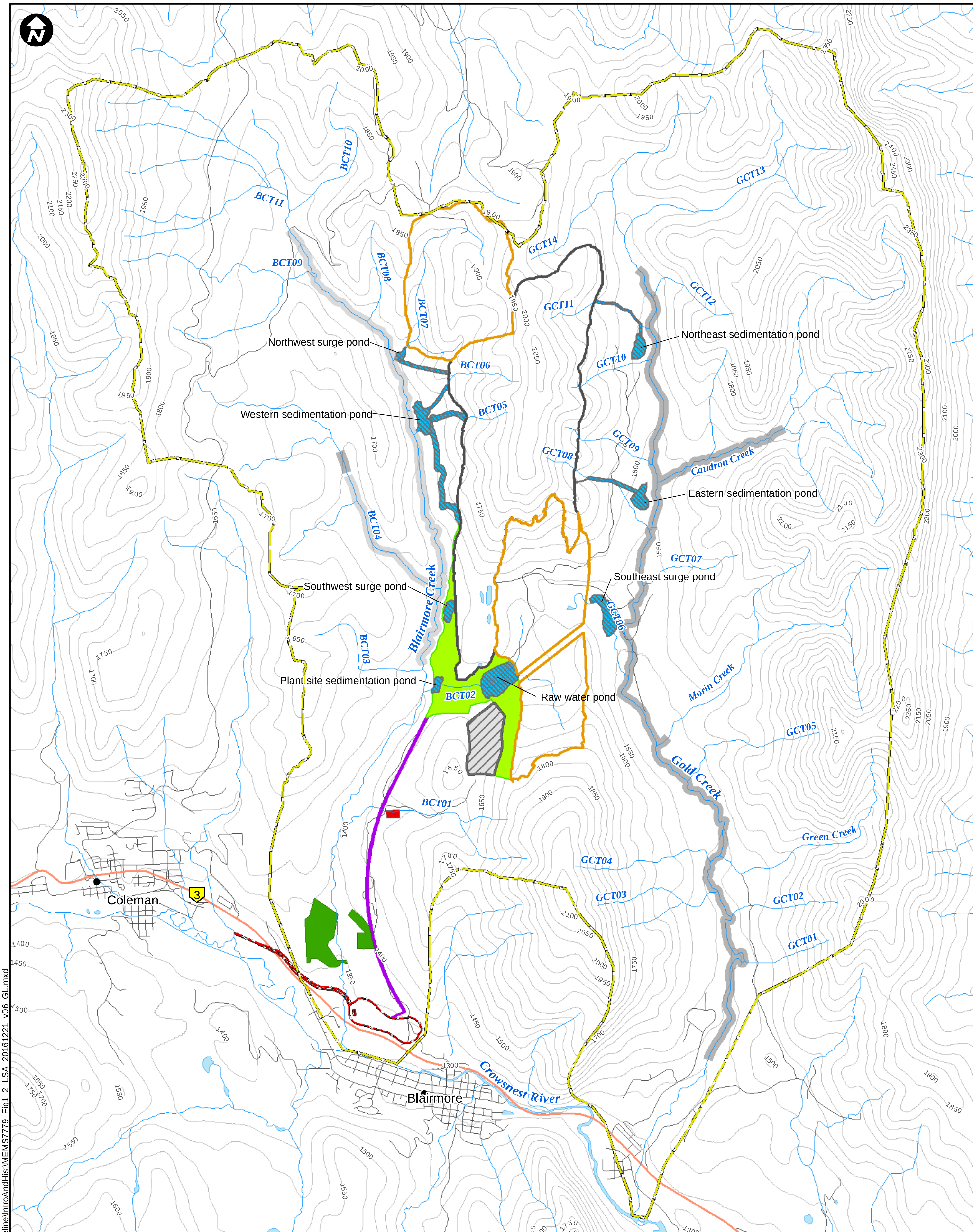
[8] Westslope cutthroat trout can only be reliably identified using genetic testing and the Recovery Plan considers a population to be genetically pure if the average genetic purity of a sample of fish from a creek is greater than 0.99.



Document Path: K:\Data\Project\MEMS7779\A_MXD\AquaticFishTechBaseline\IntroAndHist\MEMS7779_Fig1_2_LSA_20161221_v06_GL.mxd

LEGEND

- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study Area
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area
- Railway Loop

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

Hatfield CONSULTANTS

TITLE

FISHERIES AND AQUATICS LOCAL STUDY AREA

NOTES

Data Sources: Government of Canada, Government of Alberta
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 7779
DRAWN BY: SS / EDITED BY: GL
CHECKED BY: CB
DATE: December 21, 2016

FIGURE

3.1

3.2.2 Temporal Boundaries

The temporal considerations for the aquatic ecology effects assessment are based on the Project description and schedule (Section C.1.3 in Benga 2015) 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).

3.3 ASSESSMENT CASES

The three development scenarios addressed in the aquatic ecology effects assessment are the Baseline Case, the Application Case, and the Planned Development Case.

3.3.1 Baseline Case

The Baseline Case for the aquatic ecology effects assessment represents existing (baseline) environmental conditions without the Project, but include effects from other existing and approved projects or activities (Table D.2.4-2 in Benga 2015). For the purposes of this assessment, it was assumed that any effects of existing projects that aid in defining the Baseline Case for aquatic ecology (fish, fish habitat, lower trophic dynamics) were accurately reflected in data gathered to establish the baseline conditions and other existing projects will not cause any larger or different effects on fish and aquatic resources in the future than currently occur.

3.3.2 Application Case

The Application Case describes the Baseline Case combined with the effects that may result from the Project. The Application Case adds the residual environmental effects of the Project to existing environmental conditions (Baseline Case) in the study areas.

3.3.3 Planned Development Case

The planned development case (PDC) describes the Application Case with the effects of planned developments added. Planned developments include any projects or activities publicly disclosed up to six months prior to the submission of this application. It involves cumulative environmental effects assessment resulting from the designated Project as well as other planned development projects. For this Project, the PDC includes Teck Coal Limited's Coal Mountain Phase 2, 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.

3.4 ASSESSMENT METHODS

3.4.1 Identification of Effects Pathways

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 WSCT (e.g., Dominion Diamond Jay Project, Teck Resources Fording River Operations Swift Project Environmental Assessment). 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.

The first part of the analysis for the Aquatic Ecology Effects Assessment identified potential effect pathways for all stages of the Project. This step was followed by the development of environmental design features and mitigation that can be incorporated into the Project to remove a pathway or limit (mitigate) the effects on VCs. Environmental design features include Project design elements, environmental best practices, and management policies and procedures. Environmental design features and mitigation are developed through an iterative process between the Project's engineering and environmental teams to avoid or limit effects.

The legal framework of both the *Fisheries Act* (1985) and SARA were considered throughout the pathways analysis. Under the auspices of the *Fisheries Act* and the *Applications for Authorizations under Section 35(2)(b) of the Fisheries Act Regulations*, measures and standards to avoid or mitigate "serious harm" to fish is referred to as mitigation and the repair or replacement of habitat is referred to as offsetting. Additionally, the *Critical Habitat of the Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) Alberta Population Order* (the Order), of which was brought into effect under subsections 58(4) and (5) of the SARA on November 20, 2015, was considered to satisfy the obligation to legally protect any part of the species' critical habitat from destruction.

Environmental design features and mitigation actions incorporated into the Project to avoid or mitigate effects on aquatic ecology resources include measures described in the *Surface Water Quality Assessment Report* (Consultant Report #5) as well as the Project's *Surface Hydrology Baseline and Effects Assessment* (Consultant Report #4) and *Water Quality Management* (Appendix 10C), including the following additional measures:

- Scheduling construction activities that use best practices to meet regulatory requirements of DFO, AER, and AEP; and
- The preparation of an Application for Approval under the *Species at Risk Act* or Authorization under the *Fisheries Act*, obtaining an Authorization from the Minister of DFO and implementing an

Offsetting Plan approved by the Minister to offset any identified serious harm to fish, which is defined as the death of fish or any permanent alteration to, or destruction of, fish habitat.

The last step of the pathways analysis involved the application of scientific knowledge, logic, experience with similar developments, including the above-noted environmental design features and mitigation to each of the relevant effects pathways to identify those pathways expected to cause potential residual (remaining) effects. This screening step was largely qualitative and was intended to focus the effects analysis on those specific pathways that required more comprehensive assessment of effects on the VC. Pathways were examined and classified according to the following criteria:

- **No linkage** – Analysis of the potential pathway reveals that there is no valid linkage between the Project and VC, or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change. Thus, the pathway would have no residual effect on a VC relative to the Baseline Case or guideline values.
- **Secondary** – Pathway could result in a measurable minor environmental change, but would have a negligible residual effect on a VC relative to the Baseline Case or guideline values. Therefore, the pathway is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect.
- **Primary** – Pathway is likely to result in environmental change that could contribute to residual effects on a VC relative to the Baseline Case or guideline values.

Primary pathways are anticipated to result in a residual effect on the assessment endpoint defined for WSCT and require further analysis to determine the significance of the residual effect. All primary pathways that have the potential to affect aquatic ecological resources were carried forward for further evaluation through more detailed effects analysis to define aquatic residual effects of the Project (Section 3.4.2).

Linkage pathways were not assessed further if the pathway was identified as not valid or environmental design elements or mitigation removed the linkage. Pathways assigned as secondary and demonstrated to have negligible residual effect on aquatic ecology resources were not advanced for further assessment.

3.4.2 Residual Effects Analysis

The residual effects analysis considers all primary pathways that are likely to result in measurable environmental changes and residual effects on the VC (i.e., after implementing environmental design features and mitigation). Thus, the analysis is based on residual Project-specific (incremental) effects that are verified to be primary in the pathway analysis. To understand the implications of incremental residual effects of the Project alone (Application Case, Section 4.3) or in combination with other reasonably foreseeable planned developments (Planned Development Case, Section 4.4), effects are discussed in the context of existing conditions (Baseline Case, Section 4.1) and the effects of previous and existing projects.

The residual effects analysis predicts changes to measurement indicators associated with the primary Project interactions (primary pathways) that could result in measurable environmental changes to the assessment endpoint, which in this case is defined as the maintenance of self-sustaining, and overall productivity, of WSCT populations. The assessment endpoint was evaluated after implementing identified environmental design features and mitigation actions. Specific to the aquatic ecology assessment, the measurement indicators were identified in Section 3.1.3 of this report.

Each of the measurement indicators contributes to maintaining the assessment endpoint. The habitat quantity and suitability of the available habitats for WSCT and the health of individual WSCT within the populations inhabiting Blairmore and Gold creeks contribute to the productivity of the current population and its ability to remain viable for future generations.

3.4.3 Residual Effects Classification and Determination of Significance

The purpose of the residual effects classification is to describe the residual impacts (post-mitigation) from the Project on aquatic ecological resources using a scale of common words (rather than numbers and units). The definitions for these scales are ecologically or logically based on the characteristics of the aquatic ecology (fish and fish habitat), the associated assessment endpoints, and professional judgment. The classification of impacts is based on the criteria presented in Table 3.6.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to measurement indicators. Significance is determined by the risk to the VC. The following two criteria are followed to evaluate the residual effects:

- **Not significant** – Effects are measurable but are not likely to adversely affect aquatic ecological resources (namely fish and fish habitat) to an extent expected to have a significant adverse effect on WSCT; and
- **Significant** – Effects are measurable and likely to affect fish and/or aquatic resources to an extent that may eventually have an irreversible effect on WSCT.

These lower and upper bounds on the determination of significance are relatively straightforward to apply. It is the area between these bounds where ecological principles and professional judgment are applied to determine the significance.

Table 3.6 Evaluation criteria for assessing the environmental effects.

Criteria	Criteria Definition	
Magnitude	Nil	No change from background conditions anticipated after mitigation.
	Low	Disturbance predicted to be somewhat above typical background conditions, but well within established or accepted protective standards and normal socio-economic fluctuations, or to cause no detectable change in ecological, social or economic parameters.
	Moderate	Disturbance predicted to be considerably above background conditions but within scientific and socio-economic effects thresholds, or to cause a detectable change in ecological, social or economic parameters within range of natural variability.
	High	Disturbance predicted to exceed established criteria or scientific and socio-economic effects thresholds associated with potential adverse effect, or to cause a detectable change in ecological, social or economic parameters beyond the range of natural variability.
Geographic Extent	Local	Effects occurring mainly within or close proximity to the proposed development area.
	Regional	Effects extending outside of the Project boundary to regional surroundings.
	Provincial	Effects extending outside of the regional surroundings, but within provincial boundary.
	National	Effects extending outside of the provincial surroundings, but within national boundary.
	Global	Effects extending outside of national boundary.
Duration	Short	Effects occurring within development phase.
	Long	Effects occurring after development and during operation of facility.
	Extended	Effects occurring after facility closes but diminishing with time.
	Residual	Effects persisting after facility closes for a long period of time.
Frequency	Continuous	Effects occurring continually over assessment periods.
	Isolated	Effects confined to a specified period (*e.g.,* construction).
	Periodic	Effects occurring intermittently but repeatedly over assessment period (*e.g.,* routine maintenance activities).
	Occasional	Effects occurring intermittently and sporadically over assessment period.
Reversibility	Reversible in short-term	Effects which are reversible and diminish upon cessation of activities.
	Reversible in long-term	Effects which remain after cessation of activities but diminish with time.
	Irreversible - Rare	Effects which are not reversible and do not diminish upon cessation of activities and do not diminish with time.
Project Contribution	Neutral	No net benefit or loss to the resource, communities, region or province.
	Positive	Net benefit to the resource, community, region or province.
	Negative	Net loss to the resource, community, region or province.
Confidence Rating	Low	Based on incomplete understanding of cause-effect relationships and incomplete data pertinent to study area.
	Moderate	Based on good understanding of cause-effect relationships using data from elsewhere or incompletely understood cause-effect relationship using data pertinent to study area.
	High	Based on good understanding of cause-effect relationships and data pertinent to study.
Probability of Occurrence Ecological Context	Low	Unlikely
	Medium	Possible or probable
	High	Certain
Significance	Not significant	Effects are predicted to be within the range of natural variability and below guideline or threshold levels
	Significant	Effects of the Project are predicted to cause irreversible changes to the sustainability or integrity of a population or resource

4.0 EFFECTS ASSESSMENT

4.1 BASELINE CASE

This section presents a summary of the setting and characterization of existing baseline conditions for fish and fish habitat, fluvial geomorphology and hydrology that is relevant for the assessment of potential aquatic effects from the Project. The detailed *Fisheries and Aquatic Baseline Technical Report* and *Fluvial Geomorphology Assessment of Blairmore and Gold Creek* are included in Appendix A1 and A2, respectively.

4.1.1 Methods

4.1.1.1 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.

Publically 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). To date, only limited anecdotal information was found with respect to fish habitat assessments, and no information was identified specific to seasonal fish movement or reproduction dynamics specific to either watershed.

Traditional Knowledge

Information was gathered during surveys of traditional knowledge and traditional land use with members of 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).

Project-Specific Field Surveys (2014 – 2016)

Fish habitat assessments were completed from 2014 to 2016 to describe the quality, composition, and distribution of fish habitats throughout the mainstem and tributaries of Gold Creek and Blairmore Creek. Surveys were completed from August 2014 to August 2015 to characterize the biophysical habitat in Gold Creek and Blairmore Creek watersheds targeting the mainstem and tributaries of Gold Creek and Blairmore Creek. Detailed fish habitat assessments were conducted during 2016 to characterize the habitat for two different scales: macrohabitat (reach scale) and mesohabitat (hydraulic unit scale). Barriers were also assessed and documented during these surveys. The 2016 fish habitat surveys followed a modified version of BC's *Fish Habitat Assessment Procedures* ([FHAP], Johnston and Slaney 1996) as described in Lewis et al. (2004), specifically aimed at water withdrawal/alteration projects. Stream temperature monitoring was initiated in 2014 and augmented in 2016 to characterize the baseline stream temperature conditions within the LSA.

Fish inventory surveys were performed from 2014 to 2016 to confirm fish presence, distribution and habitat use within the study area following the regulator approved Work Plan (Hatfield 2016a), Fisheries Research Licenses (FRL) 16-2611, 14-2724 and SARA Permit 16-PCAA-00026. Surveys employed a suite of widely accepted standard protocols, including a combination of active capture methods (i.e., electrofishing) as well as direct visual observation (i.e., snorkel surveys). The goal of these surveys was to characterize fish species composition, distribution and abundance. Given the federal WSCT Habitat Protection Order covering the majority of Gold Creek, an approach that limited electrofishing use was adopted to reduce stress on WSCT. Where habitat conditions permitted, snorkel surveys were conducted throughout Gold Creek and Blairmore Creek mainstems and tributaries.

Information collected during all fish and fish habitat surveys throughout the LSA was used to confirm fish presence and distribution throughout Gold and Blairmore creeks and their tributaries. Results from biophysical and habitat assessments guided fish inventory sampling, by identifying habitats that could potentially be used by fish through the identification of barriers and key habitat features. Surveys for fish population also provided information on fish presence and species occurrence. Surveys targeting specific habitat usage (i.e., overwintering and spawning) were also conducted during 2016. Two methods were employed to calculate population estimates of WSCT in both Gold Creek and Blairmore Creek: relative abundance (using snorkel surveys) and a mark and recapture program (using electrofishing and angling). A blended approach for mark and recapture was undertaken to address the limitations of both techniques in certain habitat types.

To characterize the baseline metal concentrations in fish tissues, non-native trout were targeted given the sensitivities around WSCT and the low species diversity within the LSA. On August 17, 2016 BKTR fish tissue samples were collected from lower Green Creek off of Gold Creek via backpack electrofishing for a maximum of eight samples (n = 8). On October 20, 2016 BKTR, RNTR and/or RNTR x WSCT hybrids tissue samples were collected at locations downstream of the falls on Blairmore Creek via minnow traps for a maximum of eight samples (n = 8). All fish were identified to species (where possible), enumerated, weighed (g) and measured (fork length, cm).

The lower trophic dynamics of Gold Creek and Blairmore Creek were characterized in 2014 and 2016. The 2014 assessment of benthic macroinvertebrates and periphyton was conducted at four locations in the LSA and two locations in the RSA using a Neil-Hess cylinder. Samples were sorted and identified to the lowest practical level by Kilgour and Associates in Ottawa, Ontario. Periphyton biomass sampling occurred at the same sites as benthic invertebrate sampling, where three undisturbed rocks with surficial exposure in proximity to the benthic sample were selected and sampled following standard protocols. The periphyton samples were shipped to ALS Laboratories (Calgary, Alberta) to conduct the chlorophyll *a* analyses. The 2016 assessment of drift invertebrates targeted three sites on each Blairmore Creek and Gold Creek and included sampling across two seasons in June and September using nets, deployed simultaneously across the wetted width of the channel. Samples were submitted to Jack Zloty, Ph.D. in Summerland, BC for processing, and processed following standard protocols based on Environment Canada (2002) and Gibbons et al. (1993). Periphyton chemistry, water and sediment quality data have also been collected and are characterized and assessed in the *Surface Water Quality Assessment Report* (Hatfield 2016b).

4.1.1.2 Fluvial Geomorphology

The following is an overview of the methodology used to characterize the fluvial geomorphology in the LSA. A more detailed description is available in the *Fluvial Geomorphology Assessment of Blairmore and Gold Creek* (Appendix A2).

Land Use Changes

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). Alberta's Land-use Framework (SSRP 2014) was developed as a tool for regional land use and resource planning for an area of 83,764 km^2. Recommended land use categories are less detailed than those suggested by BC MOE (1986), suitable for the regional scale of analysis. The aim of land use change analysis within this assessment was to characterize recent and current condition of Blairmore Creek and Gold Creek Watersheds (total area assessed was 113.8 km^2). Therefore, preference was given to an approach that allowed for more detailed land use classification. Polygons were mapped in 3D in Summit® and ArcGIS™ after stereo models for the aerial photographs were produced. Land use was classified for each year at a 1:20,000 scale. If evidence of previous land disturbance was later absent from the landscape, the area was classified to have "No Perceived Activity". 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.

Project-Specific Field Surveys (2016)

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 (12.6 km along Blairmore Creek from 682925E, 5509923N to 683626E, 5499965N; and 10.1 km along Gold Creek from 687515E, 5509577N to 688600E, 5501125N). In total, 37 sites were assessed on Blairmore Creek, and 44 sites on Gold Creek, as well as 5 sites on Gold Creek tributaries (Caudron Creek, GCT10 and GCT11). 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 method of data collection in the field was adapted from the *Forest Practices Code of British Columbia's Channel Assessment Procedure Guidebook* (BC MOF 1996). The procedures are designed for small- and intermediate-sized channels that are too small to be assessed using aerial photographs. No known Alberta-specific guidelines were available at the time of the analysis.

