Hatfield
CONSULTANTS

# Grassy Mountain Coal Project

# Fish & Aquatic Resources Baseline and Effects Assessment Status Update

**August 2016**

*Prepared for:*

**Benga Mining Limited**
Blairmore, Alberta

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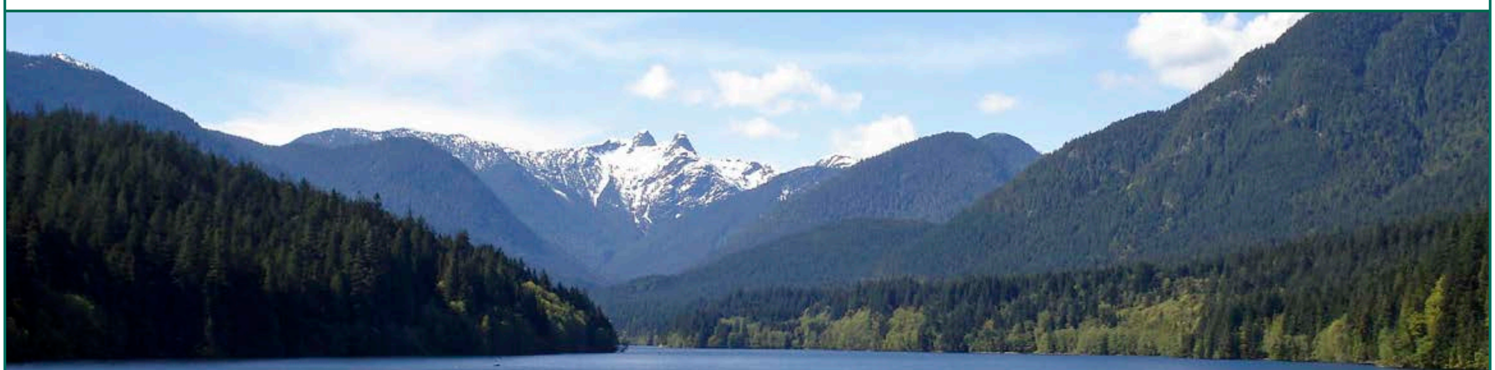

# GRASSY MOUNTAIN COAL PROJECT

# FISH & AQUATIC RESOURCES BASELINE AND EFFECTS ASSESSMENT

*Prepared for:*

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*Prepared by:*

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**AUGUST 2016**

MEMS7779

VERSION 1

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| | |
|---|---|
| **AESRD** | Alberta Environment and Sustainable Resource Development |
| **AEPEA** | Alberta Environmental Protection and Enhancement Act |
| **AER** | Alberta Energy Regulator |
| **BLTR** | Bull Trout |
| **BKTR** | Brook Trout |
| **CCME** | Canadian Council of Ministers of the Environment |
| **CEAA** | Canadian Environmental Assessment Agency |
| **COSEWIC** | Committee on the Status of Endangered Wildlife |
| **EIA** | Environmental Impact Assessment |
| **FEARO** | Federal Environmental Assessment Review Office |
| **FWMIS** | Fish and Wildlife Management Information System |
| **LSA** | local study area |
| **MEMS** | Millennium EMS Solutions Ltd. |
| **MNWH** | Mountain Whitefish |
| **RNTR** | Rainbow Trout |
| **RSA** | regional study area |
| **TOR** | Terms of Reference |
| **VIE** | Visible Implant Elastomer |
| **WQ** | Water Quality |

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|---|---|---|---|---|---|
| Cal Clark | Benga Mining Ltd. | - | - | ✓ | - |

# AMENDMENT RECORD

This report has been issued and amended as follows:

| Issue | Description | Date | Approved by | |
|---|---|---|---|---|
| 1 | First version of Fish and Aquatic Resources Baseline and Effects Assessment report | 20160805 | <Original signed by> | <Original signed by> |
| | | | Martin Davies<br>Project Director | Cory Bettles<br>Project Manager |

# 1.0 INTRODUCTION

Benga Mining Limited (Benga) conducted a fish and aquatic baseline assessment for the Grassy Mountain Coal Project (the Project) in 2014 and 2015 and are continuing with additional baseline data collection in 2016, which will provide the foundation of a detailed and comprehensive Aquatic Ecology Effects Assessment (AEA) within the defined aquatic local study area (Gold Creek and Blairmore Creek watersheds). At the time of the Project's environmental impact assessment (EIA) submission of August 2016, fish and aquatics field work was still being collected. Based on the sensitivity of both watercourses, the lack of historical or specific data, and through ongoing discussions with the Alberta Energy Regulator (AER), the Canadian Environmental Assessment Agency (the Agency) and the Department of Fisheries and Oceans (DFO) Species at Risk Act (SARA) specialists, it was agreed that once the entire 2016 baseline field program was completed, a more comprehensive and completed Fish and Aquatic Resources assessment would be provided to the AER and CEAA as an addendum to the EIA.

## 1.1 OVERVIEW

The following Fish and Aquatic Resources Consultant Report (CR#6) provides:

- a summary of the overarching fish and aquatic baseline and effects assessment approach;
- a summary of historical and recently collected baseline information generated up to August 2015;
- the plan for 2016 to collect additional fish and aquatic baseline field data, in particular data for completion of an instream flow needs (IFN) study; and
- the approach for completing the addendum aquatic ecology effects assessment (to be completed for Q1 2017), which will aim to provide a more robust assessment of predictive effects to the aquatic environment.

As the additional field data is compiled, it will provide supplementary information to guide project design and, more precisely, predict project-related effects on targeted valued components to further (and more appropriately) inform the environmental permitting process. The collection of additional fish and aquatics baseline information has been ongoing since March 2016 and will continue throughout the remainder of 2016, as appropriate.

This report has been prepared by Hatfield Consultants Partnership (Hatfield) for Benga.

## 1.2 TERMS OF REFERENCE

The scope, format and contents of the final aquatic effects assessment is being guided by the Terms of Reference (TOR) for the EIA report prepared by the AER (AER 2015, Appendix 1a) and the Guidelines for the Preparation of an Environmental Impact Statement prepared by the Canadian Environmental Assessment Agency (CEAA 2015, Appendix 2a). The final Aquatic Ecology Effects Assessment report will evaluate selected valued components (VCs) by considering key indicators and effect pathways in consideration of pertinent regulatory frameworks (e.g., Fisheries Act, Species at Risk Act etc.). The applicable TOR and guidelines for the aquatic ecology baseline and effects assessment for AER and CEAA are provided in Table 1.1 and Table 1.2, respectively.

## Table 1.1 AER Terms of Reference sections applicable to the Aquatic Ecology assessment.

| Section in Final Terms of Reference for Project (AER 2015) | |
|---|---|
| **4.5** | **Aquatic Ecology** |
| **4.5.1** | **Baseline Information** |
| [A] | Describe and map the fish, fish habitat and aquatic resources (e.g., aquatic and benthic invertebrates) of the lakes, rivers, ephemeral water bodies and other waters. Describe the species composition, distribution, relative abundance, movements and general life history parameters of fish resources. Also identify any species that are:<br>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);<br>b) Listed in Schedule 1 of the federal *Species at Risk Act*;<br>c) Listed as "at risk" by COSEWIC; and<br>d) Traditionally used species. |
| [B] | Describe and map existing critical or sensitive areas such as spawning, rearing, and over-wintering habitats, seasonal habitat use including migration and spawning routes. |
| [C] | Describe the current and potential use of the fish resources by Aboriginal, sport or commercial fisheries. |
| [D] | Describe and quantify the current extent of aquatic habitat fragmentation. |
| **4.5.2** | **Impact Assessment** |
| [A] | Describe the potential impacts to fish and fish habitat, such as stream alterations and changes to substrate conditions on water quality or quantity, while considering:<br>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;<br>b) Potential impacts on riparian areas that could affect biological resources and productivity;<br>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;<br>d) Changes to benthic invertebrate communities that may affect food quality and availability for fish; and<br>e) The potential for increased fragmentation of aquatic habitat. |
| [B] | Identify the key aquatic indicators that the proponent used to assess project impacts. Discuss the rationale for their selection. |
| [C] | Discuss the design, construction, and operational factors to be incorporated into the project to minimize impacts on fish and fish habitat and protect aquatic resources. Describe how any water intakes have been designed to avoid entrapment and entrainment of fish and provide information on the species of fish considered. |
| [D] | Identify plans proposed to offset any loss in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat. |
| [E] | Discuss the significance of any impacts on water quality and implications to aquatic resources (e.g., biota, biodiversity, and habitat) and related implications for First Nations' traditional and current use of these resources. |
| [F] | Describe the effects of any surface water withdrawals considered, including cumulative effects on fish and fish habitat. |