4.1.1.3 Hydrology

Three LSA hydrometric gauges were installed along Gold Creek in support of the IFA for the Project and the hydrology baseline study (Consultant Report #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.

4.1.2 Results

4.1.2.1 Fisheries and Aquatics Baseline

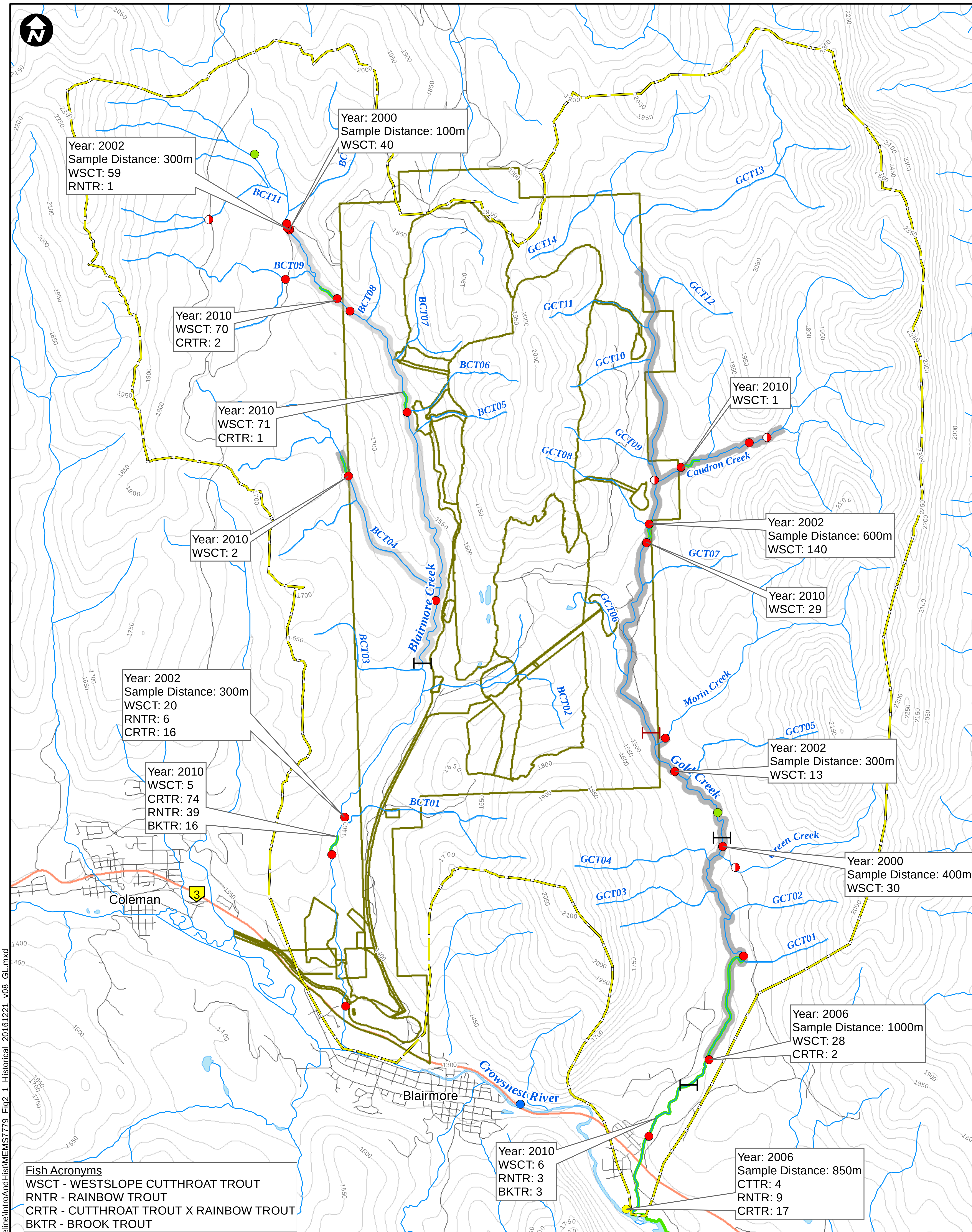
Historical Information

WSCT, RNTR, WSCT x RNTR hybrids, and BKTR have been reported in Gold Creek. The FWMIS does not distinguish between cutthroat trout (*Oncorhynchus clarkii*) and WSCT. However given the distribution of WSCT, cutthroat trout records in the FWMIS have been treated as WSCT. The majority of fish captured upstream of the most southern barrier (i.e., old water supply dam) were BKTR; however the location of their capture is unknown (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.

Gold Creek and Blairmore Creek are mapped Class B watercourses under the *Water Act* Code of Practice, which means they contain habitat important to the continued viability of a species and are considered sensitive to any type of activity. All tributaries of both Gold Creek and Blairmore Creek are also considered Class B habitat for a distance of 2 km upstream from their confluence with the mainstems and Class C habitat beyond that. Class C watercourses contain habitat of moderate sensitivity, which could potentially be damaged by unconfined or unrestricted activities within the waterbody.

WSCT have been documented in two main tributaries to Gold Creek, both of which drain into Gold Creek from the east: Caudron Creek and Morin Creek (Figure 4.1). An assessment conducted in 2002 (AESRD 2013c) characterized Morin Creek as having high fisheries potential, with moderate spawning substrate, high value rearing habitat, and moderate overwintering habitat quality. The extent of Morin Creek surveyed is unknown. Surveys of Caudron Creek in 2002 and 2010 characterized the creek as primarily riffle habitat with sparse pools. Substrate comprised equal proportions of cobble and gravel, sub-dominated by boulder and fines. The precise extent of Caudron Creek surveyed is unknown. Blackburn (2011) estimated the WSCT population abundance in upper Gold Creek to be between 65 and 271 individuals. The federal Recovery Plan designates portions of Morin and Caudron creeks as critical habitat for WSCT (DFO 2014). A fish inventory was also completed in Green Creek, but no fish were detected during the survey.

As with Gold Creek, WSCT, RNTR and BKTR have been recovered in Blairmore Creek. Blackburn (2011) compiled historical sampling records for Blairmore Creek and completed population estimates of WSCT for both upper and lower Blairmore Creek. The population of upper Blairmore Creek WSCT was estimated to be between 121 and 277 individuals, while the lower Blairmore Creek population was estimated between 201 and 310. No publically available information could be found regarding previously conducted fish habitat assessments or spawning surveys.



Document Path: K:\Data\Project\MEMS7779A_MXD\AquaticFishTechBaseline\IntroAndHist\MEMS7779_Fig2_1_Historical_20161221_v08_GL.mxd

LEGEND

- Barrier to Fish Passage
- Barrier to Fish Passage - Seasonal
- Fisheries Inventory Program
- Historical Benthic Survey
- 2009 Crowsnest River Preliminary Tote-barge Electrofishing
- FWMIS Historical Survey (no fish caught)
- FWMIS Historical Survey (fish caught)
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation
- 2010 Crowsnest River tributary sample sites
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study
- Project Footprint

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

Hatfield CONSULTANTS

TITLE

SUMMARY OF HISTORICAL FISHERIES AND AQUATICS BASELINE INFORMATION IN THE LOCAL STUDY AREA

NOTES

Data Sources: Government of Canada, Government of Alberta
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 7779
DRAWN BY: SS / EDITED BY: GL
CHECKED BY: CB
DATE: December 21, 2016

FIGURE

4.1

Traditional Knowledge

The information gathered during traditional knowledge and traditional land use surveys with members of the Aboriginal groups is summarized below (Table 4.1).

Table 4.1 Summary of information on fisheries and aquatic ecology from the Aboriginal groups.

Kainai Nation (Kainai Nation 2015)

- Observation that fish in the mountain areas tend to be smaller than fish at lower elevations
- Fishing is largely a Western practice that has been adopted by the Kanai Nation, including ice fishing in the winter
- Fish are an important source of bait used in furbearer trapping
- Members of the Kainai Nation fish for trout in September each year

Piikanii Nation (Piikanii Nation 2015)

- Generally, members of the Piikannii Nation do not fish
- Fishing becomes important to the Piikanii Nation when other sources of wild food become scarce and was and generally is restricted to times of resource scarcity in other more common sources of traditional food
- The abundance of fish is a good indicator of the health of the ecosystem

Tsuut'ina Nation (Tsuut'ina Nation 2015)

- Three different kinds of trout were observed during ground-truthing activities conducted in support of traditional knowledge and use studies for the Project
- Fish health was identified as an important issue

Siksika Nation (Siksika Nation 2015)

- There is an abundance of wildlife and plants that make up important parts of traditional use of the lands and waters in the Southern Gate, found in the Grassy Mountain Project area
- A workable, effective mitigation strategy and plan for the protection of the animals and water courses extant at the site needs to be developed jointly

Stoney Nakoda Nation (Stoney Nakoda 2015)

- Relevant fish and aquatic species will be elaborated on during the next phase of work

Métis Nation of Alberta Region 3 and Pincher Creek Local 1880 (Métis Nation of Alberta Region 3 and Pincher Creek Local 1880 2016)

- Concerned about impacts to cutthroat trout populations
- Recommend protection to cutthroat trout by following requirements outlined by SARA, follow mitigation plans outlined by Canadian Wildlife Services, improve critical habitat in areas disturbed by previous mining operations, and continue monitoring population and habitat
- Include Métis traditional ecological knowledge in habitat restoration activities
- Consult in the event of a release or incident

Métis Nation British Columbia (C. Gall, personal communication)

- Traditionally fished with members of Stoney Nakoda Nation
- Members reported harvesting trout in the area

Project-Specific Field Surveys (2014 – 2016)

The biophysical habitat in Gold and Blairmore creeks is fairly similar. Both watercourses are dominated by coarse substrate (mostly cobble with some gravel and boulders) and have tributaries with a steep gradient (>20%). There are bedrock chutes in the lower reach of Blairmore Creek, one of which creates a permanent barrier to the upstream migration of fish. Gold Creek has two permanent barriers and one seasonal barrier to upstream fish migration. Based on habitat assessment surveys, Gold Creek was delineated into nine reaches, ranging from 437 to 3,183 m long, 4.2 to 10.8 m wide, with a gradient of 0.5% to 3.3%. Blairmore Creek was delineated into five reaches, ranging from 399 to 3,942 m long, 1.1 to 4.9 m wide, with a gradient of 0.4% to 3.6%. At the mesohabitat level, both Gold and Blairmore creeks are also fairly similar, being dominated by fast-flowing habitats. By area, Gold Creek is dominated by pool-riffle (36%), riffle (30%), and riffle-run-pool (14%), and Blairmore Creek is dominated by riffle (42%), pool-riffle (30%), and riffle-run-pool (14%). Stream temperatures in Gold Creek tended to be cooler (5.4ºC) than Blairmore Creek (8.0ºC), 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 RNTR, RNTR x WSCT, and BKTR are present in Gold Creek and Blairmore Creek, with the presence of barriers largely determining their distribution. Five tributaries to Gold Creek (GCT13, GCT10, Caudron Creek, Morin Creek and Green Creek) and three tributaries to Blairmore Creek are fish-bearing (BCT11, BCT09, and BCT04). The 463 fish captured during the 2016 angling and electrofishing surveys ranged from 6 to 30 cm fork length in Gold Creek, and 2 to 26 cm fork length in Blairmore Creek. Overall fish captured in Gold Creek were larger and the young of the year (YOY) cohort was missing.

Overwintering habitat in both Gold and Blairmore creeks is limited. Pools were at least 0.7 m deep and 10 m long. Four main pools were observed in each creek containing up to 110 WSCT in Gold Creek and 151 WSCT in Blairmore Creek. Spawning was largely driven by available habitat. Larger fish (30+ cm) were observed spawning during the May survey, compared to the June survey (20+ cm) in both Gold and Blairmore creeks. Overall, the upper reaches of Gold Creek contained more spawning WSCT than the lower reaches. Spawning in Blairmore Creek was spread throughout the reaches, with the highest count observed in Reach 4 on the mainstem between BCT06 and BCT05 (22 to 29 mature WSCT).

Gold and Blairmore creeks have a higher density of smaller fish in their upper reaches, compared to their lower reaches which have lower density and larger fish. Density based on snorkel surveys in Gold Creek is estimated at 0.04 to 1.69 fish/m^2 and the estimated density from the mark-recapture is higher, ranging from 0.24 to 13.13 fish/m^2. Density based on snorkel surveys in Blairmore Creek is estimated at 2.41 to 3.37 fish/m^2, and density from the mark-recapture ranges from 0.79 to 26 fish/m^2. Based on the mark-recapture, the estimated total fish in Gold Creek is about half (1,625 fish) that of Blairmore Creek (3,210 fish). Juvenile (YOY, 1+ year) recruitment in Gold Creek appears to be limited, which may be due to the colder water flowing in from Caudron Creek. Based on the Fulton K and Relative Weight condition factors, most of the fish (>50%) sampled in both Gold and Blairmore creeks were in good to excellent condition.

Numerous authors have suggested that persistence of trout populations is related to an abundance of fish within the range of 500 to 5,000 individuals (McIntyre and Rieman 1995, Allendorf et al. 1997, Hilderbrand and Kershner 2000). Gold Creek (Total fish=1,625) is closer to this persistence threshold than Blairmore

Creek (Total fish=3,210). While WSCT occupy a larger portion of the stream in Blairmore Creek (8.4 km) compared to Gold Creek (6.5 km), stream length would not account for these differences alone. Other factors must also be influencing population density.

Levels of the 34 metals tested in collected fish tissues were all low. Concentrations of boron, lithium, and tellurium, were below detection in all trout collected from Gold Creek; concentrations of antimony, beryllium, bismuth, and zirconium were also below detection in over half of samples collected. Concentrations of boron, lithium, tellurium, and zirconium were below detection limit in all trout collected from Blairmore Creek; concentrations of beryllium and bismuth were also below detection in over half of samples collected. Mercury levels were below the concentration (0.5 mg/kg) permitted in fish and fish products specified by the *Canadian Food Inspection Agency* (CFIA 2014) and below subsistence (0.2 mg/kg) and general consumer (0.5 mg/kg) consumption advisory levels of *Health Canada* (2016).

Periphyton biomass was lower in the Blairmore and Gold creeks (i.e., 6.1 to 24.6 mg/m^2) than in the Crowsnest River (i.e., 26.8 to 73.5 mg/m^2), indicating greater primary productivity in the LSA than the RSA. Similarly, densities of benthic macroinvertebrates in 2014 surveys also were higher in the LSA, ranging from a low of 3,892 individuals/m^2 in the LSA to a high of 14,302 individuals/m^2 in the RSA. Mean taxa richness ranged from 26 in the LSA to 42 in the RSA. Diversity values ranged from 0.77 to 0.91 and evenness values ranged from 0.12 to 0.40, indicating relatively diverse communities. The composition of major taxa in communities—i.e., high Ephemeroptera, Plecoptera, and Trichoptera (EPT) and low Chironomidae—indicates cool-water watercourses with erosional substrates and good water quality. Drift benthic community metrics were similar for all locations sampled in Blairmore and Gold creeks in 2016; drift invertebrate biomass, density and diversity were higher in June relative to September. These drift invertebrates provide a primary foraging resource for WSCT in Blairmore and Gold creeks and, under current baseline conditions, greatly contribute to overall stream productivity.

4.1.2.2 Fluvial Geomorphology

Land Use Changes

The total area within the LSA classified to have perceived activity in any of the three years analyzed was 22.0 km^2. This represents 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. It is assumed that areas of historic landscape disturbance may not have been captured due to vegetation regrowth and inability to distinguish evidence of past activity at the scale available through aerial photograph analysis.

Field Assessment (2016)

Gold Creek

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.

Blairmore Creek

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. Bank material is loose and non-cohesive, showing signs of erosion and some undercutting at all sites. 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. Small-scale depositional zones were noted, particularly in pools and above bedrock waterfalls, where median grain sizes ranged from 25 to 95 mm. These finer sediments are likely flushed out during freshet, and deposited as flows wane following upland snowmelt. Large boulders were common in the channel. Reach gradients averaged 2.65% in Lower Blairmore Creek; however, knickpoints (part of a river or channel where there is a sharp change in channel slope) contributed to substantial discrete decreases in elevation along the bed. Banks are predominantly bedrock walls, and vegetation is generally sparser than in upstream sections, particularly where steep slopes occur. No avulsions were observed on Blairmore Creek along the length of assessed channel.

4.1.2.3 Hydrology

Gold Creek

The hydrometric data indicate significant flow variability along the length of Gold Creek. Figure 4.2 displays the estimated long-term mean annual discharge (MAD) values characterizing each study reach. Under normal baseline conditions, 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 and dominated by steep unforested slopes, which enhance precipitation runoff. Significant groundwater contributions dominate Caudron Creek streamflows during drier conditions.

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. Gold Creek temporarily became dry near Lille during exceptionally dry conditions in fall 2016 when the water table dropped below the level of the stream.

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.

Blairmore Creek

Flows along the length of Blairmore Creek are spatially less complex than along Gold Creek. Figure 4.2 displays the estimated long-term MAD values characterizing each study reach delineated for this IFA and other components of the *Fisheries and Aquatics Baseline Technical Report* (Appendix A1). 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.

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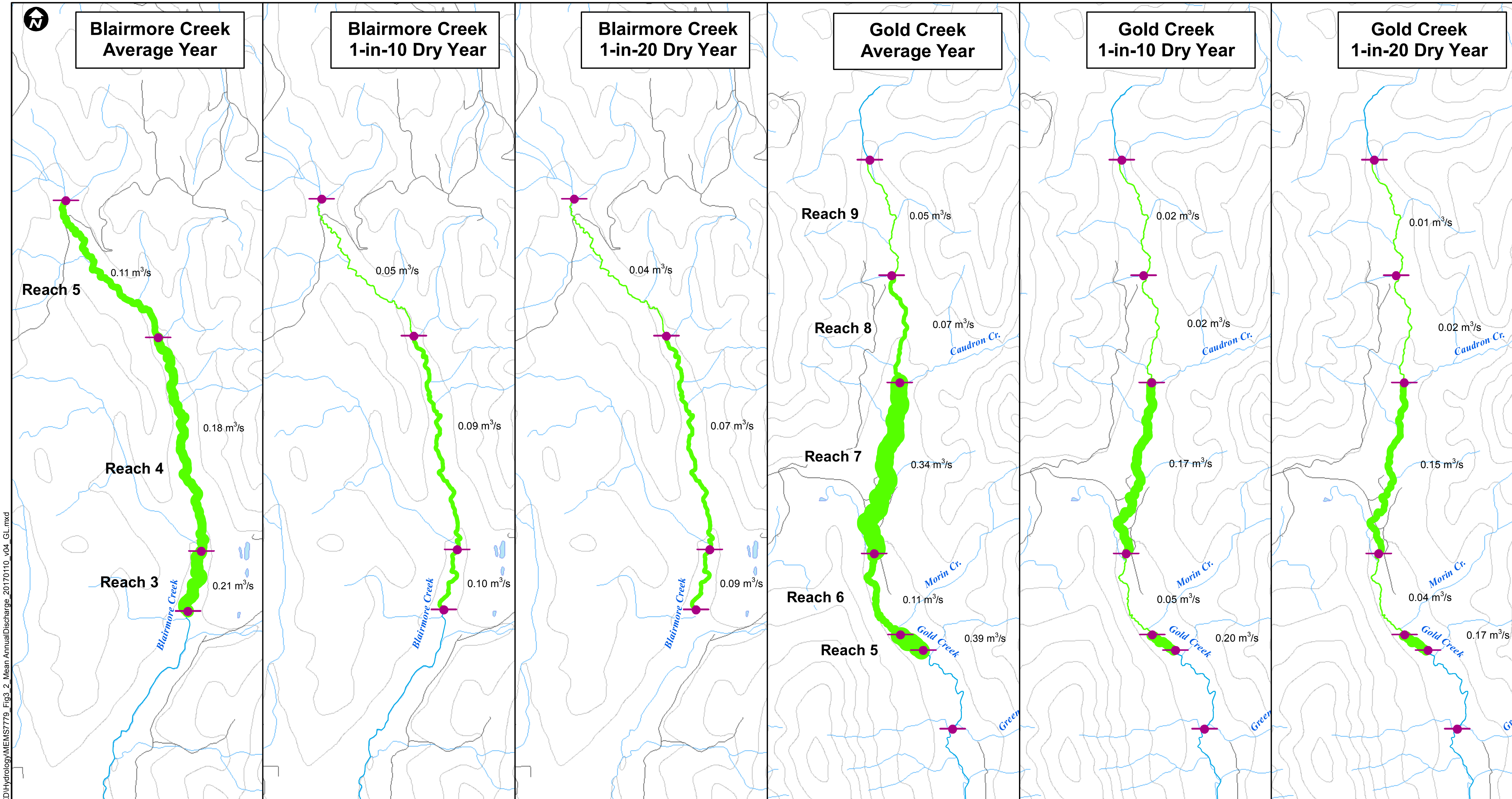

LEGEND

- Macrohabitat Reach Break
- Primary Highway
- Road
- 100m Contour
- Watercourse
- Waterbody

Mean Annual Discharge (m^3/s)

- 0.00 - 0.05
- 0.06 - 0.10
- 0.11 - 0.15
- 0.16 - 0.20
- 0.21 - 0.25
- 0.26 - 0.30
- 0.31 - 0.40

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

TITLE

REACH-SCALE MEAN ANNUAL DISCHARGE (m^3/s) APPLIED WITHIN IFN ANALYSES DURING AVERAGE AND DROUGHT CONDITIONS

NOTES

Data Sources: Government of Canada, Government of Alberta
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

Hatfield Consultants

PROJECT: 7779
DRAWN BY: GL
CHECKED BY: CB
DATE: January 10, 2017

FIGURE
4-2

Document Path: K:\Data\Project\MEMS7779\A_MXD\Hydrology\MEMS7779_Fig3_2_MeanAnnualDischarge_20170110_v04_GL.mxd

4.2 PATHWAYS ANALYSIS

The pathways analysis for aquatic ecology is summarized in Table 4.2 and is discussed in the following sub-sections.

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Table 4.2 Potential pathway for effects on Westslope Cutthroat Trout.

Project Activities	Project Stages	Effect Pathway	Environmental Design Features or Mitigation Actions	Pathway Linkage Assessment
Solid and Liquid Waste Management : Operations, and Fuel Storage and Handling	Construction, Operations, Reclamation and Closure	Changes to surface water, sediment or soil quality, which can affect WCT habitat quantity or suitability, from release or spills of hazardous substances (e.g., fuel and oil)	▪ Fuel storage tanks will be double walled with a capacity of less than 100,000 L ▪ Lube facilities will incorporate secondary containment to capture accidental leaks ▪ Fueling stations will be sited to control drainage in and around the area including end berms to contain spills. ▪ Fuelling stations will undergo regular preventative maintenance inspections ▪ A risk assessment, based on duration and proximity to water will be performed to determine whether the fuel station should be located inside a tertiary containment area to ensure that accidental leaks are captured ▪ In all cases where tertiary containment is installed, the containment areas will be equipped with controlled drainage and containment sumps to collect runoff and spills ▪ Fueling stations will be sited to control drainage in and around the area ▪ Implementation of existing Emergency Response Plan, which includes trained personnel who can be dispatched to control and contain possible spills in a timely manner	No Linkage
Site Preparation, Haul Road Construction, Open Pit Development and Resource Extraction	Construction, Operations, Reclamation and Closure	Changes in recreational access to fish bearing reaches of Gold and Blairmore creeks	▪ Educating Project workforce about WSCT and the existing AESRD regulations for the species ▪ Prohibiting public access from the Project footprint ▪ Policy for access to site by authorized users	No Linkage
Site Preparation, Open Pit Development and Resource Extraction	Construction, Operations	Blasting activities potentially causing direct mortality of WSCT	▪ Standard Operating Procedure following blasting guidelines outlined by Wright and Hopky (1998) ▪ Minimizing potential for additive effects by limiting blasts to once every 8 ms	No Linkage
Site Preparation, Soil Salvage and Haul Road Construction ▪ timber extraction ▪ clearing of vegetation ▪ access construction	Construction	Changes in water temperature, which may cause changes to the thermal regime, affecting WSCT habitat quantity and suitability	▪ Maintain appropriate riparian reserves and management zones from watercourses, where feasible ▪ Construction of online settling ponds for clean (non-contact) water and mine-influenced (contact) water in lowest reach of affected tributary streams ▪ Fish salvage from affected fish-bearing reaches ▪ Surface water management structure design and mitigation actions consistent with regulatory standards ▪ Monitoring discharges and ambient variables in receiving environments to ensure that water quality is within tolerances for WSCT ▪ Layout and design of the waste rock spoil areas within the affected watersheds reduces the area that is disturbed by construction ▪ Collection, diversion and treatment of mine-influenced surface flows ▪ Redirection of non-affected surface water flows around rock drains, where feasible (i.e., clean water diversions) ▪ Progressive reclamation to accelerate revegetation, reforestation and end land uses specified in the Reclamation and Closure Plan	Secondary Linkage
Surface Water Management and Active Water Treatment ▪ construction and operation of active water treatment facilities (e.g. Saturation Zones) ▪ collection, diversion and treatment of mine-influenced surface flows ▪ discharge of treated effluent ▪ settling ponds and erosion control	Construction, Operations			
Waste Rock Placement ▪ rock drain development ▪ development of waste rock spoils ▪ land reclamation	Operations, Reclamation and Closure			
Surface Water Management and Active Water Treatment ▪ collection, diversion, and treatment of mine-influenced surface flows ▪ discharge of treated effluent ▪ settling ponds and erosion control	Construction, Operations	Changes in WSCT food supply in Gold and Blairmore creeks, which can directly affect WSCT as well as their habitat quantity or suitability	▪ Monitoring of Gold Creek flows will be conducted to determine if any mitigation actions are needed to address potential changes in surface water flows in Gold Creek during the implementation of water management features that could affect invertebrate biomass	Secondary Linkage

Table 4.2 (Cont'd.)

Project Activities	Project Stages	Effect Pathway	Environmental Design Features or Mitigation Actions	Pathway Linkage Assessment
Open Pit Development and Resource Extraction ▪ pit excavation and coal extraction ▪ pit pumping/dewatering Waste Rock Placement ▪ rock drain development development of waste rock spoils	Operations			
Reclamation and Closure ▪ pit refilling, including return of hydrology to long term steady state	Reclamation and Closure			
Site preparation ▪ clearing of vegetation ▪ grubbing ▪ timber extraction ▪ access construction	Construction	Changes to sediment supply, transport mechanisms and sediment yield, which can affect WSCT habitat quantity and suitability,	▪ Water will be discharged to watercourses in a manner that does not cause erosion or other damage to adjacent areas ▪ Potential increases or reductions in surface water flows in Gold and Blairmore creeks that could affect the natural flow regime will be mitigated (if necessary) by managing the timing, discharge volume and location of water to mimic the natural flow regime and maintain flow increases or reductions within acceptable limits ▪ Implement erosion and sediment control based on industry standards ▪ Disturbed areas (e.g., access roads and banks) will be graded to a stable angle after work is completed, reclaimed and revegetated ▪ Salvaged soil will be stored on-site and away from surface waterbodies ▪ Erosion control practices will be applied to salvaged soil to reduce potential erosion and sediment transport off-site ▪ Materials used for shoreline stabilization will be clean and free of fine sediments and contaminants ▪ Mine-influenced runoff and pit water will be directed to existing or planned water management infrastructure (e.g., settling ponds) ▪ Site drainage and surface runoff will be managed through the incorporation of erosion control methods (e.g., ditch blocks, silt fences) so that overland flow does not direct sediment-laden water into any natural watercourses ▪ Water will be discharged to watercourses in a manner that does not cause erosion or other damage to adjacent areas	Secondary Linkage
Surface Water Management and Active Water Treatment ▪ discharge of treated effluent ▪ settling ponds and erosion control ▪ construction and operation of active water treatment facilities ▪ Collection, diversion, and treatment of mine-influenced surface flows	Construction, Operations			
Open Pit Development and Resource Extraction ▪ pit excavation and mining of coal resources Waste rock placement ▪ rock drain development ▪ development of new waste rock spoils	Operations			
Reclamation and Closure ▪ pit refilling	Reclamation and Closure			

Table 4.2 (Cont'd.)

Project Activities	Project Stages	Effect Pathway	Environmental Design Features or Mitigation Actions	Pathway Linkage Assessment
Surface Water Management and Active Water Treatment ▪ construction and operation of active water treatment facilities ▪ collection, diversion and treatment of mine-influenced surface flows ▪ discharge of treated effluent ▪ settling ponds and erosion control ▪ pumping activities ▪ pit refilling	Construction, Operations, Reclamation and Closure	Changes to surface water quality, which can affect WSCT habitat quantity and suitability and/or survival and reproduction, from surface water runoff, surface and groundwater interactions and discharge of mine-influenced water	▪ Clean-water (i.e., runoff collected from natural non-disturbed areas; non mine-influenced water) will be directed around waste rock and pit areas ▪ Water quality will be managed to comply with water quality criteria that are protective of aquatic health including WSCT ▪ Techniques identified in the mine plan and water management plan to mitigate mine-influenced water aimed to avoid the potential for water quality effects that can affect fish and fish habitat	Secondary Linkage
Waste rock placement ▪ rock drain development ▪ development of new waste rock	Operations, Reclamation and Closure			
Waste rock placement ▪ rock drain development ▪ development of waste rock spoils	Operations, Reclamation and Closure	Calcite precipitation, which can affect WSCT habitat quantity or suitability, may result from surface runoff emanating from the Project footprint and discharge of treated effluent	▪ Compact layout of the waste rock spoil areas within local watersheds will limit the area of waste rock that may come into contact with surface water systems ▪ Calcite monitoring and management is proposed to monitor the potential formation of calcite in Gold and Blairmore creeks and to control precipitation of calcite to within acceptable level (if necessary)	Secondary Linkage
Surface Water Management and Active Water Treatment ▪ development of infrastructure to collect, divert, treat and discharge mine-influenced surface flows ▪ settling ponds and erosion control	Construction, Operations	Changes to aquatic and/or riparian habitat for WSCT associated with implementation of surface water management, mining and waste rock placement	▪ Size of the Project's physical footprint has been minimized through proactive mine design ▪ Existing infrastructure, rather than new infrastructure, will be used or upgraded where feasible and sustainable ▪ Separate *Fisheries Act* Authorizations and/or SARA Approval, will be obtained prior to construction ▪ Project footprint will be minimized to the extent possible through storing of waste rock in existing disturbed locations and making best use of existing facilities, including through backfilling mined-out pits ▪ Offsetting measures will be implemented to counterbalance any permanent loss of fish habitat where serious harm to fish and fish (critical) habitat cannot be avoided	Primary Linkage
Open Pit Development and Resource Extraction ▪ pit excavation and resource extraction Waste Rock Placement ▪ rock drain development ▪ development waste rock spoils	Operations			
Surface Water Management and Active Water Treatment ▪ collection, diversion, and treatment of mine-influenced surface flows ▪ settling ponds and erosion control	Construction, Operations	Changes to hydrology resulting in the alteration of aquatic habitat of Gold and Blairmore creeks, which can affect WSCT habitat quantity, suitability or connectivity through the implementation of the water management plan and mine operations	▪ Offsetting measures will be implemented to counterbalance any permanent alteration to, or destruction of, fish (critical) habitat, where serious harm cannot be avoided ▪ Water will be pumped to the upper reaches of Gold Creek (above Caudron Creek confluence) to mitigate potential incremental reductions in flows in Gold Creek during low flow periods (e.g. 1:10, 1:20) during operations, as deemed necessary ▪ Monitoring of groundwater-surface water interactions and contributions to Gold Creek as on-site water management features are implemented	Primary Linkage

4.2.1 Pathways with No Linkage

4.2.1.1 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. Subject to spill volume, concentrations and transport mechanisms, releases of hazardous substances could contaminate runoff and surface water that could cause acute or chronic effect on the different life stages of WSCT as well as their food sources. 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).

Several environmental design features and mitigation actions and policies have been developed as part of the Project Environmental Management Plan to specifically reduce the potential for, and mitigate effects of, spills and leaks on WSCT and the species habitat, should a spill or leak occur. Spill containment supplies will be made available in designated areas. Additionally, the spill response procedure developed for the Project will include instruction for rapid response, control, and management of land- and water-based spills on site.

During construction and early operations years, fueling and lube maintenance will occur at the CHPP Maintenance Shop, which is 300 m from Blairmore Creek. During later operations years fueling may occur at one or two stations within the pit areas. At those stations fuel will be stored in double-walled tanks with a capacity of less than 100,000 L. Where oil-water separators are installed, they will be visually inspected continually to check for any potential petroleum bypass or other malfunctions. Stations will be sited to control drainage in and around the area, and would be located at least 300 m away from any watercourse. Recovered product and contaminated materials will be handled and disposed of as per the Environmental Management Plan developed for the Project.

Implementation of the above-mentioned environmental design features and mitigation actions is 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 to surface water and/or sediment as a result of the release of process-related water is assessed in the *Surface Water Quality Assessment Report* (Hatfield 2016b).

4.2.1.2 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. Possible initiatives include:

- Raising awareness among the Project workers of the existing provincial and federal regulations for the species found in the LSA;
- Educating the Project workforce on the benefits of the practice of catch-and-release angling; and
- Discouraging fishing by Project employees within the LSA.

In addition, public access will not be permitted within the Project mining footprint which includes haul roads or other access routes. Benga has developed a policy that will be used to facilitate access to the Project site by authorized users. Access control will be undertaken to both allow and restrict access to the Project area. The appropriate level of access control will be based on the level of risk to public safety and need to protect Project infrastructure.

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.

4.2.1.3 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). Additionally, as a standard operating procedure for the Project, delays will be used in all blasts to limit the explosive weight charge to one hole within any eight-millisecond timeframe so as to eliminate any additive effects from blasting due to constructive interference.

Implementation of the above-mentioned 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.

4.2.2 Secondary Effect Pathways

4.2.2.1 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. Modifications to stream temperatures can affect the suitability of overwintering, spawning, and rearing (foraging) habitats, food supply, life history cues (i.e., incubation, migration), that may ultimately affect the ongoing productivity of WSCT including their ability to maintain self-sustaining populations.

Many streams experience diel temperature flux and a range in daily temperature of more than 5°C is very common. However, the high latent heat of water can cause stream temperatures to vary much more narrowly on a daily basis than air temperatures (Hauer and Lamberti 2006). Factors such as groundwater input and riparian shading can have a large influence on stream temperature (Hauer and Lamberti 2006, Leach et al. 2012) leading to high variation in stream temperatures between habitats only a few meters apart (Hauer and Lamberti 2006, Kalb 2013). Fish move throughout waterbodies, in response to changes in temperature: as water temperature declines in the fall, juveniles move downstream seeking out deep pool habitat and other protected areas to overwinter (Jakober et al. 1998).

During construction and operations, the removal of vegetated areas, site preparation and soil salvage, waste rock placement, and surface water management have the potential to alter stream temperature in Gold and Blairmore creeks including associated select tributaries.

Sediment settling ponds will be constructed along the west side of Gold Creek (southeast surge pond [SESP], eastern sedimentation pond [ESP], northeast sedimentation pond [NESP]) and east side of Blairmore Creek (plant site sediment pond [PSSP], southwest surge pond [SWSP], west sedimentation pond [WSP], northwest surge pond [NWSP]) through select tributaries (GCT11, GCT08, GCT06, BCT02, BCT05, BCT06). Construction of these ponds will increase surface area and could result in subtle water temperature increases or decreases depending on the season and the extent to which groundwater may be intercepted. Tributary water that does not require treatment through the saturation zone and/or water treatment plant (if required) will flow through these ponds through the Operations phase of the Project.

Monthly total flow changes were predicted from the start of construction (2018) until the end of mine (2099), at five (5) model nodes each on Gold Creek and Blairmore Creek. These were calculated using a watershed model (Appendix 10B) developed using regional precipitation data, assumptions on runoff yield between undisturbed and disturbed watershed areas, and the Project WMP for controlling surface waters and groundwater affected by mine operations. Mine operations were grouped into the following main phases, including construction (2018), operations (2019 to 2042), decommissioning (2043 to 2044) and closure (2045 to 2099). The predicted total flow changes did not differentiate between the constituents of runoff (i.e., surface channel flow, interflow, and groundwater); therefore, there was assumed to be no difference between predicted changes in total and surface channel flow.

For each discharge time-series used within the stream-temperature modelling, monthly Project flows from 2018 to 2099 were simulated by applying the predicted flow changes from the most appropriate node to the appropriate mean monthly discharge (MMD) baseline (2017) time-series outlined above. Separate datasets for each node were generated, including; (1) during average hydrologic conditions throughout 2017-2099, and (2) during low-flow (drought) conditions throughout 2017 to 2099 (see Appendix A3 for more detail).

Project effects on creek water temperature were modelled using the *System for Environmental Flow Assessment* (SEFA) program. The Theurer Method was used to predict maximum water temperature downstream of each site (Jowett et al. 2014). Meteorological and water temperature time series data for an upstream and downstream site were used to calibrate the model. Changes in water temperature were assessed by taking the difference between predicted water temperature used to calibrate the model (using baseline flows) and predicted water temperature using forecasted flow changes for each phase of the mine. To determine how predicted changes in water temperature may affect each identified bioperiod of WSCT, changes in predicted water temperature relative to observed water temperatures were then compared against literature-based optimal temperature ranges for each bioperiod.

Model outputs predict that forecasted flow changes throughout all phases of the mine will cause little to no change in maximum daily water temperature for both Gold and Blairmore creeks (see Appendix A3 for more detail). For Gold Creek, differences between predicted baseline water temperature (using baseline flow data) and predicted Project-affected water temperature using forecasted flow data ranged from -0.32 to +0.19°C for months March to October across all mine phases and seasonal conditions.

Overall, the preferred temperature range of WSCT is 9 to 12°C (Alberta Westslope Cutthroat Trout Recovery Team 2013) and they are rarely found in waters exceeding 22°C (Behnke and Zarn 1976). More recent work by Bear et al. (2007) found the upper incipient lethal temperature of WSCT is 19.6°C. Observed baseline water temperatures in both Gold and Blairmore creeks were found to exceed the preferred temperature range, but did not exceed, and are not predicted to exceed, incipient lethal temperatures throughout the lifetime of the mine.

Predicted changes in water temperature were compared against optimal temperature ranges for each bioperiod (Appendix A3). Predicted increases in temperature with flow change during egg incubation (+0.20°C for Gold and +0.05°C for Blairmore) are negligible relative to baseline water temperatures at this time, which are warmer than optimal ranges for egg incubation by +6-9°C. Thus, it is unlikely that the relatively small predictive increase in temperature will result in any incremental adverse effect on incubation (e.g., earlier emergence), and the predicted decrease in temperature (-0.17°C for Gold and -0.25°C for Blairmore) would only shift temperatures towards the species preferred incubation range. However, decreases in flow predicted in Gold Creek could lead to lower hyporheic flow, the flow through subsurface sediment and porous space adjacent to stream, and an increase of deeper groundwater, which contains less dissolved oxygen, in spawning beds. Less deoxygenated water could cause decrease of egg and larvae survival (Bradford and Heinonen 2008). However, given the predicted flow reduction for Gold Creek this outcome is not expected.

For rearing, a maximum daily temperature between 13°C and 15°C ensures suitable thermal temperature for WSCT, with optimum growth occurring at 13.6°C. Bear et al. (2007) found that 15°C is the upper range for optimal growth of WSCT. Baseline water temperature during the rearing window is colder (-3°C) and warmer (+2°C for Gold Creek and +3°C for Blairmore Creek) than the preferred temperature range (Table 3) and exceeds the upper range at which optimum growth for WSCT occurs, by 2-3°C. In comparison, the predicted increase in temperature of +0.09 to 0.13°C with changes in flow is negligible and unlikely to cause any effects on WSCT rearing (nursery, feeding, holding).

Stream temperatures during overwintering already reach near-freezing temperatures. A further decrease in temperature could be problematic in Gold Creek given flows are projected to decrease, which could accentuate the freeze-up of overwintering habitat. Frozen conditions can further exacerbate already stressful conditions with the potential of frazil ice, which can damage gill tissues, and the availability of invertebrate food sources could be compromised (Bradford and Heinonen 2008). The potential effects to overwintering will ultimately be manipulated by the contribution(s) of groundwater influx during mine operations once water management features are implemented on site as the ongoing maintenance of WSCT overwintering habitat may be largely determined by this factor (Brown and MacKay 1995).