## Table 1.2 CEAA guideline sections applicable to the Aquatic Ecology assessment.

| Section in Final CEAA Terms of Reference for Project (CEAA 2015) |
|---|
| **Project Setting and Baseline Conditions** |
| **6.1.5 Fish and Fish Habitat** |
| For potential affected surface waters:<br>▪ 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);<br>▪ a description of primary and secondary productivity in affected water bodies, including a survey of benthic invertebrate communities with characterization of seasonal variability;<br>▪ a list of any fish or invertebrate species at risk that are known to be present;<br>▪ a description of the habitat by homogeneous section, including the length of the section, width of the channel from the high water mark (bankful width), water depths, type of substrate (sediments), temperature, aquatic and riparian vegetation, and photos;<br>▪ 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<br>▪ the description and location of suitable habitats for fish species at risk that appear on federal and provincial lists and that are found or are likely to be found in the study area and in particular the westslope cutthroat trout in Gold Creek and Blairmore Creek drainages. |
| **Predicted Effects on Valued Components** |
| Based on the predicted changes to the environment identified in section 6.2, the proponent is to assess the environmental effects of the Project on the followings VCs: |
| **6.3.1 Fish and Fish Habitat** |
| ▪ the identification of any potential serious harm to fish, including the calculations of any potential habitat loss (temporary or permanent) in terms of surface areas (e.g., spawning grounds, fry-rearing areas, feeding), and in relation to watershed availability and significance. The assessment will include a consideration of:<br>o the geomorphological changes and their effects on hydrodynamic conditions and fish habitats (e.g., modification of substrates, dynamic imbalance, silting of spawning beds);<br>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);<br>o potential impacts on riparian areas that could affect aquatic biological resources and productivity taking into account any anticipated modifications to fish habitat;<br>o any potential imbalances in the food web in relation to baseline; and<br>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.<br>▪ The effects of changes to the aquatic environment on fish and their habitat, including:<br>o the anticipated changes in the composition and characteristics of the populations of various fish species, including forage fish;<br>o any modifications in migration or local movements (upstream and downstream migration, and lateral movements) following the construction and operation of works; |

### Table 1.2 (Cont'd.)

| Section in Final CEAA Terms of Reference for Project (CEAA 2015) |
|---|
| **Project Setting and Baseline Conditions** |
| **6.3.1 Fish and Fish Habitat Cont'd.** |
| o any reduction in fish populations as a result of potential overfishing due to increased access to the project area; and<br>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.<br>▪ a discussion of how project construction timing correlates to key fisheries windows for fish species, and any potential impacts resulting from overlapping periods;<br>▪ a discussion of how vibration caused by blasting may affect fish behaviour, such as spawning or migrations;<br>▪ changes in concentrations of contaminants of concern in the aquatic ecosystem;<br>▪ changes to fish health resulting from increased contaminants of concern; and<br>▪ 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. |

## 1.3 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 situated in the watersheds of Blairmore and Gold creeks, which are major drainages in the Crowsnest River watershed, itself a major drainage in the Oldman River system. The Project is located in the Northern Continental Divide Ecoregion[1] and in the Rocky Mountains Front Range Physiographic Region[2].

The Project components are shown on Figure 1.1. Table 1.3 provides the estimated areas of disturbance associated with the Project components for the Project.

[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

### Table 1.3 Summary of spatial extent of the primary project components.

| Project Component | Component Area (ha) | Percentage of Development (%) |
|---|---|---|
| Coal Handling Processing Plant and Infrastructure | 94.1 | 6.2 |
| Coal Load-Out and Railway Loop | 33.1 | 2.2 |
| Construction Camp | 1.9 | 0.1 |
| Haul Road | 0.3 | <0.1 |
| Powerline, Access and Conveyor RoW | 15.2 | 1.0 |
| Reclamation Material Storage | 37.9 | 2.5 |
| Surface Water Management Ponds and Ditches | 74.6 | 4.9 |
| Ultimate Rock Disposal Extent | 589.9 | 38.8 |
| Ultimate Pit Extent | 632.4 | 41.6 |
| Proposed Water Pipeline/Service Road Right of Way | 1.5 | 0.1 |
| Proposed Golf Course Development [1] | 38.1 | 2.5 |
| Proposed Helipad Access [1] | 1.6 | 0.1 |
| **Total Mining Activities Reclamation Area** | **1,481.0** | **97.4** |
| **Total Non-Mining (Incidental) Area [1]** | **39.7** | **2.6** |
| **TOTALS[2]** | **1,520.7** | **100** |

[1] Benga Reclamation Responsibility include “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.

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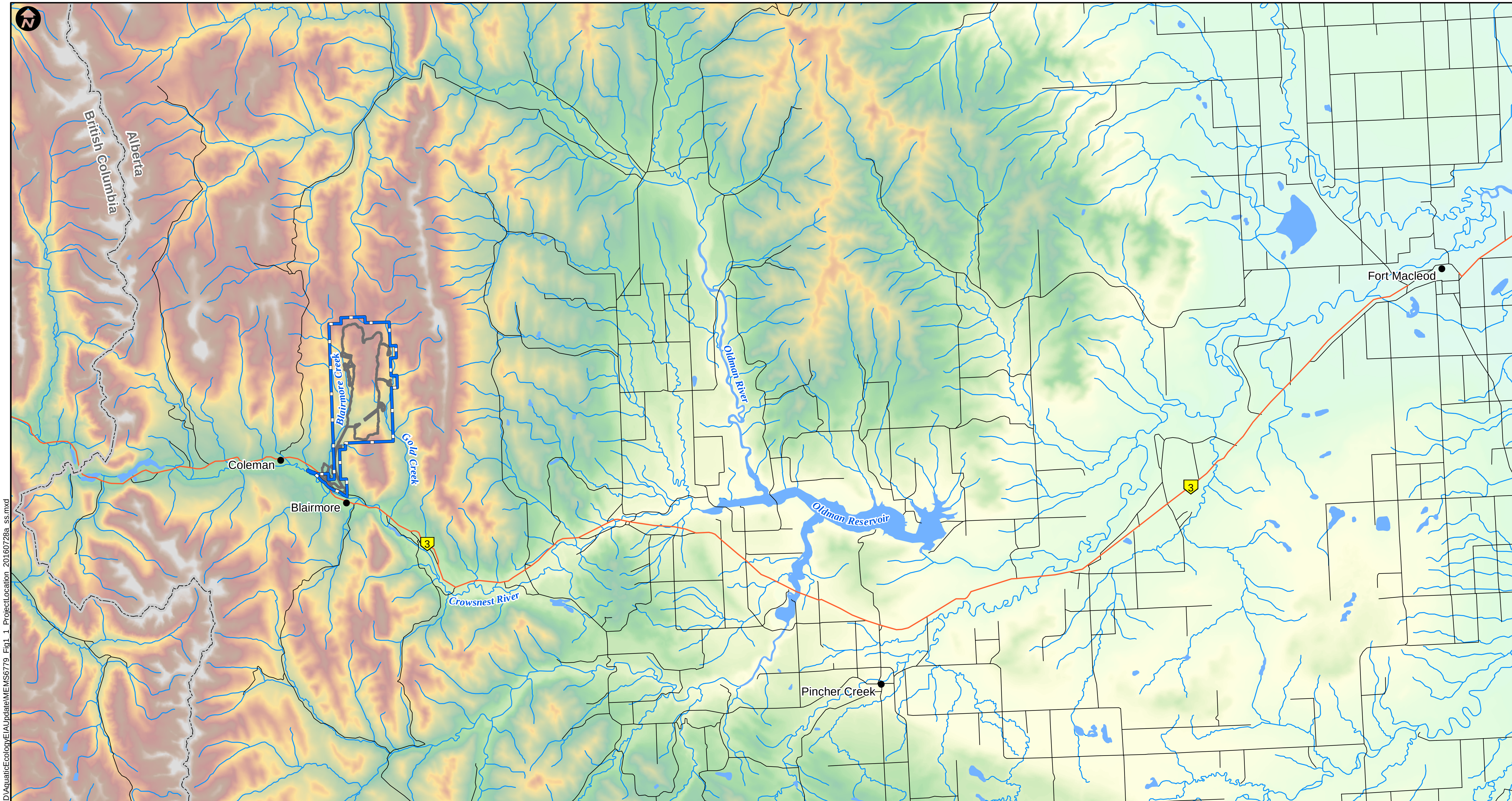


**LEGEND**

- City/Town
- Primary Highway
- Secondary Highway
- Watercourse
- Waterbody
- Provincial Boundary
- Mine Permit Boundary
- Project Footprint

**Elevation (m)**
3076
862

**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 5 10 20
Kilometres

Hatfield CONSULTANTS

PROJECT: 6779
DRAWN BY: SS
CHECKED BY: CB
DATE: JULY 28, 2016

FIGURE
1.1

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## 1.4 REGULATORY FRAMEWORK

The aquatic ecology baseline and aquatic effects assessment report takes into consideration the following 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 2013) and the Code of Practice for Pipelines and Telecommunication Lines Crossing A Water Body (AESRD 2013);
- The federal *Fisheries Act (*Minister of Justice 1985)*,* with associated regulations and amendments in force, current to August 2015 and last amended on 26 February 2015;
- The federal *Species at Risk Act*, with associated regulations and amendments in force, current to August 2015 and last amended on 15 May 2015; and
- Environmental Quality Guidelines for Alberta Surface Waters (ESRD 2014).