The collection of stream temperature data is ongoing in both Gold and Blairmore creeks through the deployment of hydrometric stations established throughout both Blairmore and Gold Creek watersheds and supplemented with additional continuous temperature data loggers (Onset Computer Corporation, Cape Cod, Massachusetts: Hobo Model UA-002-66). This data will further document baseline temperature during the winter season (October to April) as well as characterize mainstem seasonal variation associated with WSCT habitat use under varying conditions. Furthermore, Benga has partially funded the University of Lethbridge to study WSCT overwinter habitat use in both Gold and Blairmore creeks. The thermal profile being generated from this baseline dataset will be used to further understand the importance of temperature fluctuations during the overwintering period.

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).

4.2.2.2 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. Invertebrate drift refers to the downstream transport of aquatic organisms normally living in or on the stream bottom substrates by water currents. Drift can result from active (i.e., behavioral) and passive (i.e., accidental) movements into the current (Wiley and Kohler 1984) and is an important mechanism for the dispersal of invertebrates to habitats downstream in both Gold and Blairmore catchments. Invertebrate drift represents a key source of food for fish consumers (Wipfli and Gregovich 2002), in particular WSCT, which, unlike other cutthroat sub-species, tend to specialize as invertebrate feeders (AESRD and ACA 2006, Shepard et al. 1984) and feed on a mix of aquatic and terrestrial invertebrates depending on life stage.

Early studies at Teck Coal's Fording River Operations (Lister and KWL 1980) found aquatic insect larvae to be the primary food item in WSCT stomachs. Ephemeroptera (mayflies, most commonly *Baetis* sp. and *Cinygmula* sp.) was the most common insect group found, followed by Diptera (true flies, predominantly midges) and Plecoptera (stoneflies). Larger WSCT had a much more diverse diet, comprised of greater incidence of adult insects. Although stomach contents were not assessed during Project baseline studies, the invertebrate drift in Blairmore and Gold creeks in 2016 was comprised predominantly of terrestrial invertebrates and *Baetis* sp., which likely are key food sources for WSCT in both systems (Appendix A1).

The Project will remove select tributary habitat in the aquatic LSA as part of the site water management activities (e.g., placement of surge and/or settling ponds). The Project will incorporate a WMP that includes four sedimentation/release ponds, four surge ponds, and numerous contact water ditches. In addition, contact water will be routed into backfilled pits once they become available to create saturated zones suitable for attenuation of mine waste water.

Changes to riparian and/or aquatic habitat as a result of the Project footprint are described in detail in Section 4.2.3.1. The SESP, ESP, NESP as well as pit excavation and/or waste rock placement will remove approximately 5,979 m^2 of aquatic habitat from Gold Creek tributaries GCT06 (1,592 m^2), GCT08 (1,223 m^2), GCT09 (390 m2), GCT10 (208 m2), and GCT11 (2,016 m^2 (Table 4.3). There is no aquatic habitat loss predicted for Gold Creek mainstem as a direct result of the Project footprint. Furthermore, a total of 141,830 m^2 of riparian habitat in Gold Creek watershed will be permanently affected as a result of the same activities. Of this total, only 17 m^2 has been rated as high value habitat, while 110,584 m^2 has been rated medium value, and 31,229 m^2 is of low value (Table 4.4).

The construction of the camp, ROW, waste rock placement, sedimentation ponds, and pit excavation activities will remove approximately 19,929 m^2 of aquatic habitat from Blairmore Creek tributaries along the east side of Blairmore Creek (Table 4.3). There is no aquatic habitat loss predicted for Blairmore Creek mainstem as a direct result of the Project footprint. Furthermore, a total of 442,433 m^2 of riparian habitat in Blairmore Creek watershed will be permanently affected as a result of the same activities. Of this total, only 3,123 m^2 is of high value habitat, while 332,619 m^2 is of medium value, and 106,688 m^2 is of low value (Table 4.4).

Studies evaluating invertebrate drift distances in stream environments have generally found that invertebrate drift is short, indicating that drift typically originates from the area immediately upstream, rather than from a cumulative contribution from the upper stream (headwater) reaches. Under average flow conditions, most field-based studies have estimated that daily drift distances in stream habitats range from less than 1 m to typically no more than 100 m (Otto 1976; Hemsworth and Brooker 1979; Waters 1972; McLay 1970), depending on local conditions and taxa present. In terms of prey budget, various studies have suggested that even at low flows, headwater streams can move limited quantities of invertebrates. Using a watershed model, Wipfli and Baxter (2010) estimated that given an average export rate of 1.2 mg invertebrate dry mass/m^2/day, which was obtained from 52 headwater streams in southeastern Alaska (Wipfli and Gregovich 2002), headwater inputs contribute roughly 12.4% of the total salmonid diet in anadromous habitats during the summer. Local contributions to diet (i.e., food production within fish habitat) were estimated to be 24.1%, roughly double headwater (upstream) contributions. Given the relatively small distances travelled by invertebrates under normal flow conditions experienced during the summer season, it is likely that a considerable proportion of the tributary habitat lost due to the Project would not contribute measurably to the invertebrate biomass present in either the Gold Creek or Blairmore Creek mainstems, even under baseline conditions. Additionally, the flow changes in both Gold and Blairmore creeks are not expected to alter invertebrate drift, whether it is short or moderate distances.

Although it is expected that Project-related habitat losses in tributaries could adversely affect the quantity of invertebrate food exported downstream in Gold and Blairmore creeks, the relative contribution of these areas to the total invertebrate biomass in each watercourse is predicted to be minimal to what is generated by each mainstem stream. Even under existing conditions, Gold and Blairmore creeks provide substantially more habitat for invertebrate productivity and convey a much greater volume of water than the tributaries. As a result, any residual change to invertebrate biomass drift in Gold Creek or Blairmore Creek is likely to be limited to the immediate area below the confluence of each tributary. Effects of these areas are predicted to be minor, and the density of macroinvertebrates in both Gold and Blairmore creeks is not expected to change significantly from values observed during the Baseline Case. Additionally, the predicted changes in flow in Gold Creek and Blairmore Creek mainstems is not expected to alter macroinvertebrate productivity and/or drift.

In summary, 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.

4.2.2.3 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.

Suspended sediment and bedload movement are natural geomorphic processes that maintain and rejuvenate fish habitat and maintain healthy aquatic ecosystems. Sediment transport is differentiated between sediment that is suspended in the water column and those that have settled from suspension and form part of the bedload. The factors that determine if sediments are in suspension or are settled are determined by the shape and mass of sediments.

A fluvial geomorphology assessment (Appendix A2) was completed on Blairmore and Gold creeks for the Project. The geomorphic effects assessment explored potential changes in channel characteristics and geomorphic processes resulting from proposed flow changes throughout the lifetime of the mine and following closure, with an emphasis on changes that may affect aquatic and riparian habitat.

The Project will incorporate a WMP that includes four sedimentation/release ponds, four surge ponds, and numerous contact water ditches. In addition, contact water will be routed into backfilled pits once they become available to create saturated zones suitable for attenuation of mine waste water.

As part of the Project's WMP, a series of ditches are proposed on the east slopes of the Blairmore Creek Watershed and the western slopes of the Gold Creek Watershed. These ditches will intercept groundwater and surface water and direct them towards sedimentation ponds. The collected water will then be discharged back into Blairmore Creek at specific nodes to minimize impacts to flow, and in volumes proportional to the size of the catchment areas at each node.

As the mine footprint area increases over time, the undisturbed catchment area decreases and a reduction in peak flows in both Blairmore Creek and Gold Creek is predicted to occur.

Stream geomorphology results from the interaction between flow, sediment, and channel form, and, as such, alteration of one of these components can impact the other components and result in substantial changes to the characteristics of the reach. The Project WMP does not involve direct extraction from the creeks; tributary and groundwater flow from slopes will be diverted and reintroduced at nodes in Blairmore Creek (Appendix A2, Appendix 10B).

Reductions in peak flow (Appendix A2) have the potential to alter sediment transport within the channel. Corresponding changes in the current patterns of deposition and erosion may lead to alteration in the bed morphology (reach type) observed at each site during field surveys. In addition, the rate, volume and caliber of sediment delivered to Blairmore Creek and Gold Creek via hillslope flows (including surface and groundwater flows) may be altered.

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. Bank material is loose and non-cohesive, showing signs of erosion and some undercutting at all sites. The section is heavily influenced by LWD and large boulders positioned within the channel that control 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. Small-scale depositional zones were noted, particularly in pools and above bedrock waterfalls, where median grain sizes ranged from 25 to 95 mm. These finer sediments are likely flushed out during freshet, and deposited as flows wane following upland snowmelt. Large boulders were common in the channel. Reach gradients averaged 2.65% in Lower Blairmore Creek; however, knickpoints contributed to substantial discrete decreases in elevation along the bed. Banks are predominantly bedrock walls, and vegetation is generally sparser than in upstream sections, particularly where steep slopes occur. No avulsions were observed on Blairmore Creek along the length of assessed channel.

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.

Peak discharges are generally expected to decrease through the Project lifecycle (Consultant Report #4). The effects of decreased peak discharge were explored through analysis of sediment mobility. Channel beds are expected to become more stable through time due to decreases in peak flows. Gravel deposition will likely be enhanced in some locations but channel aggradation is not expected due to the nature of the steep channels.

Under the current WMP, and in particular in Blairmore Creek, low flows may increase during the Project lifecycle to discharge effluent from the mine site at discrete nodes. However, stream channels are formed during peak discharges while sediment is mobile, therefore, the changes in low flows in both Gold and Blairmore creeks are not expected to alter the morphology of the stream channels due to the low shear stresses that result from these flows.

Based on the findings from the fluvial geomorphology assessment (Appendix A2) 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).

4.2.2.4 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). Specifically, Project activities including surface water management, open pit development, waste rock placement, storage of coal rejects and tailings, and site reclamation have the potential to alter surface water quality in both Gold and Blairmore creeks and associated tributaries. Changes to surface water quality can alter the health of WSCT and subsequent suitability of fish habitat in affected watercourses, which could adversely affect WSCT populations in the LSA and potentially RSA.

An assessment of Project-related effects on surface water quality is presented in the *Surface Water Quality Assessment Report* (Consultant Report #5). Water quality modeling for 39 variables was used to simulate concentrations within the LSA and RSA and the resulting predictions were compared to water quality guidelines and objective values to identify variables of concern for the Project. The water quality model included all watercourses potentially affected by the Project: the RSA includes the entire Crowsnest River watershed, so that potential cumulative effects could be evaluated, and the LSA includes Gold Creek and Blairmore Creek watersheds.

Based on the anticipated management of runoff and controlled release rates from sedimentation ponds, negligible effects are anticipated on water quality from sediment-associated inputs. All process water with elevated selenium, nitrogen species, and other constituents will be treated in surge ponds and saturated zones with sufficient water residence time. All other elevated metal concentrations will be treated in treatment facility before releasing to the environment. All regulated water quality variables were within Alberta water quality guidelines except for sulphate, which is predicted to exceed Alberta water quality guidelines for the protection of aquatic life.

Site facilities and associated Project components will be constructed to comply with regulatory guidelines and best management practices (BMPs), to minimize the potential for leaks and spills. Pipelines and storage areas will be inspected and maintained regularly. Emergency spill procedures will be in place for rapid spill containment and clean-up. Therefore, potential effects on water quality from leaks and spills will be minimized.

Facility sewage will be collected and treated in a sewage treatment package plant located on the MIA pad. The treatment plant will treat all sewage produced at the MIA facilities and has been based on an estimated sewage treatment requirement of 30 m^3/day. Effluent water quality will be in accordance with relevant regulations as well as appropriate standards. The treatment plant effluent produced will be pumped to the PSSP located adjacent to the coal handling and preparation plant (CHPP) product stockpiles. Excess sludge will be collected for removal from the package treatment plant by vacuum trucks and disposal off site. Sewage and grey water from the CHPP service buildings will be pumped to the water treatment plant for processing and discharge.

Negligible effects are predicted from treated domestic wastewater releases on water quality of receiving surface waters. To minimize the nitrogen species, packaged explosives will be kept on-site, all runoff from the ammonium nitrate storage areas, mine pits, and mine rock piles will be contained within the water management system and treated in saturated zones. The average acid deposition due to Project air emissions is less than the monitoring level for the moderately sensitive ecosystems, therefore acidification effects are not expected to occur due to aerial emissions of the Project.

In conclusion, different water quality issues due to the Project activities would be addressed by applying appropriate mitigation measures. Effects of process-related water release are predicted on sulphate in the receiving surface water environments. The predicted sulphate concentrations were above the range of hardness-dependent sulphate guideline value which is 429 mg/L for a maximum hardness level of 250 mg/L. Therefore, development of a site-specific sulphate objective based on site water hardness is recommended. Water quality model outputs should be considered as information for decision-making rather than representing absolute predictions of receiving water quality; monitoring vigilance is recommended to track and identify any trends in water quality and further refine model predictions.

A baseline quantification of tissue contaminant levels was also completed and is described in detail in Appendix A1. Establishing a fish tissue baseline is important to characterize any potential historical mining-related effects on water-quality such as fish tainting and/or chronic/acute health effects. Given the sensitivities around WSCT and the low species diversity within the LSA, non-native trout were used as the target sentinel species to describe baseline metal concentrations in fish tissues. Levels of the 34 metals tested in collected fish tissues were all low, and mercury levels were below federal consumption guidelines. No legacy mining effects were detected in fish tissue and there are no expected effects from the Project after the proposed water quality mitigation is applied.

Based on the *Surface Water Quality Assessment Report* (Consultant Report #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.

4.2.2.5 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, in Appendix 10B). The precipitation of calcite on substrate in Gold and Blairmore creeks would have the potential to reduce benthic invertebrate production by covering cobble and gravel bed material thus limiting the productivity of benthic invertebrate habitat, which is important for generating a primary food source for WSCT in both systems. The formation of calcite could also potentially limit the productivity of WSCT spawning habitat. The formation of calcite precipitation onto WSCT spawning substrates would limit the quantity and quality of spawning gravels available in potentially affected areas.

Calcite precipitation is an observed effect in creeks where waters containing dissolved calcium carbonate emerge from waste rock dumps and equilibrate with the atmosphere (e.g., MacGregor et al. 2012). Equilibration results in off-gassing of carbon dioxide which, in turn, increases pH and allows calcite to precipitate. Precipitation can occur over several kilometers of streams and can result in cementation of streambeds (Robinson and MacDonald 2014). Effects may be limited where waste rock dump waters are diluted by mixing with waters containing low levels of dissolved calcium carbonate. This results in dilution of the contact waters so that calcium and carbonate concentrations are below levels required to precipitate calcite. Since the coal measures for the Project are hosted by rocks containing sulphide and carbonate minerals, it is expected that weathering processes in waste rock will result in acid generation which will be internally neutralized by reaction with carbonate minerals. The resulting contact waters are therefore expected to contain dissolved calcium carbonate under CO_2 partial pressures exceeding the ambient atmosphere. As a result this calcite precipitation could be expected to occur as contact waters emerge and CO_2 off-gassing occurs (Appendix A in 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 (Appendix A1). Thus, the potential for calcite formation to precipitate to the extent where it could affect fish or fish habitat is currently considered low. Calcite monitoring, that includes surveys for calcite deposits using the methods described by Teck Coal (2013), will be part of the Project's WMP, focusing on key reaches in Gold and Blairmore creeks with high value spawning habitat as a basis for development of appropriate mitigation measures, should calcite precipitation be observed during operations. The monitoring plan will also include treatment measures (e.g., aeration and/or dilution) if calcite precipitation is observed.

4.2.3 Primary Effect Pathways

The Project mine life is currently proposed to be 24 years (Section C.5, Benga 2015) and includes the following processes and/or infrastructure which could potentially affect WSCT habitat and hydrology in the LSA and RSA:

- Mining coal by conventional open pit methods;

- Ex-pit disposal of waste rock until in-pit locations for backfilling become available. Three areas have been delineated: the North Rock Disposal Area (NRDA), the Central Rock Disposal Area (CRDA), and the South Rock Disposal Area (SRDA);
- Blending of potentially acid rock drainage generating (PAG) and non-PAG waste rock to mitigate acid rock drainage potential;
- Optimized pit and waste rock dump design and scheduling to allow the routing of contact water to saturated zones in backfilled pits, and attenuation of nitrate, nitrite, and selenium in sub-oxic conditions. The hydraulic residence time of impacted water will be maximized within the saturated zones;
- Disposal of coarse and fine coal processing wastes as a combined filtered product in dedicated disposal areas at locations where contact water will report to the saturated zones;
- Water management to limit contact of clean water with waste piles;
- High efficiency capture of contact water; and
- Active pumping of contact water from collection/surge ponds into saturated zones to enhance attenuation of selenium, nitrate and nitrite as needed.

The following were determined to be the primary effects on the maintenance of self-sustaining and ongoing productivity of WSCT populations:

- Changes to tributary and mainstem aquatic and/or riparian habitat in Gold and Blairmore creeks as a result of the Project footprint; and
- Changes to hydrology resulting in alteration of aquatic habitat in Gold and Blairmore creeks.

These primary pathways will result in a direct loss of habitat, thereby affecting changes in WSCT habitat quantity and suitability measurement indicator, and, potentially WSCT abundance. Potential reductions in relative abundance, survival, and reproduction measurement indicators are secondary effects of habitat loss or alteration.

These two pathways are likely to result in an environmental change that could contribute to residual effects and are carried forward to the residual effects analysis. Together, these primary interactions could contribute to the loss of fish habitat and associated effects to the long-term sustainability and overall productivity of WSCT populations. Together, the two primary pathways represent the effects mechanisms that will create a loss of fish habitat as a result of the Project, thus result in the need for offsetting. Offsetting can be considered a form of mitigation used to avoid detrimental reductions in productivity that could affect the identified measurement indicators and, in turn, overall productivity and sustainability of WSCT. These primary pathways are analyzed and quantified together in the prediction and assessment of residual effects for the Project with a focus on the habitat quantity and suitability measurement indicator.

4.2.3.1 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. For example, short-term habitat losses result from the construction of crossings over creeks or ROWs. By comparison, long-term habitat losses result from the permanent removal of habitat during the lifespan of the mine. Open pit development, resource extraction, and water management activities may cause permanent loss of aquatic and riparian habitat in Gold Creek and Blairmore Creek watersheds, which can affect WSCT habitat quantity, habitat suitability, and/or connectivity between habitats. Changes in habitat in Gold and Blairmore creeks have been predicted using the baseline characterization (Appendix A1) and mapping software (ArcGIS). The methodology is described in more detail below.

Aquatic Habitat

The aquatic habitat in the LSA was characterized (Appendix A1 and A2) to provide an overview of the existing fish and fish habitat prior to any Project activities (shown in Figure 3.1). The direct effects to aquatic habitat were calculated using ArcGIS based on the aquatic habitat characterization and Project design. Project activities are estimated to potentially cause a loss to 26,947 m^2 of aquatic habitat in the LSA (Table 4.3). The majority of this habitat is located in Blairmore Creek watershed (20,967 m^2) with a small amount in the Gold Creek watershed (5,979 m^2). It is estimated that the Project will remove or alter 1,796 m^2 of fish-bearing aquatic habitat (Blairmore Creek: 1,038 m^2, GCT10: 208 m^2, and GCT11: 550 m^2) prior to applying any mitigation. The remainder of the habitat that will be potentially affected (25,151 m^2) is non-fish bearing. Major activities that will potentially change the aquatic habitat include:

- Waste rock placement, estimated to remove 10,344 m^2 of BCT02, BCT07 and GCT06;
- Ponds (part of WMP), estimated to remove 8,542 m^2 of BCT02, BCT05, BCT06, BCT07, GCT06, GCT08 and GCT11; and
- Pit excavation, estimated to remove 5,341 m^2 of BCT05, BCT06, GCT08, GCT09, GCT10 and GCT11.

Table 4.3 Estimated loss of aquatic habitat in the local study area due to Project activities.

Watercourse	Aquatic Habitat Loss Length (m)	Width[1] (m)	Area (m^2)	Fish presence (m^2)	Project activity potentially causing change to aquatic habitat
Blairmore Creek	154	6.8	1,038	Fish-bearing	Golf Course, railway
BCT01	220	2.0	441	Non-fish bearing	Camp, ROW
BCT02	3,581	2.0	7,162	Non-fish bearing	CHPP, waste rock placement, pond (RWP)
BCT05	1,359	2.5	3,399	Non-fish bearing	Pit excavation, pond (WSP)
BCT06	1,687	1.4	2,362	Non-fish bearing	Pit excavation, pond (WSP)
BCT07	3,752	1.8	6,566	Non-fish bearing	Waste rock placement, pond (NWSP)
Blairmore Creek Watershed			**20,967**		
GCT06	936	1.7	1,592	Non-fish bearing	Waste rock placement, pond (SESP)
GCT08	874	1.4	1,223	Non-fish bearing	Pit excavation, pond (ESP)
GCT09	244	1.6	390	Non-fish bearing	Pit excavation
GCT10	116	1.8	208	Fish bearing	Pit excavation
GCT11	1,152	1.8	2,016	Non-fish bearing	Pit excavation, pond (NESP)
GCT11	314	1.8	550	Fish bearing	Pond (NESP)
Gold Creek Watershed			**5,979**		

1. Based on bankfull width measurements taken during fish and fish habitat surveys (Appendix A1) and fluvial geomorphology assessments (Appendix A2)
2. Assessed during fish and fish habitat surveys (Appendix A1)

Riparian Habitat

Riparian habitat is considered important fish habitat because it contributes to the maintenance of fisheries resources (DFO 1993). The federal *Fisheries Act* defines fish habitat as "spawning grounds and nursery, rearing, food supply, migration and any other areas on which fish depend directly or indirectly in order to carry out their life processes." In the case of the Project, this includes riparian habitat along all fish-bearing waters and non-fish-bearing waters that flow into fish-bearing waters in the Project area.

Riparian buffer zones were established to conserve riparian function for Gold and Blairmore creeks and their tributaries. The riparian buffer zone widths were established through consultation of *Stepping Back from the Water: A Beneficial Management Practices Guide for New Development Near Water Bodies in Alberta's Settled Region* (AESRD 2012) as well as considering the riparian needs to prevent serious harm to fish under Section 35 of the *Fisheries Act*. The following riparian buffer zones have been applied to the watercourses in the LSA:

- 50 m on the mainstem of Gold and Blairmore creeks;

- 30 m on the fish-bearing tributaries; and
- 20 m on the non-fish bearing tributaries.

Riparian habitat value was assessed at all riparian sites within the Project to determine riparian habitat quality. Riparian habitat quality can vary widely within a single stream reach since different riparian habitats provide different values to fish resources, and disturbance patterns, soil types and microclimates are all variable across time and space. More mature, structurally complex habitat provides the most valuable fish habitat. Riparian habitat was assessed and classified as “low”, “medium”, and “high” value based on fish presence and the age and structural stage of riparian vegetation that was found during the assessment (Figure 4.3). Riparian condition was assessed in the *Vegetation Baseline and Effects Assessment* (Millennium 2015) and fish presence was determined in the *Fisheries and Aquatics Technical Baseline Report* (Appendix A1).

Riparian habitat value was rated following the criteria described below:

1. **Low riparian habitat value** - Site within the riparian buffer zone of a non-fish bearing stream which has been previously impacted. Forest within this zone is classified as young[9].
2. **Medium riparian habitat value** - Site within the riparian buffer zone of a non-fish bearing stream were the forest is classified as mature[9]. Or, alternatively, a site within the riparian buffer zone of a fish-bearing stream where the forest is classified as young[9] or previously impacted.
3. **High riparian habitat value** - Site within the riparian buffer zone classified as a wetland or old-growth, or a fish-bearing stream with mature forest.

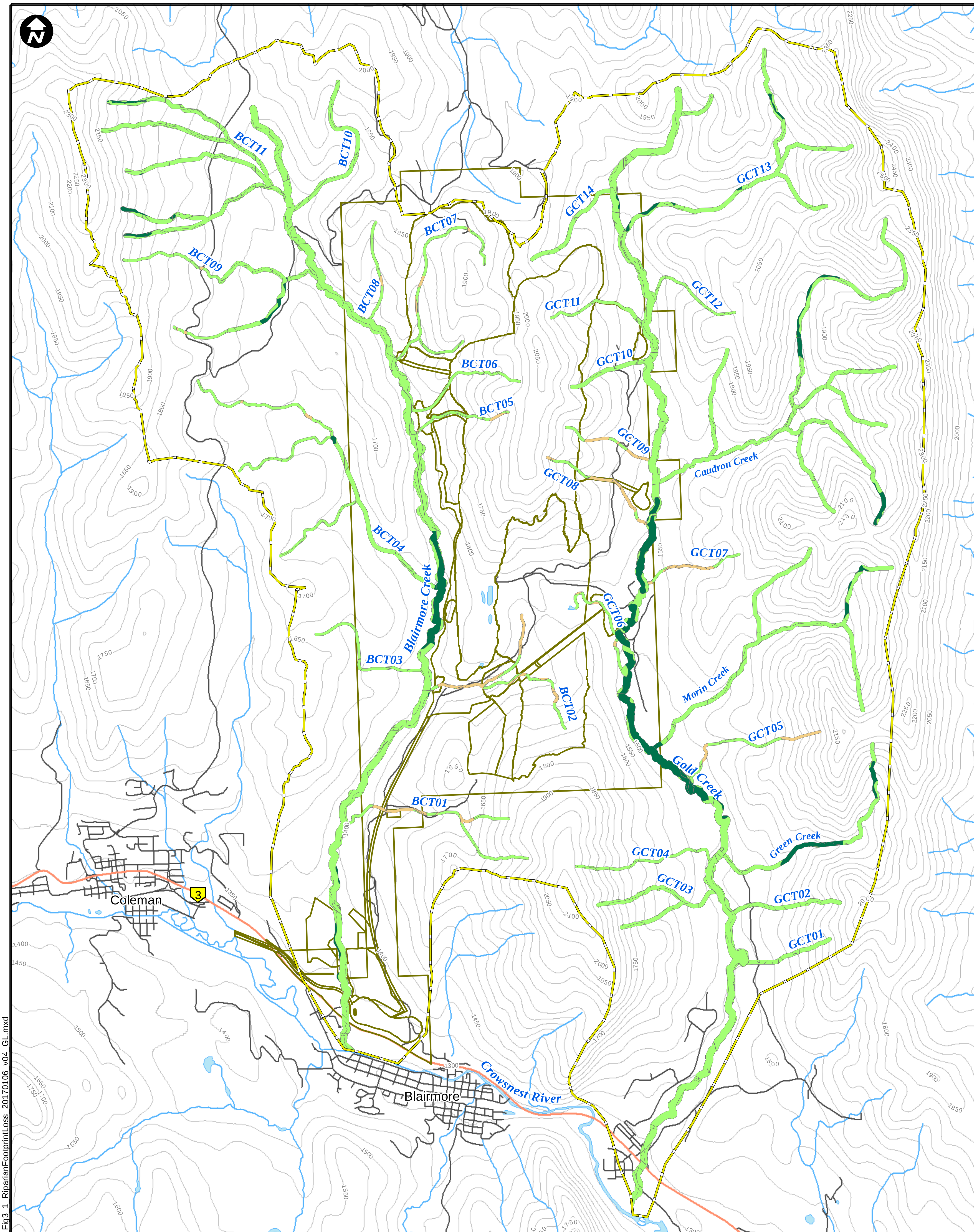
The direct effects to riparian habitat were calculated using ArcGIS based on riparian habitat characterization and Project design. Project activities are estimated to potentially result in a loss or alteration of 584,263 m^2 of riparian habitat in the LSA (Table 4.4). The majority of this habitat is located in Blairmore Creek watershed (442,433 m^2) with a smaller amount in the Gold Creek watershed (141,830 m^2). It is estimated that the Project will remove or permanently alter 3,140 m^2 of high value riparian habitat on mainstem Gold and Blairmore creeks. The remainder of the habitat that will be potentially affected is rated as medium (443,204 m^2) or low (137,917 m^2) value. Major activities that will potentially affect the riparian habitat include:

- Waste rock placement, estimated to remove 228,990 m^2 of riparian habitat;
- Ponds (part of WMP), estimated to remove 169,273 m^2 of riparian habitat; and
- Pit excavation, estimated to remove 131,600 m^2 of riparian habitat.

[9] According to the Alberta Vegetation Inventory (AVI) stand origin data.

Table 4.4 Estimated loss of riparian habitat in the local study area due to Project activities.

Watercourse	Riparian Habitat Loss (m^2)				Fish presence	Project activity potentially causing change to riparian habitat
	Low	Medium	High	Total		
Blairmore Creek	0	17,669	3,123	20,793	Fish bearing	Ponds (WSP), railway loop, golf course
BCT01	8,493	0	0	8,493	Non-fish bearing	Conveyor access powerline ROW
BCT02	74,254	69,710	0	143,965	Non-fish bearing	CHPP Facilities
BCT05	9,284	45,433	0	54,717	Non-fish bearing	Ponds (WSP), pit excavation
BCT06	241	64,911	0	65,153	Non-fish bearing	Ponds (WSP), pit excavation
BCT07	14,417	134,896	0	149,313	Non-fish bearing	Ponds (NWSP), waste rock placement
Blairmore Creek Watershed	**106,688**	**332,619**	**3,123**	**442,433**		
Gold Creek	0	1,672	17	1,689	Fish bearing	Ponds (NESP, SESP)
GCT06	2,858	34,638	0	37,496	Non-fish bearing	Pipeline service road, pond (SESP), waste rock placement
GCT08	19,433	14,350	0	33,783	Non-fish bearing	Pond (ESP), pit excavation
GCT09	0	10,145	0	10,145	Non-fish bearing	Pit excavation
GCT10	8,459	0	0	8,459	Fish bearing	Pit excavation
GCT11	479	49,780	0	50,258	Non-fish and fish bearing	Pond (NESP), pit excavation
Gold Creek Watershed	**31,229**	**110,584**	**17**	**141,830**		



LEGEND

- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study Area
- Project Footprint

Riparian Habitat Value

- High
- Medium
- Low

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

Hatfield CONSULTANTS

TITLE

RIPARIAN HABITAT WITHIN THE LOCAL STUDY AREA

NOTES

Data Sources: Government of Canada, Government of Alberta
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 7779

DRAWN BY: SS / EDITED BY: GL

CHECKED BY: CB

DATE: January 06, 2017

FIGURE

4.3

Document Path: K:\Data\Project\MEMS7779\A_MXD\Riparian\MEMS7779_Fig3_1_RiparianFootprintLoss_20170106_v04_GL.mxd

4.2.3.2 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. Changes in hydrology in both Gold and Blairmore creeks were predicted in the *Hydrology Baseline and Effects Assessment* (Consultant Report #4). The methods for modeling flows in both mainstem watercourses under Baseline Case and Application Case are described therein.

Throughout the mine life, four sedimentation/release ponds, four surge ponds and numerous contact water ditches are to be constructed in carefully selected locations to collect the contact water from the site. The sedimentation ponds will be used to settle total suspended solids (TSS) from surface runoff and pit water (that was not in contact with any mine waste) and then released to either Blairmore Creek or Gold Creek. In the event the quality does not meet the identified provincial, federal, or Project specific release criteria it will be directed towards the appropriate saturation zone, as needed. The surge ponds will collect and store water that becomes in contact with waste material as part of the selenium mitigation plan. This mine waste contact water will be either pumped to the raw water pond for use in the coal wash plant or directed to the saturated zones. Any acid-generating waste rock will be managed to minimize the generation of acid and associated oxidation products at the source (SRK 2016).

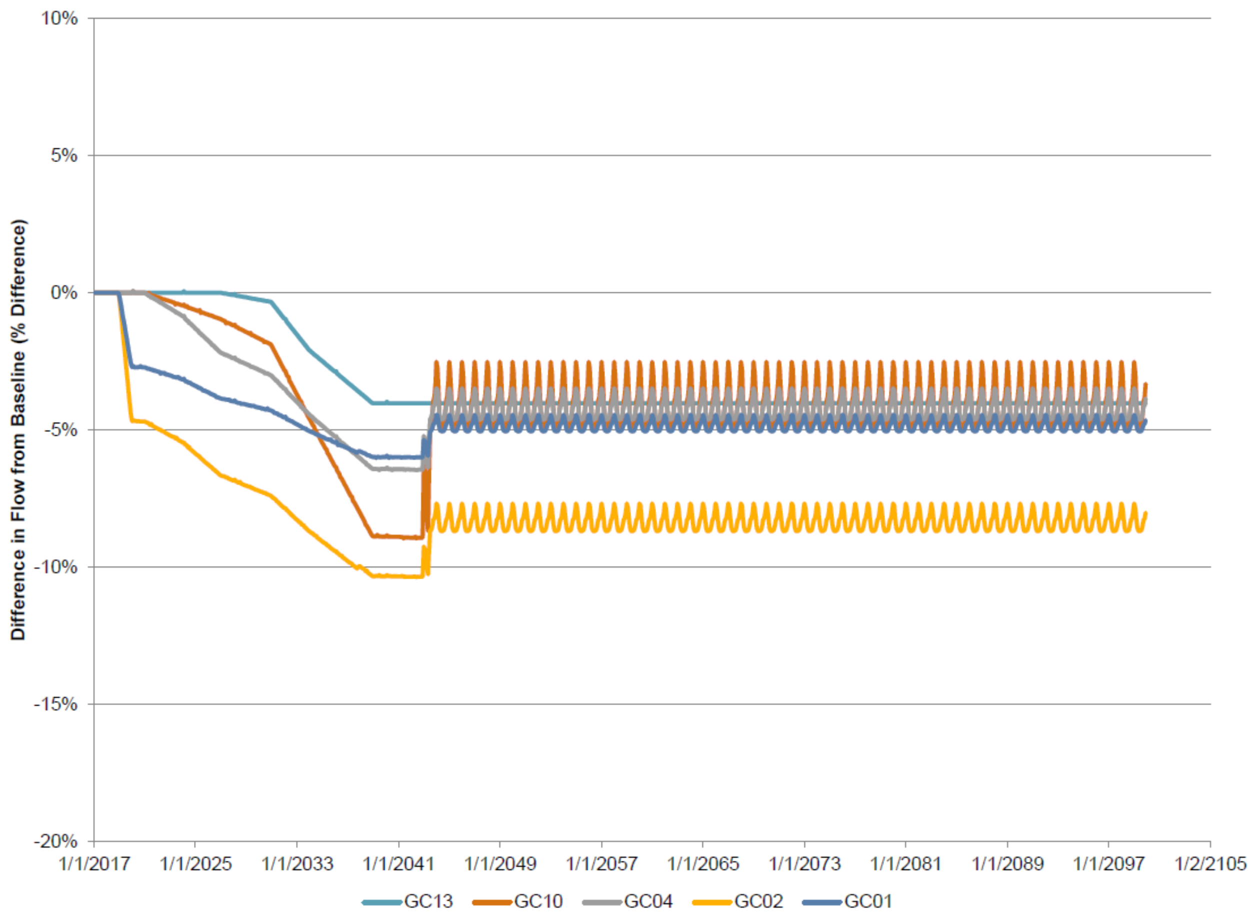
A potential change to runoff was evaluated at various stations along Gold and Blairmore creeks. Consultant Report #4 outlines the location of the stations/model nodes in Gold and Blairmore creeks along with catchment delineations for each node. Estimates of potential changes to runoff for average hydrological conditions are illustrated in Figure 43 of for Gold Creek and Figure 46 for Blairmore Creek in Consultant Report #4. The estimated runoff changes are based on the results of the water and load balance model (Appendix 10B) that was developed for the Project. The water and load balance model operates on a monthly time-step. Therefore, flows and flow changes are evaluated on the basis of monthly flows. A complete description of methodology and assumptions used in the development of the water balance model is provided in Appendix 10B. Estimated runoff changes include both surface flow, interflow and base flow (i.e., groundwater flow).

A separate assessment was completed for specific changes to the groundwater flow regime (CR #3:Appendix C). Table 17 within CR#3 summarizes predicted changes to base flow in Blairmore Creek, Gold Creek and Daisy Creek. The water-balance model incorporated the combined effects of the estimated changes to the groundwater flow regime and to surface flow. The estimated groundwater reduction is caused by interception of open pit mine water and seepage from waste rock areas. The intercepted mine water will be conveyed through the saturated backfills where nitrate and selenium will be attenuated, through a discharge treatment system (if deemed required as part of the water quality monitoring program) at which point the water will be discharged to locations in Blairmore Creek where the water was originally collected. Therefore, the estimated reduction in groundwater flow is matched by an increase in surface water flow at those nodes.

Gold Creek

The proposed open pit intersects portions of the upper reaches of the western catchments for Gold Creek. Water intercepted by those areas is proposed to be routed to a saturated zone, which would then be discharged to Blairmore Creek. Based on the model outputs (Appendix 10B, Appendix 10C, Consultant Report #3 Appendix C, shown in Figure 4.4 below), net losses of total flow are anticipated in all reaches of Gold Creek, reaching a maximum of 4% at node GC-13, 6-9% at nodes GC-10, GC-04 and GC-01, and just over 10% at node GC-02.

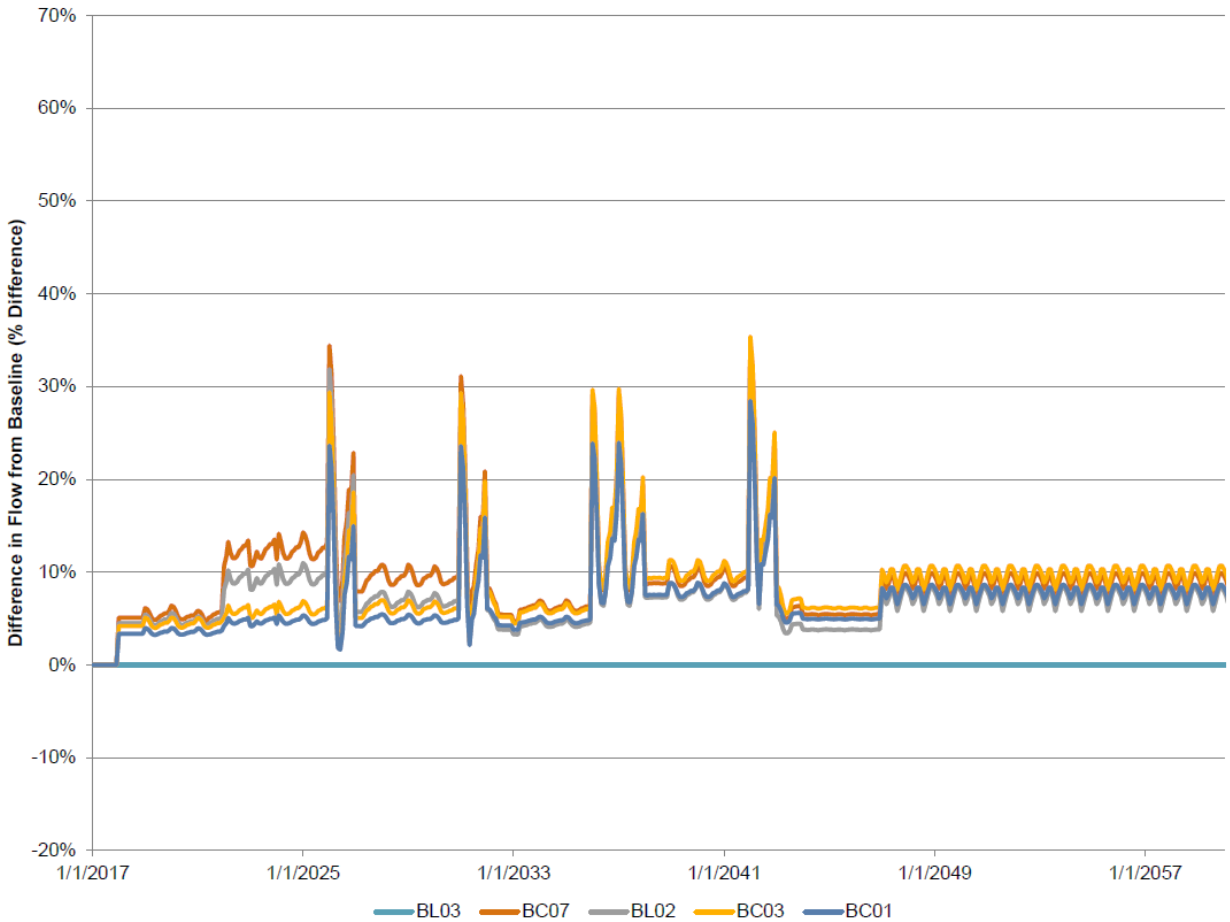
Figure 4.4 Total flow changes at Prediction Nodes on Gold Creek (Appendix 10B, Appendix 10C, Consultant Report #3 Appendix C) in average hydrological conditions.