# 2.0 VALUED COMPONENT SELECTION, ASSESSMENT BOUNDARIES, AND ASSESSMENT CRITERIA

## 2.1 SELECTION OF VALUED COMPONENTS

Valued Components (VCs) are considered by the proponent, public, First Nations groups, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance. Since it is not possible to address every species or issue of concern, VCs are selected to represent a similar species or issue(s). The fish and aquatic resources VCs and assessment boundaries described herein reflect Benga's current understanding of the aquatic environmental issues associated with the Project.

A set of VCs has been selected to assess key fish and aquatic resources in the defined assessment areas (Table 2.1). The selected VCs meet at least one of the following criteria:

- potential for interaction with the Project and sensitivity to effects;
- captured in baseline field programs conducted as part of this assessment;
- recent challenges and experience with similar projects in the region;
- fish species identified as important traditional resources; and
- species designated as having a status of special concern under SARA, COSEWIC, or Alberta Species at Risk.

Based on the criteria above, the Fish/Aquatic Resource VCs selected include westslope cutthroat trout (WSCT; *Oncorhynchus clarkii lewisi*) and, more broadly, Aquatic Health, which is represented by brook trout (BKTR; *Salvelinus fontinalis*) and lower trophic level organisms (periphyton and benthic macroinvertebrates). WSCT was selected as the primary fish VC based on their provincial and federal status in the Aquatic Ecology local study area (LSA). They are also the only native fish species within the LSA to be potentially affected through potential habitat loss and/or alteration (i.e., changes in flow). The Aquatic Health VC was included to consider potential water quality-related effects throughout the life of the mine and includes multiple fish species and lower trophic organisms. Non-native BKTR are used as a surrogate to evaluate potential water quality-related effects to all fish in the LSA given the conservation sensitivities surrounding WSCT. Evaluation of potential effects on the Aquatic Health VC are addressed primarily through the Surface Water Quality Environmental Effects Assessment Consultant Report (CR#5).

## Table 2.1 Summary of valued components used in the effects assessment.

| Valued Component | Recovered in FWMIS Database | Traditional Use[3] | Captured in Baseline Field Studies | Status of Special Concern[4] |
|---|---|---|---|---|
| **Fish** | | | | |
| westslope cutthroat trout | √ | √ | √ | √ |
| **Aquatic Health** | | | | |
| brook trout (surrogate for other fish species) | √ | √ | √ | |
| benthic macroinvertebrates | √ | √ | √ | |
| periphyton | √ | √ | √ | |
| aquatic sediment | √ | √ | √ | |
| **Supporting Effect Pathways or Indicators Include:** | | | | |
| Flow regimes (water quantity); fish habitat; water quality, benthic invertebrate communities; periphyton | | | | |

## 2.2 ASSESSMENT AREAS

The Local Study Area (LSA) is comprised of Blairmore and Gold Creek watersheds, as the Project footprint is located entirely within these two watersheds (Figure 2.1). The LSA for fish and aquatic resources, water quality, and hydrology are congruent and encompass areas where Project activities have the potential to impact aquatic habitat or fish populations and communities.

The LSA is located east of the High Rocky Mountain range. Blairmore Creek and Gold Creek collect runoff from an upstream area of 50 $km^2$ and 60 $km^2$, respectively, and both discharge into the Crowsnest River. The Blairmore Creek and Gold Creek watersheds are part of the Oldman River watershed flowing into the Saskatchewan River ultimately discharging into Lake Winnipeg.

The Blairmore Creek watershed is relatively steep, with an average slope of 22% and elevations ranging between 2,300 and 1,300 masl. Gold Creek has similar geomorphological characteristics with an average slope of 19% and elevations ranging from 2,500 to 1,300 masl in the region.

Project effects have the potential to interact with other projects within the Crowsnest River watershed; therefore, the Regional Study Area (RSA) is comprised of the entire Crowsnest River watershed to evaluate potential cumulative effects at the regional level (Figure 2.2) if residual effects remain after mitigation. Taken together, Blairmore and Gold creeks represent approximately 11% of the watershed area of the Crowsnest River.

[3] Information gathered during traditional knowledge and traditional land use surveys with members of Treat 7 First Nations conducted as part of Project preparation (Kanai Nation 2015, Piikanii Nation 2015, Tsuut'ina Nation 2015, Siksika Nation 2015, Table 0.2) suggest no particular fish species are more important for traditional uses than others and therefore all fish species found in the LSA and RSA are denoted as traditional use species.

[4] 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

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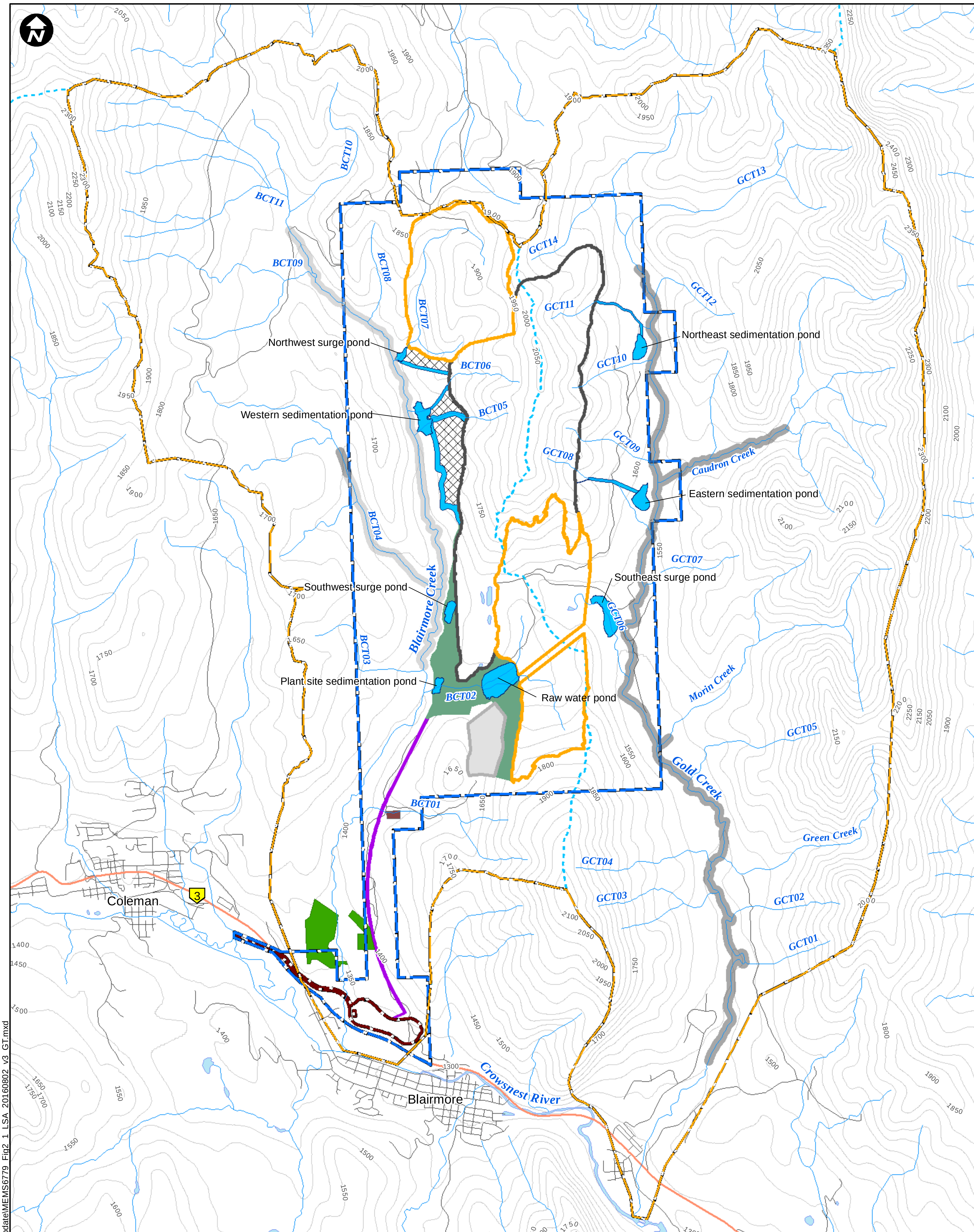