Blairmore Creek

Flows in Blairmore Creek are expected to increase relative to baseline conditions because of the additional contribution of flow from some Gold Creek sub-catchments, but more importantly because of the estimated increase in runoff caused by changes to the hydrological characteristics of developed mine areas (i.e., increase in runoff coefficients for pit walls and waste rock areas) (Appendix 10B, Appendix 10C, Consultant Report #3 Appendix C). For most of the year, the maximum increase to flow is expected to be less than +15% for all stations (Figure 4.5). Large flow changes are possible during the low flow season (December to March). However, the water balance model (Appendix 10B) assumes that the discharge from the saturated zones will be controlled based on the rate of accumulation of water in the saturated zone and the stream flow conditions in Blairmore Creek.

Figure 4.5 Total flow changes at Prediction Nodes on Blairmore Creek (Appendix 10B, Appendix 10C, Consultant Report #3 Appendix C) in average hydrological conditions.



4.3 APPLICATION CASE

As presented in Section 4.2.3, the following were determined to be the primary pathways on the maintenance of self-sustaining, and overall productivity of, WSCT populations:

- Permanent loss or alteration to 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 potentially affecting WSCT habitat.

The Project mine plan has been developed to minimize or prevent direct physical effects to available, suitable fish habitat in both Blairmore Creek and Gold Creek mainstems. Based on the proximity of the Project footprint there will be the direct loss to portions of specific tributaries of both Blairmore Creek and

Gold Creek. Additionally, there is predicted to be flow alterations in both Gold and Blairmore creeks. The activities associated with the construction, operations, and reclamation phases that will affect mainstem and/or tributary watercourses are summarized in Table 4.5.

Table 4.5 Project activities that will result in residual effects on aquatic ecological resources in the LSA.

Mining Phase	Description/Activities
Construction	▪ Land clearing and construction of the rail loop and bridge crossing of Blairmore Creek; ▪ Land clearing and construction of the CHPP located near Blairmore Creek; and ▪ Construction of initial haul road and water management facilities (i.e., sedimentation and surge ponds) in Blairmore Creek and Gold Creek watersheds.
Operation	▪ Progressive mine phasing resulting in changes to surface water and groundwater baseflows and water quality for Blairmore Creek and Gold Creek; ▪ Operation of water management facilities (i.e., sedimentation and surge ponds, as well as attenuation zones) near Blairmore Creek and Gold Creek; ▪ Operation of roadways and watercourse crossings to water management facilities on Blairmore Creek and Gold Creek; and ▪ Operation of watercourse bridge crossing for the rail loop on Blairmore Creek.
Reclamation	▪ Reclamation of water management facilities; and ▪ Potential (if necessary) inputs from the final end pit lake to Gold Creek.

4.3.1 Changes to Tributary and Mainstem Aquatic and/or Riparian Habitat

4.3.1.1 Local Study Area

Validity of Effects Pathway

Components of the Project footprint and site water management that are expected to result in a loss of fish habitat (riparian or aquatic) include land clearing, construction of the CHPP facility, camp, golf course, rail loop, bridge crossings, haul road and water management features (surge/sedimentation ponds). The fish-bearing watercourses that will be affected are Blairmore Creek, Gold Creek and its tributaries GCT10 and GCT11 (locations shown in Figure 3.1). Currently GCT11 and GCT10 are not classified as critical habitat; however they are contributing directly to critical habitat on Gold Creek. A summary of the anticipated effects from these activities is provided in Table 4.3 and Table 4.4 for each watercourse that will be affected.

During pit excavation, about 6,324,000 m^2 (632.4 Ha) of the LSA will be affected. The watercourses flowing through these areas that will be affected by excavation include: BCT05, BCT06, GCT08, GCT09, GCT10 and GCT11 (locations shown in Figure 3.1). The tributaries GCT10 and GCT11 are fish-bearing watercourses containing WSCT. The remaining tributaries have been classified as non-fish bearing. It is expected that after removal and processing of the coal deposits in the Project footprint about 5,899,000 m^2 of waste rock disposal areas will be required. Waste rock from the Project will be deposited in either external or internal pit waste rock disposal areas. The watercourses flowing through the spoil areas that will be affected by waste rock placement include: BCT07, BCT02 and GCT06 (locations shown in Figure 3.1). These tributaries are non-fish bearing watercourses.

During the construction, operation and closure phases, surface water runoff from mining areas, haul roads, overburden disposal areas and any other disturbed areas as well as groundwater runoff from the pit will be collected and directed to six water management ponds (PSSP, SWSP, WSP, ESP, NESP and loadout sedimentation pond [LSP]). During operations, mine affected water from external rock disposal areas will be collected in three surge ponds (RWP, SESP, and NWSP). The total surface area of these ponds is 746,000 m^2 (74.6 ha). The aquatic and/or riparian habitat of nine watercourses flowing through these areas will be affected, including four fish-bearing watercourses (GCT10, GCT11, Gold Creek, Blairmore Creek).

Mitigation Measures

Environmental design features to avoid or mitigate adverse effects were developed through an iterative process between the Project's engineering and environmental teams and are summarized in Table 4.2. Environmental design features and mitigation actions incorporated into the Project to avoid or mitigate effects on fish and fish habitat include:

- Scheduling construction activities and use best practices, including sediment and erosion control, to meet regulatory requirements of DFO and AEP;
- Preparing an Application for Authorization under the *Fisheries Act*, obtaining an Authorization from the Minister of Fisheries and Oceans Canada, and implementing an Offsetting Plan approved by the Minister to offset an serious harm to fish, which is defined by the *Fisheries Act* as the death of fish or any permanent alteration to, or destruction of, fish habitat; and
- Fish salvage during construction of the Project on fish-bearing watercourses, following appropriate standards and permit conditions.

Environmental design features include the avoidance of watercourses within the LSA to the extent feasible when designing the Project footprint. The mine plan was developed to keep the disturbance to a minimum. The external rock disposal areas have been kept to a minimum with only two being proposed. Most of the rock material will be disposed of within the mined-out pit areas, which helps to keep the disturbance footprint considerably smaller than if additional external disposal areas were proposed. This effort to keep the disturbed area to a minimum has successfully avoided critical aquatic habitat for WSCT (the mainstems of both Gold and Blairmore creeks). Where possible, the Project will use existing roads to avoid new disturbance. Construction of the CHPP facility, camp, golf course, rail loop, bridge crossings, and haul road will follow BMPs and mitigation, including *Code of Practice for Watercourse Crossings* (AESRD 2013a) and *Stepping Back from the Water: A Beneficial Management Practices Guide for New Development Near Water Bodies in Alberta's Settled Region* (AESRD 2012). Detail design will aim to avoid any in-stream work for these features, particularly on mainstem watercourses.

Riparian areas and management zones along watercourses will be maintained where feasible. Measures to avoid causing harm to fish and fish habitat (DFO 2013b) and BMPs will be followed for applicable Project activities (i.e., activities outside of areas of direct habitat destruction) occurring adjacent to or across streams (e.g., watercourse crossings). During rehabilitation from the Project, a closure drainage plan will be implemented. The spoils will be rehabilitated following sequencing that reduces disturbance and maximizes reclamation opportunities. Progressive reclamation to accelerate revegetation, reforestation and end land uses will be applied as sites become available. Salvage, stockpile and soils will be selectively place to maximize reclamation success. The terrain will be re-sloped and recon toured to achieve variation of slope steepness, slope length, aspect and shade to create terrain diversity suitable for the establishment of varied plant communities.

A Preliminary Habitat Offsetting Plan (Appendix A4) has been developed for residual effects of the Project that result post-mitigation and an Application for Authorization under Section 35(2) of the *Fisheries Act* will be submitted for the Project. Offsetting measures are not used to break pathways, but considered in the follow-up actions identified for the VC after residual effects are analyzed and characterized. The efficacy and potential lag time for offsetting measures will be addressed in the Final Habitat Offsetting Plan to be prepared.

Residual Effects Analysis

After mitigation measures are applied to the 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 actions will be used, the pit excavation and pond development (NESP, SESP, WSP) will result in permanent loss of WSCT aquatic habitat in GCT10 and GCT11, and WSCT riparian habitat in Blairmore Creek, Gold Creek, GCT10 and GCT11 (Table 4.6). The habitat losses will be offset and exceeded by gains in habitat attained through the implementation of an Offsetting Plan (Appendix A4) required as a component of a *Fisheries Act* Authorization (FAA). Design and implementation of an Offsetting Plan early in the Project development will offset any destruction of alteration of habitat that could result in effects on the productivity of WSCT.

Table 4.6 WSCT habitat that will be permanently changed within the Local Study Area post-mitigation.

Watercourse	Aquatic habitat (m^2)	Riparian habitat (m^2)	Project activity causing permanent change to WSCT habitat
Blairmore Creek	0	402	Pond (WSP)
Gold Creek	0	1,689	Ponds (NESP, SESP)
GCT10	208	8,459	Pit excavation
GCT11	550	8,720	Pit excavation, pond (NESP)
Total	**758**	**19,270**	

4.3.1.2 Regional Study Area

Residual Effects Analysis

The Project footprint does not extend into the RSA therefore there are no anticipated residual effects to fish habitat.

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

4.3.2.1 Local Study Area

Validity of Effects Pathway

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. Full details of the following components are provided in full in Section C.5.3 of the application (Benga 2015).

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 (Consultant Report #4).

The watershed boundaries, drainage patterns and flow characteristics of sub-catchments on the west side of Gold Creek watershed and the east side of Blairmore Creek watershed will be permanently modified as a result of the Project. The resulting Project infrastructure will have long-term effects on Gold Creek and Blairmore Creek as water is diverted from associated tributaries and intercepted en route to both Gold Creek and Blairmore Creek mainstems, treated, and discharged directly to Blairmore Creek at select nodes.

The IFA (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. It was performed by comparing model-predicted indices of species-specific habitat availability and suitability in Gold and Blairmore creeks during the different Project phases to these same indices under baseline conditions (i.e., natural, pre-construction flows).

For the operations phase, predictions were calculated for scenarios post-implementation of the WMP in both Gold Creek and Blairmore Creek watersheds. This operation scenario was investigated to reflect the state of flows in Gold and Blairmore creeks as surface water and groundwater are intercepted and then augmented by pumping water to select nodes into Blairmore Creek (Consultant Report #4). This flow-augmentation scheme would continue through the closure phase as various Project components are decommissioned after mining. The closure phase includes predicted increases in flow to upper Gold Creek as the end-pit lake fills and discharges (Consultant Report #4).

The hydrology data used to support the IFA analyses were developed using various sources, including regional hydrometric stations with long-term records, local hydrometric stations with short-term records, and other local data collected specifically to support the IFA analyses. While the spatial and temporal runoff dynamics were previously established for Gold and Blairmore Creek (Consultant Report #4), this particular analysis did not differentiate between the separate pathways contributing to runoff (i.e., surface flows, interflow, and groundwater), since only total flows were needed to support the *Water and Load Balance Model* (Appendix 10B). Only surface flows, which support fish habitat, are of relevance to this IFA. The results from streamflow gauging programs identified complex relationships between surface and subsurface (ultimately total) flows, especially on Gold Creek, that must be fully characterized in this document in order to confidently support the IFA analyses. The hydrology data and the methods applied to produce the data are included in Appendix A3.

Selected HSC curves were used to translate the flow-based predictions of hydraulic variables into habitat indices. The primary metric of habitat generated by the hydraulic habitat models was Area Weighted Suitability (AWS). Units of AWS were square meters of habitat per meter of stream channel length (m^2/m).

Curves of habitat (AWS) as a function of flow were generated for key life stages of WSCT and subsequently applied in the assessment. They included:

- Spawning and egg incubation;
- Fry rearing (nursery);
- Juvenile rearing;
- Adult rearing (holding);
- Overwintering; and
- Food supply (Invertebrate drift).

Other physical habitat attributes for maintaining ecological function and fish habitat (e.g., channel stability, sediment mobility/supply, bedload movement) were assessed as part of the *Fluvial Geomorphology Effects Assessment of Blairmore Creek and Gold Creek* (Appendix A2) and described in Section 4.2.2.3 (Secondary Pathways).

The assessment of potential effects on fish habitat due to changes in flows was completed using a time series approach. A time series of simulated mean monthly flows were generated from the 41-year time series of daily flows estimated for each study reach along Gold and Blairmore creeks; this time series was assumed to represent baseline flow conditions during 2017 (prior to mine construction in 2018). This monthly time series was converted to corresponding simulated monthly habitat time series for WSCT spawning and incubation, fry/juvenile/adult rearing, overwintering, and food supply in each watercourse. This was done using selected WSCT HSC and the hydraulic models.

The simulated monthly habitat time series for each species life stage during each Project phase were compared to the baseline (1-year) monthly habitat time series to assess potential flow related effects. The Project phases included construction (2018; 1-year length), operations (2019-2042; 24-year length), decommissioning (2043-2044; 2-year length) and closure (2045-2099; 54-year length). Doing so provided a comparison of total habitat availability over time (i.e., area under the curve) during different Project phases in each watercourse.

The percentage change in average monthly area weighted suitability (AWS), as expressed in metres squared (m^2/m), during "biologically relevant stanzas" was the metric used to assess potential effects of predicted flow changes to fish habitat in Gold and Blairmore creeks during each Project phase. Average monthly AWS was calculated as the total stanza habitat during each calendar month, divided by the total number of months included in the total stanza estimate.

The threshold for “no significant” effect to WSCT due to predicted flow changes in each Project watercourse was that at least 90% of total habitat availability remained over the relevant biological stanzas for WSCT (i.e., no more than a 10% reduction in total AWS over each Project phase).

The 10% flow threshold was used as the significance screening based on recommendations from recent publications. A recent proposal for a broadly applied “presumptive standard” for evaluating flow departure from natural conditions using a sustainable boundary approach argued that a departure from natural flow conditions of less than or equal to 10% would result in a high level of ecological protection whereby the natural structure and function of the ecosystem would be maintained (Richter et al. 2012). In reviewing available environmental flow assessment methods, a framework for ecological flows to support fisheries in Canada was recently published that incorporates several of the concepts discussed above (DFO 2013b). The framework applies a percent-of-flow approach and recommends that cumulative flow alterations remain within 10% of natural instantaneous flow. Maintaining flows within 10% of natural flow was expected to have a low likelihood of having detectable negative effects on the ecosystem (DFO 2013b). Due to the complex hydrological dynamics and predicted flow reductions in Gold Creek as well as the notable predicted flow increases in Blairmore Creek, multiple macro-reaches within both watercourses were assessed below the 10% threshold.

Mitigation Measures

Improvement of water quality in the LSA through the capture and treatment mitigation (see Section 4.1.1.2 in the *Surface Water Quality Assessment Report* [Consultant Report #5]) involves trade-offs related to providing acceptable water quality on (and off) site versus maintaining sufficient flows for the preservation of fish habitat for WSCT in Gold Creek from which mine-influenced water is being collected, diverted and treated, then discharged to Blairmore Creek. As a result, achieving improved water quality has a corresponding and interdependent effect that results in flow reductions (and associated losses of tributary habitat, described above) that otherwise could potentially be retained. Furthermore, flow increases are predicted for Blairmore Creek. Although there are predicted habitat improvements in Blairmore Creek with increased flows, there are predicted habitat alterations in Gold Creek. Given Blairmore Creek and Gold Creek currently are protected under differing regulatory statutes (Gold Creek – *Species at Risk Act*; Blairmore Creek – *Wildlife Act* and/or Regulation), it is expected that habitat gains in Blairmore Creek would not sufficiently counterbalance predicted residual habitat changes in Gold Creek. Thus, additional mitigation, in the form of offsetting, would be necessary. Currently, a Preliminary Offsetting Plan has been developed with an aim to compensate for residual effects in Gold Creek as a result of changes to hydrology including footprint-related residual effects within the LSA (Section 4.3.1.1).

For dry or drought years encountered during the mine life, if stream flows in a given year are expected to be lower than average conditions (e.g., 1:10; 1:20), then short-term mitigation measures will be executed to account for those flow reductions thus alleviate any elevated alterations to critical habitat in Gold Creek.

Residual Effects Analysis

Gold Creek

The predicted changes in AWS on Gold Creek, for each reach, bioperiod, and Project phase are summarized for average hydrological conditions in Table 4.7. During mine construction in 2018, there were no changes predicted to surface flows along the length of Gold Creek; therefore, no changes in habitat were predicted.

Reach 9

For Reach 9 during the operations phase (2019 to 2042), there were marginal habitat losses predicted, which averaged 1 to 2 % (2 to 32 m^2) of the baseline habitat area depending on the bioperiod. The largest habitat loss calculated for any individual month within a given bioperiod and Project phase was 9%, which approached, but does not exceed, the 10% threshold. During the decommissioning phase (2043 to 2044), average habitat losses (1 to 4%, equivalent to 2 to 52 m^2) were slightly higher than during operations, but the maximum monthly habitat loss was again 9% suggesting that no significant adverse effects are anticipated. Similarly during the closure phase, when the land is increasingly reclaimed and flows recovered slightly, the average habitat losses (1 to 3%, equivalent to 2 to 47 m^2) and worst-case individual month (9%) all remained below the 10% significance threshold.

Reach 8

For Reach 8, mean habitat losses averaged across each bioperiod were broadly similar to corresponding values for Reach 9, including 1 to 2% (1 to 46 m^2) during operations, 0 to 3% (2 to 69 m^2) during decommissioning, and 0 to 2% (1 to 61 m^2) during closure. Of particular note, monthly habitat losses were predicted to be as high as 12% in the case of adult rearing, which occurred each April from 2038 to 2042 (operations) and again in April 2043 (decommissioning). This represents approximately 99 m^2 of habitat change (loss), relative to the predicted baseline April value (723 m^2). The April MMD value (0.023 m^3/s during baseline) was the lowest of all six months with adult rearing and falls within the most sensitive area of habitat changes with flow as shown in Table 4.7. This factor coupled with the maximum flow losses predicted to occur between 2038 to 2043 combined to produce this particular result.

Reach 7 and 5

In the much higher flow environment of Reach 7, habitat changes were much less sensitive to the predicted flow changes occurring post-construction. For adult/juvenile rearing and overwintering bioperiods, both average and worst-case habitat losses during an individual month were up to 3%. Small habitat gains of 1 to 2% (on average) were predicted for the spawning and fry bioperiods, since the slight flow reductions improved habitat quality based on the corresponding flow-AWS relationships shown in Table 4.7. Similarly for Reach 5, worst-case habitat losses during an individual month were up to 4%, whereas very small average gains in habitat (0 to 4%) were predicted for all bioperiods and post-construction mine phases.

Reach 6

In Reach 6, with the exception of fry habitat, which remained largely unchanged between mine phases, post-construction habitat losses for the four other bioperiods all averaged 2-5% and did not exceed 9% in any individual month. Flows here were approximately 50% higher than in Reach 8, and these were sufficient to keep individual month habitat losses below 10%, even though the predicted total flow reductions in this reach (node GC-02, Appendix 10C, Table 4.7) were higher than at all other nodes on Gold Creek (reaching 10.4% during 2041 to 2042, ~1.5% higher than at node GC-10 applied within Reach 8 predictions).

All reaches

Cumulative predicted habitat changes across all five study reaches were as follows. Approximately 214-272 m^2 of adult rearing habitat was predicted to be lost during the three post-construction mine phases, but in relative terms this represented around 1 to 2% of the baseline habitat area. Similarly, 151 to 192 m^2 of juvenile rearing habitat and 8-10 m^2 of overwintering habitat is predicted to be lost, representing 2% and 1% of the corresponding baseline habitat areas, respectively. Approximately, 24 to 28 m^2 of spawning habitat is predicted to be lost, while 75 to 96 m^2 of fry habitat is predicted to be gained, but in both instances these changes rounded to 0% change relative to corresponding baseline habitat areas. All bioperiod-habitat changes under average flow conditions remained well below the 10% threshold, suggesting that significant adverse effects are not anticipated. On an individual monthly basis, the losses of adult rearing habitat did briefly exceed the 10% (12% during consecutive April months between 2038 to 2043, the peak flow reduction period), which may result in some limitations to this particular life stage.

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Table 4.7 Gold Creek Habitat Area predictions, 2017-2099, during average hydrological conditions.

					Baseline 2017	Construction 2018				Operations 2019-2042				Decommissioning 2043-2044				Closure 2045-2099			
Reach details			*Westslope Cutthroat Trout*		Mean Suitable Area	Mean Suitable Area	Difference from baseline period: Mean		1-month max	Mean Suitable Area	Difference from baseline period: Mean		1-month max	Mean Suitable Area	Difference from baseline period: Mean		1-month max	Mean Suitable Area	Difference from baseline period: Mean		1-month max
#	Description	Length (m)	Bioperiod	Stanza	m² AWS[1]	m² AWS[1]	m² AWS[1]	% AWS[1]	% AWS[2]	m² AWS[1]	m² AWS[1]	% AWS[1]	% AWS[2]	m² AWS[1]	m² AWS[1]	% AWS[1]	% AWS[2]	m² AWS[1]	m² AWS[1]	% AWS[1]	% AWS[2]
9	GCT10 trib to North Creek	2,130	Rearing (Adult)	Apr 1-Sep 30	1,371	1,371	0	0%	0%	1,338	-32	-2%	-9%	1,319	-52	-4%	-9%	1,323	-47	-3%	-9%
			Rearing (Juvenile)	Apr 1-Sep 30	1,199	1,199	0	0%	0%	1,177	-22	-2%	-6%	1,164	-34	-3%	-5%	1,168	-31	-3%	-5%
			Spawning	May 1-Jul 31	638	638	0	0%	0%	624	-14	-2%	-9%	615	-23	-4%	-5%	618	-20	-3%	-5%
			Fry	Jul 1-Sep 30	3,235	3,235	0	0%	0%	3,214	-21	-1%	-2%	3,205	-31	-1%	-2%	3,205	-31	-1%	-2%
			Overwintering	Oct 1-Mar 31	191	191	0	0%	0%	189	-2	-1%	-5%	190	-2	-1%	-5%	190	-2	-1%	-5%
8	Above Caudron Creek to GCT10 trib	1,906	Rearing (Adult)	Apr 1-Sep 30	2,684	2,684	0	0%	0%	2,638	-46	-2%	-12%	2,615	-69	-3%	-12%	2,623	-61	-2%	-6%
			Rearing (Juvenile)	Apr 1-Sep 30	1,461	1,461	0	0%	0%	1,438	-23	-2%	-6%	1,426	-35	-2%	-6%	1,430	-30	-2%	-3%
			Spawning	May 1-Jul 31	1,428	1,428	0	0%	0%	1,415	-14	-1%	-5%	1,407	-21	-1%	-3%	1,410	-18	-1%	-3%
			Fry	Jul 1-Sep 30	4,658	4,658	0	0%	0%	4,646	-11	0%	-1%	4,646	-11	0%	-1%	4,646	-11	0%	-1%
			Overwintering	Oct 1-Mar 31	149	149	0	0%	0%	148	-1	-1%	-3%	147	-2	-1%	-3%	148	-1	-1%	-3%
7	Gold Creek Bridge to Caudron Creek	3,183	Rearing (Adult)	Apr 1-Sep 30	8,950	8,950	0	0%	0%	8,930	-20	0%	-2%	8,924	-25	0%	-1%	8,924	-26	0%	-1%
			Rearing (Juvenile)	Apr 1-Sep 30	4,702	4,702	0	0%	0%	4,666	-37	-1%	-3%	4,652	-51	-1%	-3%	4,654	-48	-1%	-2%
			Spawning	May 1-Jul 31	2,514	2,514	0	0%	0%	2,553	39	2%	0%	2,575	61	2%	1%	2,568	54	2%	1%
			Fry	Jul 1-Sep 30	6,430	6,430	0	0%	0%	6,505	75	1%	0%	6,530	101	2%	1%	6,530	101	2%	1%
			Overwintering	Oct 1-Mar 31	456	456	0	0%	0%	453	-2	-1%	-1%	453	-3	-1%	-1%	453	-3	-1%	-1%
6	Above Morin Creek to Gold Creek Bridge	1,683	Rearing (Adult)	Apr 1-Sep 30	3,626	3,626	0	0%	0%	3,501	-124	-3%	-9%	3,474	-152	-4%	-8%	3,478	-148	-4%	-8%
			Rearing (Juvenile)	Apr 1-Sep 30	1,583	1,583	0	0%	0%	1,515	-67	-4%	-8%	1,500	-82	-5%	-7%	1,503	-79	-5%	-7%
			Spawning	May 1-Jul 31	1,395	1,395	0	0%	0%	1,351	-43	-3%	-8%	1,341	-53	-4%	-7%	1,344	-51	-4%	-7%
			Fry	Jul 1-Sep 30	4,301	4,301	0	0%	0%	4,309	8	0%	-1%	4,310	9	0%	-1%	4,310	9	0%	-1%
			Overwintering	Oct 1-Mar 31	185	185	0	0%	0%	181	-3	-2%	-3%	181	-4	-2%	-3%	181	-3	-2%	-2%
5	Below Morin Creek	502	Rearing (Adult)	Apr 1-Sep 30	1,491	1,491	0	0%	0%	1,499	8	1%	-2%	1,502	11	1%	-2%	1,501	10	1%	-2%
			Rearing (Juvenile)	Apr 1-Sep 30	612	612	0	0%	0%	609	-3	0%	-4%	609	-3	0%	-3%	609	-3	0%	-3%
			Spawning	May 1-Jul 31	227	227	0	0%	0%	235	8	3%	1%	236	9	4%	3%	236	9	4%	3%
			Fry	Jul 1-Sep 30	764	764	0	0%	0%	789	25	3%	1%	791	28	4%	3%	791	28	4%	3%
			Overwintering	Oct 1-Mar 31	20	20	0	0%	0%	20	1	3%	0%	20	1	3%	2%	20	1	3%	2%
GOLD CREEK SUMMARY		**Total Length (m)**	**Bioperiod**	**Stanza**	TOTAL AWS (m²)	TOTAL AWS (m²)	**TOTAL CHANGE AWS (m²)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)	TOTAL AWS (m²)	**TOTAL CHANGE AWS (m²)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)	TOTAL AWS (m²)	**TOTAL CHANGE AWS (m²)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)	TOTAL AWS (m²)	**TOTAL CHANGE AWS (m²)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)
ALL REACHES (5 to 9)		**9,404**	**Rearing (Adult)**	**Apr 1-Sep 30**	18,121	18,121	**0**	**0%**	0%	17,907	**-214**	**-1%**	-12%	17,833	**-288**	**-2%**	-12%	17,849	**-272**	**-2%**	-9%
			Rearing (Juvenile)	**Apr 1-Sep 30**	9,556	9,556	**0**	**0%**	0%	9,405	**-151**	**-2%**	-8%	9,351	**-205**	**-2%**	-7%	9,364	**-192**	**-2%**	-7%
			Spawning	**May 1-Jul 31**	6,202	6,202	**0**	**0%**	0%	6,177	**-24**	**0%**	-9%	6,174	**-27**	**0%**	-7%	6,175	**-26**	**0%**	-7%
			Fry	**Jul 1-Sep 30**	19,387	19,387	**0**	**0%**	0%	19,462	**75**	**0%**	-2%	19,483	**96**	**0%**	-2%	19,483	**96**	**0%**	-2%
			Overwintering	**Oct 1-Mar 31**	1,001	1,001	**0**	**0%**	0%	992	**-8**	**-1%**	-5%	991	**-10**	**-1%**	-5%	992	**-8**	**-1%**	-5%

Notes:

Boxed values represent predicted habitat changes of 10% or more

[1] AWS = Area Weighted Suitability; the total surface area of predicted suitable habitat, calculated as the product of reach length and m² suitable wetted width (weighted by individual cross-section suitability results)

[2] This represents the single month within a given reach, stanza and mine life stage which produces the largest % habitat loss below the corresponding monthly baseline value

Blairmore Creek

The predicted changes in habitat (AWS) in Blairmore Creek, for each reach, bioperiod, and Project phase are summarized for average hydrological conditions in Table 4.8.

Reach 5

Reach 5 as approximated by the model prediction node BL-03 (Table 4.8) was assumed to remain upstream of all mine-related effects on total flow (Consultant Report #4); therefore, no changes from baseline (2017) habitat area were predicted during any Project phase.

Reaches 3 and 4

Project effects were predicted to increase flows downstream of Reach 5, relative to the baseline period, beginning during the construction (2018) phase (Consultant Report #4). The flow changes simulated at model prediction node BL-02, located at the transition between Reaches 3 and 4 (Table 4.8), were applied within habitat change predictions for both reaches and provided a more conservative estimate of the positive flow changes than at node BC-07 (upper Reach 4; Table 4.8). The predicted flow gains at BL-02 remained below 10% during 92% of all months from 2018 to 2099. Flow gains of 10% or higher were predicted primarily during winter and some fall months during certain operations-phase years, and most months of 2042 including January when the largest individual monthly flow gain (33%) was predicted.

Mean habitat changes in AWS for Reach 4 were extremely small for each Project phase and bioperiod. Since the predicted flow gains primarily occurred during winter, predicted habitat changes during spawning (May-July) were essentially absent, whereas the highest gains (4% average, equivalent to 10 m^2) were during the overwintering bioperiod with very limited baseline habitat (233 m^2). No habitat losses were predicted for any bioperiod and Project phase, even at the (worst-case) individual monthly timescale. Results were similar across Reach 3, but gains in the overwintering habitat reached 7% on average during construction, and 3 to 5% on average during other phases, though the baseline habitat area in this reach (70 m^2) was even more limited.

Cumulative predicted habitat gains across all three study reaches ranged between 111 to 196 m^2 of adult rearing habitat (1% of baseline), 84-155 m^2 of juvenile rearing habitat (1 to 2% of baseline), 9 to 18 m^2 of spawning habitat (0% of baseline), 85 to 147 m^2 of fry habitat (0 to 1% of baseline) and 7 to 15 m^2 of overwintering habitat (1 to 3% of baseline).

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Table 4.8 Blairmore Creek Habitat Area Predictions, 2017-2099, during average hydrological conditions.

					Baseline 2017	Construction 2018				Operations 2019-2042				Decommissioning 2043-2044				Closure 2045-2099		
Reach details			*Westslope Cutthroat Trout*		Mean Suitable Area	Mean Suitable Area	Difference from baseline period: Mean		1-month max	Mean Suitable Area	Difference from baseline period: Mean		1-month max	Mean Suitable Area	Difference from baseline period: Mean		1-month max	Mean Suitable Area	Difference from baseline period: Mean		1-month max
#	Description	Length (m)	Bioperiod	Stanza	m^2 AWS[1]	m^2 AWS[1]	m^2 AWS[1]	% AWS[1]	% AWS[2]	m^2 AWS[1]	m^2 AWS[1]	% AWS[1]	% AWS[2]	m^2 AWS[1]	m^2 AWS[1]	% AWS[1]	% AWS[2]	m^2 AWS[1]	m^2 AWS[1]	% AWS[1]	% AWS[2]
5	Above Mine Influence	3,230	Rearing (Adult)	Apr 1-Sep 30	4,657	4,657	0	0%	0%	4,657	0	0%	0%	4,657	0	0%	0%	4,657	0	0%	0%
			Rearing (Juvenile)	Apr 1-Sep 30	2,850	2,850	0	0%	0%	2,850	0	0%	0%	2,850	0	0%	0%	2,850	0	0%	0%
			Spawning	May 1-Jul 31	1,006	1,006	0	0%	0%	1,006	0	0%	0%	1,006	0	0%	0%	1,006	0	0%	0%
			Fry	Jul 1-Sep 30	6,075	6,075	0	0%	0%	6,075	0	0%	0%	6,075	0	0%	0%	6,075	0	0%	0%
			Overwintering	Oct 1-Mar 31	222	222	0	0%	0%	222	0	0%	0%	222	0	0%	0%	222	0	0%	0%
4	Northwest Surge Pond to BLT4 trib	3,942	Rearing (Adult)	Apr 1-Sep 30	7,463	7,561	98	1%	1%	7,605	142	2%	0%	7,542	79	1%	0%	7,604	141	2%	1%
			Rearing (Juvenile)	Apr 1-Sep 30	4,113	4,180	67	2%	1%	4,211	98	2%	0%	4,167	55	1%	1%	4,215	102	2%	1%
			Spawning	May 1-Jul 31	3,104	3,112	8	0%	0%	3,115	11	0%	0%	3,110	7	0%	0%	3,117	13	0%	0%
			Fry	Jul 1-Sep 30	9,219	9,273	54	1%	0%	9,297	78	1%	0%	9,263	44	0%	0%	9,286	67	1%	0%
			Overwintering	Oct 1-Mar 31	233	237	5	2%	0%	243	10	4%	0%	237	4	2%	0%	241	8	3%	0%
3	1km reach below BLT4 trib	1,167	Rearing (Adult)	Apr 1-Sep 30	2,832	2,868	35	1%	1%	2,886	54	2%	0%	2,864	32	1%	0%	2,883	51	2%	1%
			Rearing (Juvenile)	Apr 1-Sep 30	1,805	1,839	35	2%	1%	1,857	52	3%	1%	1,835	30	2%	1%	1,858	53	3%	1%
			Spawning	May 1-Jul 31	1,148	1,151	3	0%	0%	1,152	4	0%	0%	1,150	2	0%	0%	1,152	5	0%	0%
			Fry	Jul 1-Sep 30	4,019	4,063	44	1%	0%	4,088	69	2%	0%	4,061	41	1%	0%	4,073	54	1%	0%
			Overwintering	Oct 1-Mar 31	70	72	2	3%	2%	75	5	7%	2%	72	2	3%	2%	74	4	5%	2%
BLAIRMORE CREEK SUMMARY		**Total Length (m)**	**Bioperiod**	**Stanza**	TOTAL AWS (m^2)	**TOTAL AWS (m^2)**	**TOTAL CHANGE AWS (m^2)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)	TOTAL AWS (m^2)	**TOTAL CHANGE AWS (m^2)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)	TOTAL AWS (m^2)	**TOTAL CHANGE AWS (m^2)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)	TOTAL AWS (m^2)	**TOTAL CHANGE AWS (m^2)**	**AVERAGE CHANGE AWS (%)**	1-month max loss AWS (%)
ALL REACHES (3 to 5)		**8,339**	**Rearing (Adult)**	**Apr 1-Sep 30**	14,952	**15,085**	**133**	**1%**	0%	15,148	**196**	**1%**	0%	15,062	**111**	**1%**	0%	15,144	**192**	**1%**	0%
			Rearing (Juvenile)	**Apr 1-Sep 30**	8,768	**8,869**	**102**	**1%**	0%	8,918	**150**	**2%**	0%	8,852	**84**	**1%**	0%	8,923	**155**	**2%**	0%
			Spawning	**May 1-Jul 31**	5,257	**5,268**	**11**	**0%**	0%	5,272	**15**	**0%**	0%	5,266	**9**	**0%**	0%	5,275	**18**	**0%**	0%
			Fry	**Jul 1-Sep 30**	19,313	**19,410**	**97**	**1%**	0%	19,460	**147**	**1%**	0%	19,398	**85**	**0%**	0%	19,434	**121**	**1%**	0%
			Overwintering	**Oct 1-Mar 31**	525	**532**	**7**	**1%**	0%	540	**15**	**3%**	0%	531	**7**	**1%**	0%	536	**12**	**2%**	0%

Notes:
Boxed values represent predicted habitat changes of 10% or more
1- AWS = Area Weighted Suitability; the total surface area of predicted suitable habitat, calculated as the product of reach length and m^2 suitable wetted width (weighted by individual cross-section suitability results)
2- This represents the single month within a given reach, stanza and mine life stage which produces the largest % habitat loss below the corresponding monthly baseline value

4.3.2.2 Regional Study Area

Residual Effects Analysis

Under baseline conditions the long-term estimates of MMD at Crownest River (WSC gauge), Gold Creek (WSC gauge), and Blairmore Creek (BC-H01 gauge) are provided (Table 4.9). Blairmore Creek watershed is approximately 13% of the size of Crowsnest River watershed but contributions are estimated to be even less because the catchment is flat, forested, and drier than the Crowsnest River. Gold Creek watershed is about 14% of the size of Crowsnest River watershed and contributions are approximately equal to that during summer and higher in winter due to large groundwater contribution. These estimated contributions from Gold Creek are very conservative since Gold Creek drains into the Crowsnest River downstream of the Crowsnest WSC Gauge. Gold Creek MMD as a proportion of Crowsnest River at the confluence (i.e., Crowsnest River and Gold creek tributaries) would be lower.

Table 4.9 Baseline conditions in the Regional Study Area, mean monthly discharge (MMD).

	Crownest River at Frank 1910-2014	Blairmore Creek 1975-2016		Gold Creek 1975-2016	
	m^3/s	m^3/s	% of Crowsnest	m^3/s	% of Crowsnest
Jan	1.47	0.061	4%	0.338	23%
Feb	1.31	0.058	4%	0.313	24%
Mar	1.52	0.064	4%	0.351	23%
Apr	4.1	0.286	7%	0.537	13%
May	14.4	0.772	5%	1.395	10%
Jun	15.7	0.917	6%	1.673	11%
Jul	7.49	0.254	3%	0.905	12%
Aug	3.83	0.114	3%	0.643	17%
Sep	2.97	0.085	3%	0.544	18%
Oct	2.67	0.08	3%	0.505	19%
Nov	2.2	0.072	3%	0.435	20%
Dec	1.67	0.067	4%	0.383	23%

Predicted worst case Project effects (highest gains or losses have been assumed) were considered using the nodes at mouth of Blairmore and Gold creeks, during 1:10 dry years, which occur at the peak/end of operations around 2042 (Table 4.10). Baseline flows multiplied by the percentage of Project effects provide Project-affected MMD. These values were then compared to the Crowsnest River baseline predictions. Gold Creek changes in hydrology are likely conservative (i.e., calculated predicted losses to Crowsnest River are likely higher than will actually occur) for the same reason described above. The net results, in all months, worst case (highest) flow gains to Crowsnest River (through Blairmore Creek) resulting from the

Project are 1.5%, worst case (highest) flow losses to Crowsnest River (through Gold Creek) resulting from the Project are 1.4%.

Table 4.10 Project flows in the Regional Study Area (worst-case), mean monthly discharge (MMD).

	Crownest River at Frank	Blairmore Creek			Gold Creek			
	1910-2014 (m^3/s)	Flow Gain (%)	Flow Gain (m^3/s)	Flow Gain as % of Crowsnest	Flow Loss (%)	Flow Loss (m^3/s)	Flow Loss as % of Crowsnest	Flow Loss (%)
Jan	1.47	37%	0.023	1.5%	-6%	-0.020	-1.4%	-6%
Feb	1.31	34%	0.020	1.5%	-6%	-0.019	-1.4%	-6%
Mar	1.52	26%	0.017	1.1%	-6%	-0.021	-1.4%	-6%
Apr	4.1	14%	0.040	1.0%	-6%	-0.032	-0.8%	-6%
May	14.4	7%	0.054	0.4%	-6%	-0.084	-0.6%	-6%
Jun	15.7	7%	0.064	0.4%	-6%	-0.100	-0.6%	-6%
Jul	7.49	9%	0.023	0.3%	-6%	-0.054	-0.7%	-6%
Aug	3.83	15%	0.017	0.4%	-6%	-0.039	-1.0%	-6%
Sep	2.97	17%	0.014	0.5%	-6%	-0.033	-1.1%	-6%
Oct	2.67	21%	0.017	0.6%	-6%	-0.030	-1.1%	-6%
Nov	2.2	20%	0.014	0.7%	-6%	-0.026	-1.2%	-6%
Dec	1.67	26%	0.017	1.0%	-6%	-0.023	-1.4%	-6%

In summary, the contribution of stream flows from Gold and Blairmore creeks to the Crowsnest River are low. Thus, any predicted flow reductions in the Crowsnest River as a result of predicted flow changes in Gold Creek are expected to be negligible during key bioperiods for fish species that inhabit the Crowsnest River. Additionally, with the increase in flows predicted for Blairmore Creek, any change in flow in the Crowsnest River downstream from the Gold Creek confluence will be very short in duration until such time the time lag in flow from Blairmore Creek connects with the flows at the Gold Creek confluence.

As a result, no residual effects to fish or fish habitat in the RSA are expected as a result of changes in hydrology in Gold and Blairmore creeks.

4.4 PLANNED DEVELOPMENT CASE

Residual effects on aquatic ecological resources resulting from the primary pathways identified for the Project were assessed for the Application Case (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* (Consultant Report #5) and 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.