## LEGEND

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

**PROJECT**

RIVERSDALE RESOURCES

**GRASSY MOUNTAIN COAL PROJECT**

Hatfield CONSULTANTS

**TITLE**

# 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: 6779
DRAWN BY: GT
CHECKED BY: CB
DATE: AUGUST 02, 2016

**FIGURE**

**2.1**

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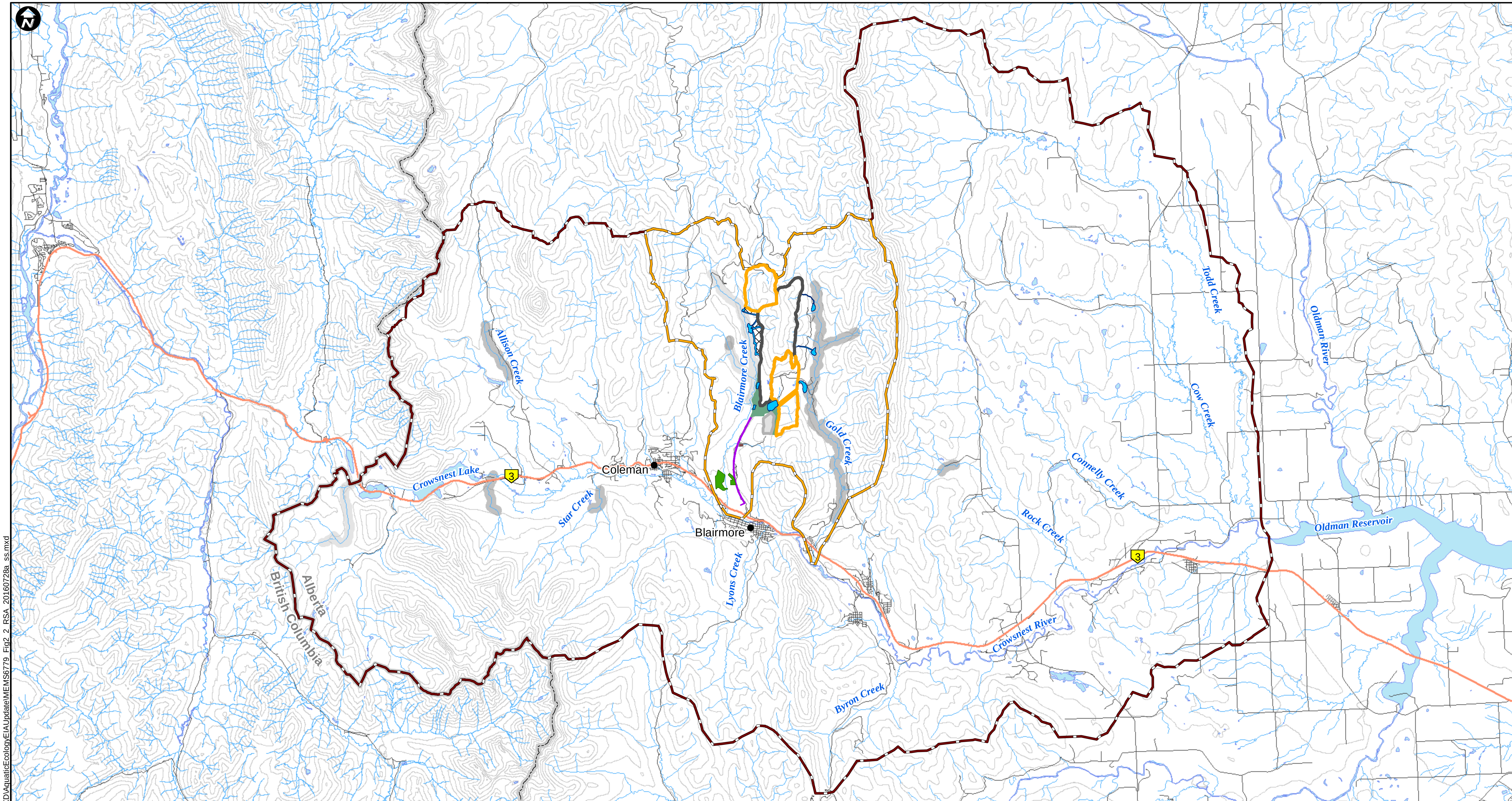


**LEGEND**

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

**PROJECT**

RIVERSDALE RESOURCES

# GRASSY MOUNTAIN COAL PROJECT

**TITLE**

## LOCAL AND REGIONAL STUDY AREAS

**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: 6779
DRAWN BY: SS
CHECKED BY: CB
DATE: July 28, 2016

**FIGURE**
**2.2**

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## 2.3 EFFECTS ASSESSMENT CRITERIA

The Aquatic Ecology Effects Assessment will be conducted using the Government of Alberta's Guideline for Preparing EIA Reports (Government of Alberta 2013) as well as measured, estimated, or reasonably expected changes in some attributes of a selected VC (or environmental attributes/indicators). Full details on the effects assessment criteria used for the Project are provided in Section D.2.4 of the application. The selected fish and aquatic resource VCs are considered representative of the larger aquatic environment, with the assumption that if little to no effect to the receptor is identified, the broader environment will not be affected. The identification of VCs is dependent upon scientific understanding of the respective ecological components and their interactions in the overall environment within which the Project will be developed. Work activity is guided both by issues identified during the course of impact assessment and in response to the final Terms of Reference (ToR) for the Project.

For each identified fish and aquatic resource VC, an assessment of the potential effect will be made using the attributes of direction, geographic extent, magnitude, duration, likelihood, reversibility, and confidence in the relationships between cause and effect. An overall impact assessment rating for each VC is derived based on the individual attributes.

A residual Project effect is defined as an effect that cannot be fully reversed. Thus, the quantification and description of a residual Project effect, by definition, includes consideration of available mitigation procedures and opportunities. Effects discussed in this EIA, and the final Q1 2017 AEA report submission, include those occurring due to the maximum disturbance scenario (e.g., all Project components developed and operating at one time) and those effects remaining after mitigation and reclamation activities have been completed (i.e., residual Project impacts).

# 3.0 CHARACTERIZATION OF FISH AND AQUATIC RESOURCE BASELINE CONDITIONS

Fish, fish habitat, and aquatic resources (e.g., benthic invertebrates and periphyton) baseline information has been compiled from multiple sources. Sources include historical information, data/information collected in the field as part of the Project in summer 2014 to summer 2015, and further data collected through an intense and focused field study program implemented in 2016.

## 3.1 HISTORICAL FISH AND AQUATIC INFORMATION

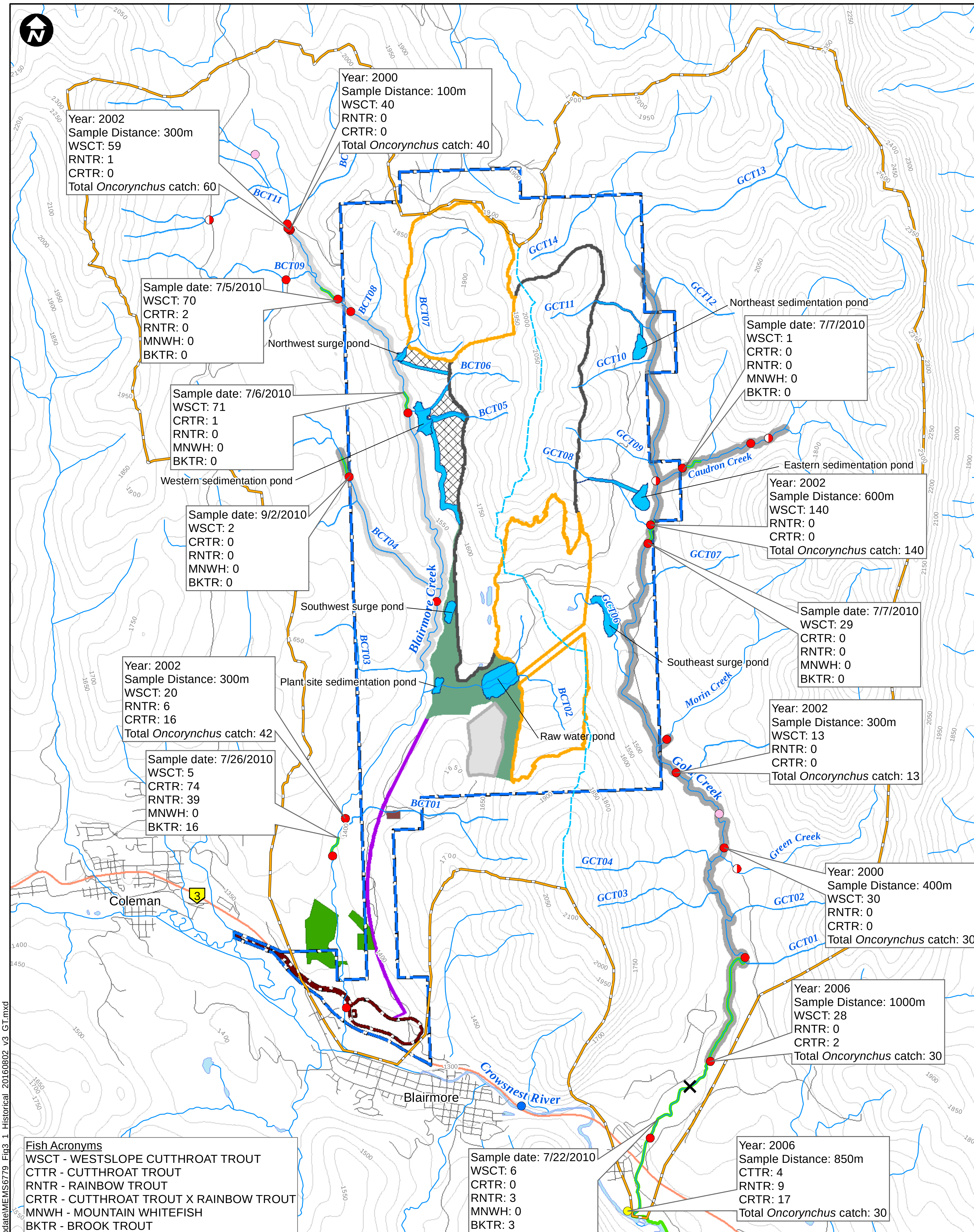
The following summarizes publically available information describing fish and aquatic resources within the LSA (Figure 3.1). Pertinent historical information has been generated from the following resources:

- 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 2013) that included information on barriers to fish passage;
- Information contained in the recovery plans prepared for the westslope cutthroat trout *(*Alberta Westslope Cutthroat Trout Recovery Team 2013, Fisheries and Oceans Canada 2014);
- Published reports from the Alberta Conservation Association and available scientific literature; and
- Information gathered during traditional knowledge and traditional land use surveys with members of the Treaty 7 First Nations conducted as part of Project preparation (Kanai Nation 2015, Piikanii Nation 2015, Tsuut'ina Nation 2015, Siksika Nation 2015, Appendix 7c).

### 3.1.1 Fish and Fish Habitat

Publically available fisheries inventory and/or detailed habitat assessment information for either Gold Creek or Blairmore Creek watersheds is relatively limited. Sparse information is available through the Alberta Government Fish and Wildlife Management Information System (FWMIS) (i.e., fish presence/absence, species distribution) and peer reviewed publications or technical reports (i.e., interspecific hybridization, population estimates) for both mainstem and/or associated tributaries. To date, only limited anecdotal information has been found with respect to fish habitat assessments and no information uncovered with respect to seasonal fish movement or reproduction dynamics specific to either watershed.

Westslope Cutthroat Trout (WSCT), non-native Rainbow Trout (RNTR), WSCT x RNTR hybrids, and non-native brook trout (BKTR) have been reported in Gold Creek. A vast number of fish reported as being captured (upstream of the known migration barrier) were apparently BKTR; however, the location of their capture is unknown. The source of these non-native fish has been traced to deliberate stocking and not a result of barriers on the Gold Creek mainstem being passable to upstream fish movement.

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## LEGEND

- Historical Benthic Survey Location
- Fisheries Inventory Program
- 2009 Crowsnest River preliminary tote-barge electrofishing
- FWMIS Historical Sampling Location (no fish caught)
- FWMIS Historical Sampling Location (fish caught)
- Barrier
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT Population (95% to 99% pure)
- 2010 Crowsnest River tributary sample sites
- Primary Highway
- Road
- 50 m Contour
- Watershed Boundary
- Watercourse
- Waterbody
- Local Study Area
- Railway Loop
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
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**PROJECT**

RIVERSDALE RESOURCES

**GRASSY MOUNTAIN COAL PROJECT**

Hatfield CONSULTANTS

**TITLE**

**SUMMARY OF HISTORICAL FISHERIES RESOURCE 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: 6779
DRAWN BY: GT
CHECKED BY: CB
DATE: AUGUST 02, 2016

**FIGURE**
**3.1**

**Table 3.1 Fish species reported to occur in the Aquatic Assessment Study Area.**

| Common Name | Scientific Name | Acronym | Provincial Status | Federal Status |
|---|---|---|---|---|
| Westslope cutthroat trout | *Oncorhynchus clarkii lewisii* | WSCT | Threatened | Threatened |
| Brook trout | *Salvelinus fontinalis* | BKTR | Exotic/Alien | - |
| Rainbow trout | *Oncorhynchus mykiss* | RNTR | Exotic/Alien | - |
| Mountain whitefish | *Prosopium williamsoni* | MNWH | Secure | - |
| Bull trout | *Salvelinus confluentus* | BLTR | Threatened | Threatened |

Both Blairmore Creek and Gold Creek are mapped Class B watercourses under the *Water Act* Code of Practice, which means they contains habitat important to the continued viability of a species and is considered sensitive to any type of activity. The restricted activity period (RAP) for both Blairmore Creek and Gold Creek is May 1 to August 15 and September 1 to April 15. All tributaries of both Blairmore Creek and Gold 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.

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. An assessment conducted in 2002 (Blackburn 2011) characterized Morin Creek as containing high fisheries potential with moderate spawning substrate, high value rearing habitat, and moderate overwintering habitat quality. The extent of Morin Creek surveyed is unknown. Caudron Creek was assessed in both 2002 and 2010 and was characterized as being primarily comprised of riffle habitat with sparse pools with substrate comprised of 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 and found that the population ranged between 65 and 271 individuals. The federal Recovery Plan designates portions of Morin and Caudron creeks as critical habitat for WSCT.

Similar to Gold Creek, WSCT, RNTR and BKTR have been recovered in Blairmore Creek. Blackburn (2011) has 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 lower Blairmore Creek was estimated between 201 and 310. No publically available information could be found regarding previously conducted fish habitat assessments or spawning surveys.

The potential presence and distribution of mountain whitefish (MNWH) and bull trout (BLTR) is primarily contained within the Crowsnest River, with no documented presence in either lower Gold or Blairmore creeks, below impassable upstream migration barriers. Both non-native BKTR and RNTR have been reported/documented in lower Gold and Blairmore creeks as well as the Crowsnest River.

Additionally, a recent study that focused on spatial and temporal variation of benthic macroinvertebrate communities in Blairmore Creek, Gold Creek, and Daisy Creek was recently obtained (Ree, 2014). The study's objective was to describe and determine factors affecting benthic invertebrate communities in three Rocky Mountain watercourses that inhabit pure strain WSCT. Findings suggested that macroinvertebrate abundance in lower elevations did not significantly differ among the watercourses thus food availability is likely suitable in high-elevation reaches.

Important fisheries information was provided by the Treaty 7 First Nations, of which has been summarized in Table 3.2.