The Crowsnest River has a long-standing reputation as a quality fishery for large RNTR and mountain whitefish (*Prosopium williamsoni*), drawing anglers to the Crowsnest Pass from considerable distances (Blackburn 2011). Numerous outfitters and guides make a living from the sport fishery, as well as, local fly shops and businesses that benefit from visiting anglers. The Crowsnest River is considered one of the most popular trout fisheries in Alberta. An angler survey conducted in 2001, indicated that 12,000 anglers fished a total of 32,000 hours on the portion of the Crowsnest River between Crowsnest Lake and the Oldman Reservoir, during the summer of 2001 (June–September) targeting mainly RNTR and mountain whitefish (Genereux and Bryski 2002).

The sport fishery in the Crowsnest River drainage has undergone considerable change as a result of landscape disturbance and past fisheries management decisions. The historical sport fish assemblage in the Crowsnest River mainstem included mountain whitefish, bull trout (*Salvelinus confluentus*), and WSCT. Through several plantings in the 1930s and 1940s, RNTR became established, displacing native WSCT and restricting them to select tributaries (AESRD and ACA 2006, Taylor and Gow 2007). Bull trout, which once occurred in tributaries above and below Lundbreck Falls (Fitch 1997), have been restricted to the main-stem river below the falls (AESRD and ACA 2009) as a result of over harvest and habitat loss. Continued habitat degradation from recreational, industrial and municipal development activities, as well as competition from less desirable exotic species threaten the sport fishery. Species introduced into the drainage since the 1960s include lake trout (*Salvelinus namaycush*), brown trout (*Salmo trutta*) and BKTR (Blackburn 2011).

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 (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.

4.5 RESIDUAL EFFECTS CLASSIFICATION AND DETERMINATION OF SIGNIFICANCE

The purpose of the residual effects classification is to describe the incremental and cumulative effects from the Project and other developments on the VC using a scale of common words rather than numbers and units. The use of common words or criteria is an accepted practice in environmental assessment. The following criteria have been used to classify the residual effects from the Project based on the definitions in Table 3.6:

- Direction;
- Magnitude;
- Geographic extent;
- Duration;
- Frequency;
- Reversibility; and
- Likelihood.

The classification of residual effects on WSCT from the Project for the Application Case is summarized in Table 4.11.

Table 4.11 Classification of application case residual adverse effects on Westslope Cutthroat Trout.

Valued Component	Issue	Study Area	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Project Contribution	Confidence Rating	Probability of Occurrence	Significance Rating
Westslope Cutthroat Trout	The physical footprint of surface water management infrastructure and open pits will cause the permanent change to WSCT habitat. The loss of habitat will be offset by gains achieved through implementing an Offsetting Plan approved by DFO.	Local Study Area	Moderate	Local	Long	Continuous	Reversible in long-term	Positive (with application of Mitigation and Offsetting)	Moderate	High	Not Significant
		Regional Study Area	Not assessed as there will be no design impacts of the Project in the Regional Study Area								
	Changes in hydrology causing alteration in WSCT aquatic habitat of Gold and Blairmore creeks. The alteration of habitat will be offset by gains achieved through implementing an Offsetting Plan approved by DFO.	Local Study Area	Moderate	Local	Extended	Continuous	Reversible in long-term	Positive (with application of Mitigation and Offsetting)	Moderate	High	Not Significant
		Regional Study Area	Low	Regional	Short	Continuous	Reversible in short-term	Neutral	High	High	Not Significant

A direct, moderate magnitude, long-term, reversible (in the long-term) loss of fish habitat (aquatic and/or riparian) within the LSA is expected due to the Project footprint. The duration and reversibility of losses consider that a period of time of approximately 10 years between the losses occurring and the offsetting measures becoming fully functional will likely occur. The frequency is deemed continuous over the duration of the effect. The geographic extent of the residual effects associated with tributary habitat losses are expected to be limited to the LSA. Design and implementation of an Offsetting Plan (a preliminary version is included in Appendix A4) early in the Project development will offset any permanent loss of habitat that could result in effects to the productivity of WSCT.

A moderate magnitude, extended duration, continuous and reversible loss of flow in Gold Creek is predicted, thus changes to suitability to fish habitat within the LSA is expected. These effects are caused by a combination of the Project footprint and site water management for water quality variable exceedances. Although appropriate BMPs and other mitigation measures will be applied, the construction of water management features and the execution and operation of on-site water management will result in a permanent loss of WSCT tributary habitat in Gold Creek watershed. Additionally, it is predicted that 288 m^2 of adult holding, 27 m^2 of spawning, 205 m^2 juvenile rearing, and 10 m^2 of overwintering will be altered during average flow (runoff) conditions. If stream flows in a given year are expected to be lower than average conditions (e.g., 1:10 dry, 1:20 dry), then short-term mitigation measures (through operational onsite flow augmentation) will be executed to account for those flow reductions thus alleviate any elevated alterations to critical habitat.

Preliminary fish habitat offsetting options have been identified to counterbalance the loss of fish-bearing tributary habitat associated with both the footprint of the Project and alterations resulting from changes to hydrology in Gold Creek (Appendix A3). Key objectives considered in the identification and prioritization of offsetting options was to provide habitat to provide the functional use and productivity of habitats that will be lost within the affected tributaries and focus on the creation or enhancement of habitat that is determined to be limiting to WSCT in Gold Creek and (to a lesser degree) Blairmore Creek (given Blairmore Creek is expected to experience habitat gains or improvement). Many factors will be considered thoroughly as the Habitat Offsetting Plan is finalized such as land ownership, engineering feasibility, confirmation of limiting WSCT habitat, and WSCT Recovery Strategy priorities and objectives. Preliminary offsetting options have been presented in Appendix A4. These conceptual offsetting options were devised through the collection of baseline information during field investigations. It is believed that these proposed options will provide meaningful habitat offsets that will more than compensate for the functional habitat predicted to be lost as a result of the Project.

For the WSCT relative abundance and distribution measurement indicator, no net change in the abundance of WSCT has been predicted based on ongoing productivity of offsetting options aimed to counterbalance or exceed any predicted loss of WSCT tributary habitat (currently not included as part of the Critical Habitat designation) or habitat altered as a result of changes in hydrology in Gold Creek.

The measurement indicator for survival and reproduction of WSCT considers changes both in fish habitat as well as the health of WSCT. Spawning habitat surveys completed for the Project in 2016 identified key spawning areas in both Gold and Blairmore creeks that will be monitored further to confirm the spawning window and key reaches given the abnormally low flows experienced in 2016. The apparent fry recruitment failure in Gold Creek under 2016 baseline conditions highlights the importance of understanding what may have caused the failure (spawning and/or incubation effects) and whether WSCT fry recruitment is a consistent limiting factor in Gold Creek or is specific to low flow scenarios (as experienced in 2016). Ultimately this will ensure adequate accounting of the WSCT life-history in Gold Creek and allow for more effective mitigation (e.g., flow augmentation during spawning in low flow years) and selection of offsetting (e.g., enhancement of spawning habitat). As noted in Section 4.2.2 changes to WSCT survival as a result of water quality and fish health were considered secondary pathways that are not expected to affect the maintenance of self-sustaining (and overall productivity) of WSCT in both the LSA and RSA with the planned water quality mitigation established and operating effectively.

The magnitude of residual effects associated with the tributary habitat loss was determined to be moderate. The residual effect on WSCT and its habitat is measurable in that tributary habitat will be removed or altered and the productivity contributions specifically provided by those tributary habitats will be lost; these losses will be reversed and additional gains exceeding the losses will be realized once the Habitat Offsetting Plan is finalized, implemented, and deemed functionally effective confirmed through monitoring. Thus, the effects of the losses are reversible and are not expected to extend beyond the resilience limits of the WSCT population in Gold Creek.

The geographic extent of the residual effects associated with tributary habitat effects are expected to be limited to the LSA. Design and implementation of the Habitat Offsetting Plan once finalized will compensate any destruction or alteration of habitat that could result in effects to the productivity of WSCT. Therefore, the residual effects associated with the loss or alteration of tributary and mainstem habitat is considered reversible in the short-term to medium-term. Additionally, the frequency of residual effects for loss of Gold Creek WSCT tributary habitat due to the Project footprint or changes to hydrology in the Gold Creek mainstem is expected to be continuous over the duration of the effect.

4.5.1 Determination of Significance

The residual effects from the Project, once the Habitat Offsetting Plan is finalized and implemented for the Project, are not predicted to be large enough to influence the maintenance of self-sustaining, or overall productivity of, WSCT populations in the LSA. The residual effects from the Project are not expected to cause irreversible changes at the population level or decrease resilience of WSCT populations within the LSA or RSA. Overall, the residual effects from the Project (as a whole) on the maintenance of self-sustaining, and overall productivity of, WSCT populations in Gold and Blairmore Creek watersheds are predicted to be ***not significant***.

4.6 PREDICTION CONFIDENCE AND UNCERTAINTY

Like all scientific results and inference, residual effects predictions are subject to uncertainty. Uncertainty can stem from various factors. For example, uncertainty may be associated with various assumptions and limitations inherent in the data, the extent of current knowledge of the system under study, the collective biology of a species, and natural variability and resilience to change.

The confidence in residual effect predictions for the Project is related to the following:

- The adequacy of baseline data for understanding conditions in the Project footprint;
- The accuracy of predicted and modeled data; and

- The understanding of the Project-related residual environment (aquatic) effects on the system.

There is a high degree of confidence and certainty that some WSCT habitat in affected tributaries will be permanently lost or altered through Project construction and operation. The affected reaches have been identified based on the Project footprint as well as stream flows (hydrology) during average conditions that are predicted to occur within the affected watercourses (Gold and Blairmore creeks) in the LSA.

The quantity of fish habitat (aquatic and/or riparian) losses due to the Project (largely by way of sedimentation/surge pond development) in Gold and Blairmore creek watersheds is well recognized since the calculation of losses takes into consideration physical parameters and ecological value.

Detailed fish habitat assessments that characterized habitats at the macro- and mesohabitat unit (i.e., pools, riffles, runs) scales were conducted during abnormally low flow circumstances, which allowed for assessment of these habitats at a time when each system was under potentially low flow conditions (1:10, 1:20 drought). Thus, the conditions experienced provided a conservative snapshot of how each system responds during a dry event. Further, all predicted habitat changes (gains/losses) are calculated following the same approach, regardless of the overall contribution of a specific reach to the productivity of the WSCT population under assessment. In other words, losses in reaches that may have a lower contribution to the maintenance of Gold Creek WSCT population will be offset at the same ratio as those that have a greater contribution.

There is some uncertainty associated with the extent of fish habitat loss that is expected in the affected tributaries as the design of water management features (sedimentation/surge ponds) are not finalized. For example, it is possible that the location of the proposed NESP that currently is designed over GCT11 could be re-configured, which could reduce the amount of aquatic and riparian habitat losses currently estimated. A footprint impact verification assessment could be performed once designs are finalized to re-confirm the actual fish habitat changes.

Some uncertainty is present in the process used for identifying and constructing offsetting options to counterbalance for losses of fish habitat expected due to Project activities. Due to the many features and processes that control complex systems, it is challenging to design and construct offsetting habitat that will simulate naturally occurring fish habitat. Benga is committed to the sustainability of the environment and communities for which they operate. Further, as a requirement of any *Fisheries Act* and associated SARA approval, Benga will be required to estimate the cost of offsetting measures and required to submit a letter of credit in an amount agreed to by the Minister of DFO. The amount of the letter of credit is to be sufficient to complete a final Offsetting Plan and monitoring program upon agreement of the aquatic ecology residual effects for the Project.

The monetary value of the letter of credit is determined by an estimate of the cost for implementing all elements of the Habitat Offsetting Plan, including elements related to monitoring and maintenance of offsetting features. The estimate considers any additional costs that could be incurred by DFO to complete the Habitat Offsetting Plan and allows for cost overruns for remobilizing machinery to a work site (DFO 2013a).

The flow modeling results used in the IFA (Appendix A3) to estimate potential effects related to changes in runoff (thus streamflow) in Gold Creek is considered to provide a reasonable prediction of the magnitude of incremental effects. Predicted changes in runoff (streamflow) including groundwater/surface water interactions, and parameters applied to the model used to generate effects predictions were taken from Consultant Report #4 and were assumed to be generated using acceptable industry standards. Proposed follow up flow monitoring is outlined in the IFA (Appendix A3).

The IFA conducted for this Project used calibrated hydraulic habitat models to represent and predict how the availability and suitability of habitat for various bioperiods associated with WSCT varies with stream flow. These models were used to assess potential effects to the species during mine-phase scenarios. These models relied on four sources of input data:

- Species-specific HSC that depict the preference for different water depths, velocities, and substrate (where applicable) by different life stages of WSCT;
- Mapped distribution of mesohabitats across model reaches for weighting cross-section results;
- Hydraulic relationships depicting how water depths and water velocities vary with flow; and
- A hydrological data time series that depicts baseline flows and predicts flows under different future conditions.

There are limitations within each of these inputs that translates into uncertainty within the predictions and results of the IFA. The IFA (Appendix A3) provides a detailed accounting of uncertainties and recommended future monitoring, which are touched on in Section 6.0 (Monitoring and Follow-up).

Uncertainty was addressed in the Aquatic Ecology Effects Assessment by incorporating available historical information for the LSA and RSA and collecting additional representative fish and aquatic resource data specific for the Project (Appendix A1). This information was used to provide a reliable and consistent description of WSCT habitat availability, abundance, distribution and use in the LSA. The methods and analytical procedures applied over the course of the assessment were based on established techniques that are supported by published literature, experts, and experience gained from other projects in proximity to this Project that include the same species and interactions. As stated, predicted residual loss or alteration of fish habitat will be replaced through the implementation of a finalized Habitat Offsetting Plan for the Project. Overall a net gain in fish (critical) habitat is targeted for Gold Creek given its species at risk (i.e., critical habitat) status. It is expected that the final Habitat Offsetting Plan will be agreed to (in principle) with DFO and provincial regulators.

5.0 CONCLUSIONS

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. These pathways were:

- Permanent loss or alteration to 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.

A summary of the quantified residual effects from these pathways is provided in Table 5.1.

Table 5.1 Summary of quantified residual effects on fish habitat for the Project.

Valued Component	Watercourse	Issue	Residual Effect	Quantity (m^2)
Westslope Cutthroat Trout	Gold Creek	Permanent change to Fish Habitat in the LSA due to Project Footprint	Aquatic Habitat	-758
			Riparian Habitat[1]	-18,868
		Changes to hydrology resulting in affects to WSCT Critical Habitat[2]	Spawning/Incubation	-27
			Adult Holding	-288
			Juvenile Rearing	-205
			Fry Rearing	+96
			Overwintering	-10
	Blairmore Creek	Permanent change to Fish Habitat in the LSA due to Project Footprint	Aquatic Habitat	0
			Riparian Habitat[1]	-402
		Changes to hydrology resulting in affects to WSCT habitat[2]	Spawning/Incubation	+18
			Adult Holding	+192
			Juvenile Rearing	+155
			Fry Rearing	+121
			Overwintering	+12

[1] Quantified riparian habitat value includes classified medium and high valued habitat on fish bearing watercourses
[2] Habitat alterations are based on average flow scenario for the Project

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 are predicted to be altered as a result in changes to the Gold Creek hydrological regime (Table 5.1).

The Project will result in a loss of 402 m^2 of riparian habitat on Blairmore Creek (Table 5.1). 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.

Changes in hydrology are predicted to result in a 96 m^2 increase of functional habitat (i.e., fry rearing) in Gold Creek and 498 m^2 (i.e., spawning/incubation, adult holding, juvenile rearing, fry rearing and overwintering) in Blairmore Creek (Table 5.1).

6.0 PROPOSED MONITORING AND FOLLOW-UP

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. For example, the monitoring plan for potential changes in flow on WSCT in Gold Creek will consider Lewis et al. (2004) that developed recommendations for monitoring of hydroelectric projects in BC and Yukon. Guidelines on monitoring frequency and intensity are provided by Lewis et al. (2004) and were reviewed by Connors et al. (2014).

The purpose of the ARMP will be to test the predictions of the EA regarding the efficacy of mitigation measures proposed to protect fish and fish habitat during the construction phase. One component of that plan that is directly relevant to fish will be salvage methods appropriate for fish and the habitat being salvaged from the mine site. Fish salvage during construction of the mine site on tributaries that were identified as fish bearing during the baseline investigations is one of the mitigation measures that will reduce direct fish mortality to WSCT. Live capture methods appropriate for fish and fish habitat being salvaged will be used to capture fish live. Appropriate standards and permit conditions will be followed for all live captures. All live fish will be re-located to reaches in Gold Creek, or as approved by Regulators.

Scientific uncertainty associated with the assessment of Project effects on the WSCT VC will be addressed through an AEMP. The purpose of the AEMP is to test predictions of the EIA regarding potential Project effects on stream flows, water quality, sediment quality (i.e. calcite precipitation), and 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 and reducing costs of sampling, administration and reporting. The AEMP will be developed by Benga in consultation with regulatory agencies and taking into account public and Aboriginal concerns.

Where applicable, the preferred study design for the AEMP is a Before-after-control-impact (BACI) monitoring design. BACI monitoring designs are used elsewhere in Canadian mines (e.g., EKATI Diamond Mine of the Northwest Territories). BACI designs are preferred for situations where appropriate control sites (also called reference sites) are available (Lewis et al. 2004). BACI designs control for potential confounding effects of temporal variability by measuring simultaneous change at both study and control (also called reference) sites. As much as possible, statistical criteria will be used to make that determination.

Fish components of the AEMP will be developed using results of baseline sampling conducted from 2014 to 2016. Given some data was only recently collected in 2016, additional baseline data collection in Gold and Blairmore creeks will be required to strengthen the baseline data set and confirm findings in 2016 given the low flow year experienced. Where 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.

Fish and fish habitat components of the AEMP may include the following (but is not limited to):

- WSCT spawner surveys in both Gold and Blairmore creeks, conducted yearly following the back-end of spring freshet. Initial surveys would be to confirm the timing window in average flow years as 2016 was extremely low flow and it is hypothesized that spawning occurred earlier than expected;
- WSCT fry/juvenile recruitment and density surveys, body size and age at sites in Gold Creek and Blairmore Creek measured each year in August post-fry emergence;
- Trout tissue metals concentration monitoring;
- Validation of WSCT HSC curves used in the IFA (Appendix A3) for the Project;
- Stream flows and water temperatures in Gold and Blairmore creeks, measured continuously at the same established (hydrometric and temperature data logger) monitoring locations deployed in 2016 and install additional hydrometric stations in Gold and Blairmore creeks in key reaches that are data deficient (Appendix A3). Of note, all hydrometric stations and select temperature data loggers deployed in 2016 continue to collect baseline data;
- Stream habitat quality (e.g., water depth and velocity, substrate composition) at sites in Gold and Blairmore creeks at various flows. Monitoring will be required to determine if physical habitat effects occur in Gold Creek based on the predicted changes in hydrology. 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. Monitoring should continue until long-term trends in habitat availability have been confirmed;
- Calcite precipitation monitoring of key WSCT spawning areas in both Gold and Blairmore creeks as per initial recommendations described by SRK (2016b; Appendix 10B);

- Stream periphyton and benthic macroinvertebrate sampling at sites in both Gold and Blairmore creeks measured once per year in August.

It should be highlighted that Benga has partially funded a research project that specifically investigates the quality, extend and use of overwintering habitat by WSCT in Gold and Blairmore creeks. This research is ongoing and is being run through the University of Lethbridge (Dr. Jospeh Rasmussen). This information will build upon the baseline overwintering habitat data collected as part of this effects assessment and provide valuable information moving forward to ensure the Gold and Blairmore populations of WSCT are well protected.

The third monitoring program will be compliance and effectiveness monitoring required under a Fisheries Authorization and/or SARA approval that will be sought from DFO to allow permanent alteration and destruction of fish habitat on the mine site. The preliminary Offsetting Plan (Appendix A4) describes a suite of identified conceptual offsetting options that offer plenty of in-kind opportunity to counterbalance the identified residual effects for the Project, increase ongoing productivity of WSCT, and support the Recovery Strategy objectives for WSCT populations in Alberta. Compliance monitoring would be continuous throughout a monitoring period as described in the Preliminary Offsetting Plan report (Appendix A4) and will be defined further through consultation with DFO. Further field investigations are necessary to more accurately define the cost, feasibility, and offset value of each option presented in the Preliminary Offsetting Plan, which would be presented in a more detailed report.

6.1.1 Adaptive Management

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.

If a monitoring and follow-up program identifies that adverse environmental effects are greater than predicted, then Benga will evaluate whether they result in changes to the conclusions presented in this effects assessment. If changes are confirmed, then Benga will evaluate the need for revised mitigation actions and management practices to manage effects. Where the need for revised mitigations is identified, they will be developed and implemented.

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