**Table 3.2 Summary of information on aquatic ecology from the Treaty 7 First Nations.**

| |
|---|
| Kainai Nation (Kainai Nation 2015, Appendix 7c)<br>▪ Observation that fish in the mountain areas tend to be smaller than fish at lower elevations.<br>▪ Fishing is largely a Western practice that has been adopted by the Kanai Nation, including ice fishing in the winter.<br>▪ Fish are an important source of bait used in furbearer trapping.<br>▪ Members of the Kainai Nation fish for trout in September each year. |
| Piikanii Nation (Piikanii Nation 2015, Appendix 7c)<br>▪ Generally, members of the Piikannii Nation do not fish.<br>▪ 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.<br>▪ The abundance of fish is a good indicator of the health of the ecosystem. |
| Tsuut'ina Nation (Tsuut'ina Nation 2015, Appendix 7c)<br>▪ Three different kinds of trout were observed during ground-truthing activities conducted in support of traditional knowledge and use studies for the Project.<br>▪ Fish health was identified as an important issue. |
| Siksika Nation (Siksika Nation 2015, Appendix 7c)<br>▪ 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.<br>▪ 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. |

#### 3.1.1.1 Westslope Cutthroat Trout Species at Risk Designation

Westslope Cutthroat Trout are the only subspecies of CTTR that are native to Alberta. Currently, genetically pure WSCT occur in isolated populations and inhabit only a small portion of the original WSCT distribution. As a result of their limited distribution, decline in extent of occurrence, the fragmented populations, decline in habitat quality, and barriers to dispersal, the Minister of Sustainable Resource Development supported the listing of WSCT as Threatened under Alberta's *Wildlife Act* in 2009.

***Critical Habitat***

Blairmore Creek and Gold Creek watersheds contain watercourses that DFO and the Alberta Westslope Cutthroat Trout Recovery Team have designated as critical habitat for WSCT. In November 2015, Fisheries and Oceans Canada issued a formal habitat protection order under SARA for the designated areas identified to occur in the Gold Creek watershed.

In addition to (and prior to) the habitat protection order, the Governments of Alberta (Alberta Westslope Cutthroat Trout Recovery Team 2013) and Canada (Fisheries and Oceans Canada 2014) have developed a recovery plan and 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 of: "*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."* (The Alberta Westslope Cutthroat Trout Recovery Team 2013).

The Recovery Plan identifies parts of four watercourses in the LSA, totaling approximately 16.5 km of watercourse, as critical habitat, each containing a population "*that has no evidence of recent or contemporary introgression as determined by genetic testing (i.e., >0.99 pure on average)"*[5]. 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 3.2 and Table 3.3). Fish recovered in these designated critical habitats were determined to be 99% genetically-pure (Alberta Westslope Trout Recovery Team 2013, Fisheries and Oceans Canada 2014)[6]. 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 (Figure 3.2 and Table 3.3).

Watercourses within the Projects Aquatic Ecology RSA designated as critical habitat (greater than 99% genetically pure) and near-pure (95% to 99% genetically pure) WSCT is summarized in Table 3.4.

[5] page 33 of Alberta Westslope Cutthroat Trout Recovery Team (2013)

[6] 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.

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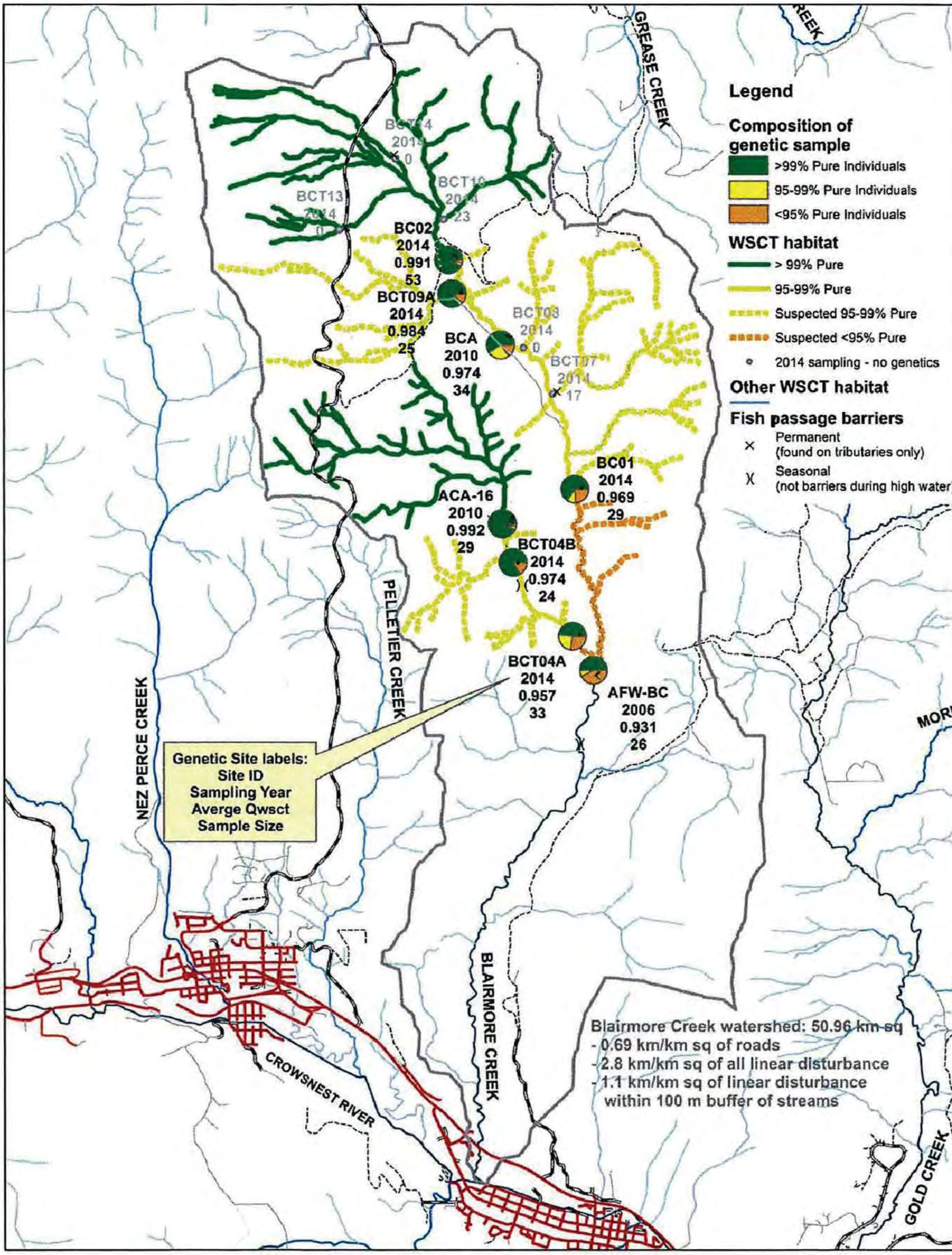



PROJECT

RIVERSDALE RESOURCES GRASSY MOUNTAIN COAL PROJECT

TITLE

DISTRIBUTION OF WESTSLOPE CUTTHROAT TROUT GENETIC SAMPLING IN THE BLAIRMORE CREEK WATERSHED

NOTES

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

PROJECT: 6779
DRAWN BY: GT
CHECKED BY:
DATE: AUGUST 02, 2016

FIGURE 3.2

Document Path: K:\Data\Project\MEMS7779A_MXD\AquaticEcologyEIAUpdate\MEMS6779_Fig3_2_Genetic_20160802_v3_GT.mxd

**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 |

* Under DFO SARA Habitat Protection Order (November 2015)

**Table 3.4 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 |

## 3.2 SUMMARY OF 2014 AND 2015 FISH AND AQUATIC RESOURCE BASELINE DATA

A set of field programs were completed from August 2014 to August 2015 in support of the Application. Figure 3.3 provides a visual summary of information and the locations of field programs conducted and Table 3.5 provides an overview of the field programs that were completed. Appendix A1 contains a description of field methods used in these field programs.

### Table 3.5 Summary of Project specific field programs conducted in 2014 and 2015.

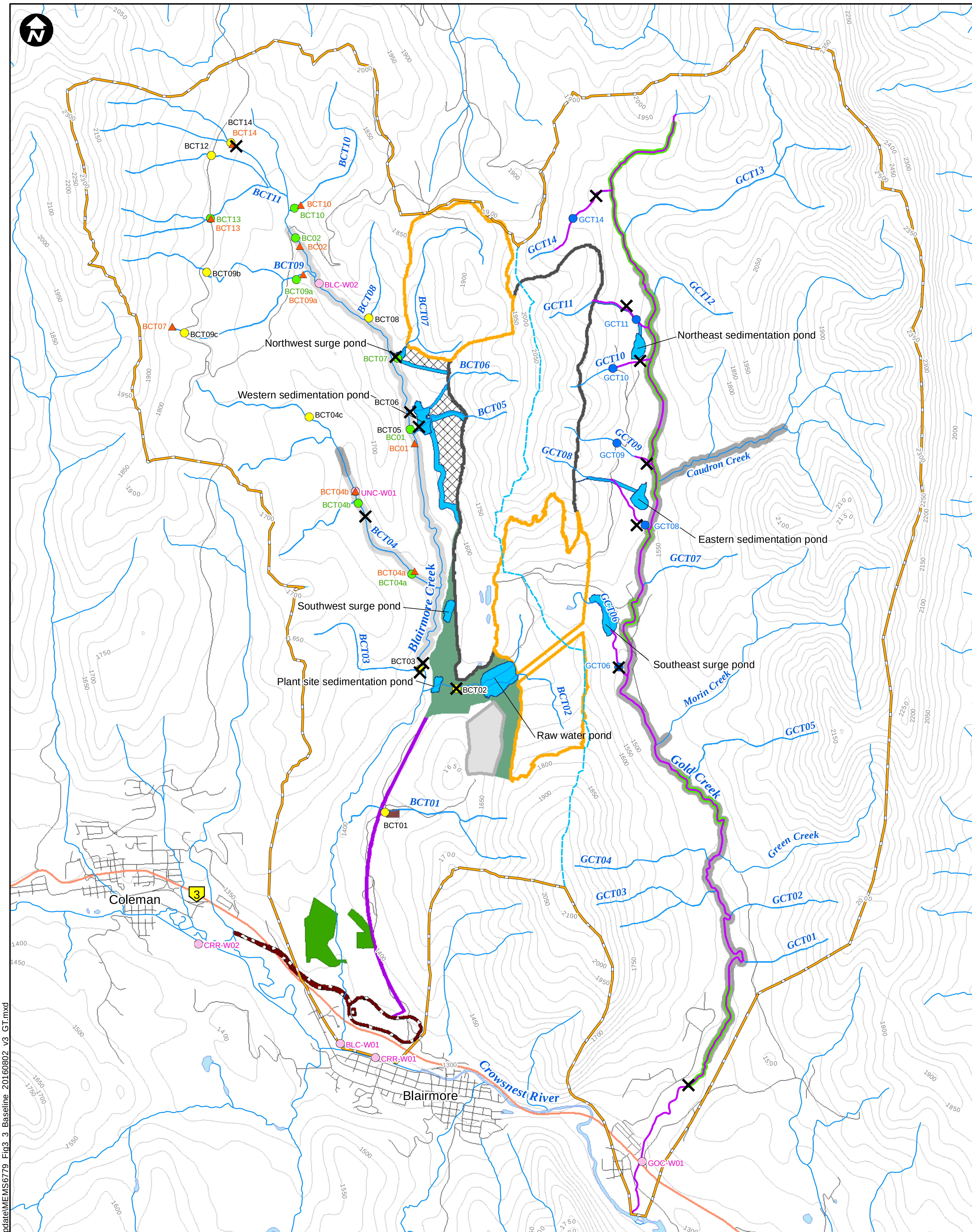
| Date | Description of Field Program |
|---|---|
| August 2014 | ▪ Aquatic habitat assessments and fish inventories at two locations on Blairmore Creek.[1]<br>▪ Aquatic habitat assessments at 17 locations on tributaries of Blairmore Creek and fish inventories at eight of these locations.[1] |
| October 2014 | ▪ Benthic invertebrate and periphyton surveys at four locations in the Blairmore Creek watershed and two locations on the Crowsnest River. |
| February 2015 | ▪ Assessment of winter flow conditions at one location on each of five of the six tributaries of Gold Creek that originate within the Project footprint.[2] |
| June 2015 | ▪ Watercourse habitat surveys of the lower reaches of six tributaries of Gold Creek that originate within the Project footprint, starting at their confluence to Gold Creek.[3]<br>▪ Aquatic habitat assessments of three tributaries of Blairmore Creek that originate within the Project footprint. |
| August 2015 | ▪ Watercourse habitat surveys of Gold Creek from the downstream delineation of critical habitat for westslope cutthroat trout to the upper reaches of Gold Creek, upstream of the Project footprint. |

[1] A total of 170 samples of genetic material from fish captured at five sites were collected and submitted to AESRD for genetic testing. Electrofishing could not be conducted at nine of the locations due to either insufficient water depth or lack of a defined channel.

[2] One of the six tributaries (GCT14) could not be accessed in February 2015 due to deep snow conditions.

[3] The length of watercourses covered by the aquatic habitat surveys of these tributaries in June 2015 was constrained by steep terrain and access limitations.

Note: Locations of potential permanent barriers to fish migration were noted in all field programs.




## LEGEND

- Habitat Reconnaissance Survey Locations
- June 2015 Aquatic Habitat Assessment
- August 2014 Fish Inventory and Habitat Assessment Location (no fish caught)
- August 2014 Fish Inventory and Habitat Assessment Location (fish caught)
- October 2014 Benthic and Periphyton Survey Location
- Barrier to fish passage
- August 2015 Reach Habitat Assessment
- Reaches surveyed in August 2015 in which fish were observed
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT Population (95% to 99% pure)
- Primary Highway
- Road
- 50 m Contour
- Watershed Boundary
- Watercourse
- Waterbody
- Local Study
- Railway Loop
- Ultimate Pit Extent
- Ultimate Rock Disposal Area
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course
- Undisturbed

**PROJECT**

RIVERSDALE RESOURCES

**GRASSY MOUNTAIN COAL PROJECT**

Hatfield CONSULTANTS

**TITLE**

**SUMMARY OF 2014-2015 COLLECTED FISH AND AQUATIC RESOURCE BASELINE DATA 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: 6779
DRAWN BY: GT
CHECKED BY: CB
DATE: AUGUST 02, 2016

**FIGURE**
**3.3**

### 3.2.1 Fish and Fish Habitat

#### 3.2.1.1 Gold Creek

Fish and fish habitat information for portions of the Gold Creek watershed was obtained from watercourse habitat assessments in June 2015 and in reconnaissance surveys conducted in August 2015. Surveys were conducted from the downstream delineation of critical habitat for WSCT to the upper reaches of Gold Creek, upstream of the Project footprint. Some important features to note for Gold Creek include:

- The substrate of Gold Creek is dominated by cobble associated with gravel patches or boulder. Only a small proportion of the substrate of Gold Creek is comprised of embedded silts and fines, with the exception of the middle reaches of the creek, which contain varying amounts of coal sediments and fines, likely either: (i) from coal outcroppings; or (ii) coal fines and sediments generated from previous mining activities in the watershed and deposited in Gold Creek.
- Groundwater inputs were documented along both the east and west slopes of Gold Creek that supply shallow groundwater to the mainstem at various locations.
- There are a series of barriers to fish migration in lower Gold Creek approximately 1 km above the confluence of Gold Creek with the Crowsnest River consisting of an old water supply dam, three significant waterfalls, and a smaller dam. The most significant of these is the old water supply dam that is impassable to fish and marks the downstream extent of critical habitat on the Gold Creek mainstem for westslope cutthroat trout designated in the Recovery Plan.
- Additional waterfalls and chutes occur throughout most of the Gold Creek mainstem above the significant barriers described above. These do not appear to be barriers to migration of fish along Gold Creek.
- A number of reaches within Gold Creek display evidence of anthropogenic disturbance. In addition to known legacy mine outputs (e.g., coal and sediments depositing to Gold Creek), rangeland activities (e.g., grazing pastures, cattle crossings), recreational land use (e.g., ATV vehicle ford crossings, bridges, and fence crossings), and private land use occur at various points along the Gold Creek mainstem (Figure 3.4).

No fish inventory field programs were completed on Gold Creek in 2014 or 2015.

#### 3.2.1.2 Blarimore Creek

Fish and fish habitat information for Blairmore Creek was obtained from watercourse habitat assessments conducted in August 2014, June 2015 and August 2015. Some important features of Blairmore Creek include:

- Blairmore Creek is composed primarily of riffles and runs with interspersed pool habitat. The creek flows over bedrock in certain areas creating plunge pools.
- There was evidence of groundwater seeps along Blairmore Creek that likely supply shallow groundwater to the mainstem at various locations.

- There are a set of waterfalls on the Blairmore Creek mainstem immediately upstream of tributary BCT03.
- Additional waterfalls and chutes occur throughout on the Blairmore Creek mainstem above the barrier described above. These do not appear to be barriers to migration of fish along Blairmore Creek.
- Blairmore Creek is frequently confined by steep valley walls, which have potentially limited anthropogenic disturbances in the middle portion of the drainage. Oil and gas and forestry activities occur in some of the upstream tributaries (above BCT10), but disturbance along the portion of the creek adjacent to the Project (from BCT10 to BCT01) is limited to recreational use as evidenced by the presence of several fords across Blairmore Creek (Figure 3.4).
- Aquatic habitat information for a number of other tributaries of Blairmore Creek that will not be directly affected by the Project was obtained from habitat surveys conducted in June 2015 (Figure 3.3). Aquatic habitat in these tributaries is similar to the aquatic habitat in the Project-affected tributaries of Blairmore Creek; this is supported by the aquatic habitat information in the FWMIS that suggests these tributaries are suitable habitat for trout species. The Recovery Plan designates a portion of BCT04 as critical habitat for westslope cutthroat trout (Figure 3.3).
- A fish inventory sampling program was conducted in August 2014 in Blairmore Creek mainstem. All fish captured were identified as westslope cutthroat trout. A total of 132 fish were captured ranging in length from 62 mm to 250 mm with an average of fork length of 139 mm (Table 3.6).

**Table 3.6 Details of fish captured on Blairmore Creek mainstem, August 2014.**

| Site | WSCT Captured | Average Fork Length (mm) | Size Range (mm) | Total Effort (seconds) | CPUE (No. fish/ 100 sec) |
|---|---|---|---|---|---|
| BC01 | 75 | 141.7 | 65-249 | 791 | 9.48 |
| BC02 | 57 | 136.6 | 62-250 | 821 | 6.94 |
| TOTAL | 132 | 139 | 62-250 | 1611 | 8.19 |

Note: Figure A4.2 and Figure A4.4 in Appendix A4 present detailed information on the sizes of fish captured in these inventories.

Genetic samples collected in August 2014 from 170 trout collected from two sites in Blairmore Creek, were provided to Alberta Environment and Parks (AEP) to support their WSCT mapping program. Results provided by the AEP from the samples identified 132 of those fish as pure (100%) WSCT ranging in fork length from 62 mm to 250 mm. The remaining fish were identified as backcross hybrids comprised genetically of WSCT and non-native RNTR. No new hybridization events (production of F1 hybrids) between pure strain WSCT and RNTR were evident based on the data (Figure 3.2).


Photo 1: Example of recreational vehicle use occuring around Blairmore Creek and Gold Creek. Image taken by Wildlife Camera (GM06) located on main trail running parallel to Blairmore Creek. This trail crosses the creek multiple times (March 2016).

Photo 2: Example of livestock grazing that occurs near Blairmore Creek and Gold Creek. Image captured on Wildlife Camera GM06 (June 2014).

Photo 3: Looking north east from the west shore of a legacy pit lake on the lower portion of the mine. Note the legacy mining disturbance on the mountain in the background (July 2014).

Photo 4: Coal fine deposits acting as streambanks on the mainstem of Gold Creek.

Photo 5: View looking downstream past old water supply dam that defines the downstream end of that part of Gold Creek designated in the Recovery Plan as critical habitat for west slope cutthroat trout.

Photo 6: Coal fine deposits and legacy infrastructure along the mainstem of Gold Creek.

Photo 7: Example of ATV/Vehicle crossing that occur on both Gold Creek and Blairmore Creek. This specific crossing is located on Gold Creek.

Photo 8: View of the landscape degradation along Gold Creek resulting from Legacy mining activity (July 2014).

## LEGEND

- Photo Location
- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Road Access
- Existing Trails
- Existing Railway
- Proposed Mine Permit Boundary
- Proposed Mine Permit Boundary Addition
- Project Footprint
- Undisturbed Area
- Legacy Mine Disturbance

**PROJECT**

RIVERSDALE RESOURCES

**GRASSY MOUNTAIN COAL PROJECT**

MILLENNIUM EMS Solutions Ltd.

**TITLE**

# EXISTING DISTURBANCE OCCURING ON THE BLAIRMORE CREEK AND GOLD CREEK

**NOTES**

AltaLIS, 2016; Geobase, 2016; MEMS, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JL
CHECKED BY: DM
DATE: JULY 8, 2016

**FIGURE**

**3.4**

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\C and R\Resubmission\Fig F.2.1-2 - Existing Disturbance on Blairmore and Gold Creek.mxd

### 3.2.2 Aquatic Resources

Macroinvertebrates and their habitats are important food sources for fish, because many fish species, in particular all stream-rearing salmonids, depend on drift of invertebrates from upstream areas.

#### 3.2.2.1 Lower Trophic Levels – Benthic Invertebrates

Benthic invertebrate communities were sampled at three locations in the Blairmore Creek watershed and at one location in the Gold Creek watershed, on the Gold Creek mainstem, in the fall season (October) of 2014 (Figure 4, Appendix A1 provides a description of the field methods used for sampling benthic invertebrate communities). Metrics presenting benthic invertebrate community abundance and composition in the LSA are summarized in Table 3.7 and Figure 3.5 and the complete dataset obtained from these four locations is presented in Appendix A2 Total mean abundance/density ranged from 5,032 individuals/$m^2$ to 7,613 individuals/$m^2$ with the highest abundance measured at the downstream location on Blairmore Creek (BC-W01), and the lowest abundance at the location on the unnamed tributary to Blairmore Creek (UNC-W01). Benthic invertebrate communities at the Gold Creek location had an abundance of 7,052 individuals/$m^2$. The standard deviations of the means ranged from 1,479 individuals/$m^2$ to 4,367 individuals/$m^2$ indicating high variability among the sample replicates collected from the same location.

Ephemeroptera and Plecoptera were the most dominant taxonomic groups accounting for 27% to 39% and 27% to 40% of the total abundance, respectively, depending on the locations sampled. Chironomidae contributed 6% to 18% to the total abundance across all locations and ranked third in abundance at all locations except the unnamed tributary to Blairmore Creek (UNC-W01), at which Collembola was the third-most dominant group, comprising 23% of the total abundance. The pollution-sensitive EPT taxa comprised a higher percentage of the total number of individuals at the downstream location on Blairmore Creek (BC-W01, 69%) compared to both the upstream location (BC-W02, 58%) and the location on the unnamed tributary to Blairmore Creek (UNC-W01, 59%). %EPT at the location sampled on Gold Creek (GC-W01) was 75%.

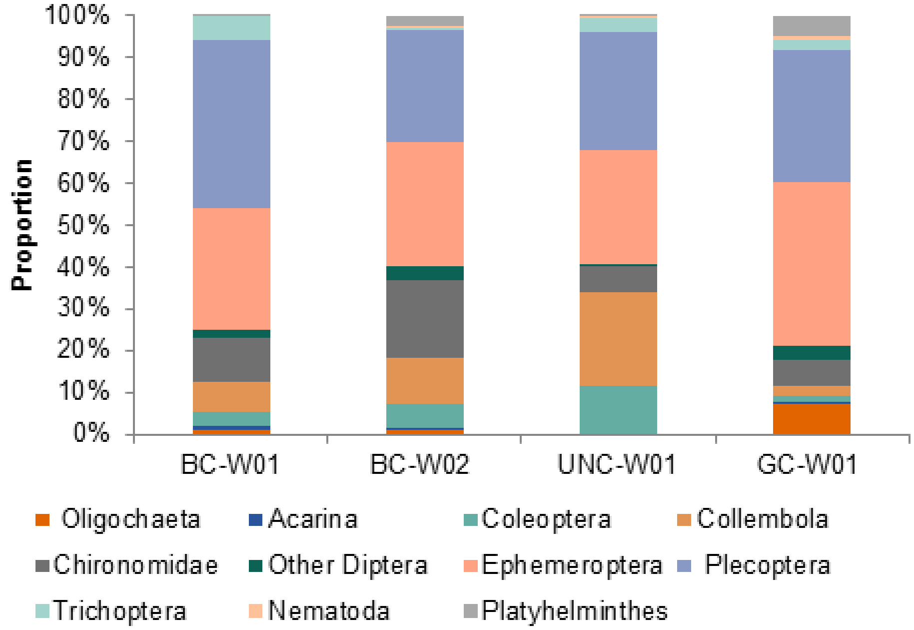
Mean taxa richness ranged from 26 to 37 taxa with the highest and lowest taxa recorded at the downstream location on Blairmore Creek (BC-W01) and the location on the unnamed tributary to Blairmore Creek (UNC-W01), respectively. Diversity and evenness were similar at all sampled locations. Diversity values ranged from 0.86 to 0.91 and evenness values ranged from 0.24 to 0.28, indicating relatively homogenous community composition. The values of the Family Biotic Index indicates “very good” water quality at the upstream location on Blairmore Creek and “excellent” water quality at all other sampled locations (Resh et al. 1996).

## Table 3.7 Baseline conditions for the benthic invertebrate community in Blaimore and Gold watersheds within the LSA, October 2014.

| Variables | BC-W01 (N=5) | | BC-W02 (N=5) | | UNC-W01 (N=3) | | GC-W01 (N=5) | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| **Abundance/Density (number/m$^2$)** | | | | | | | | |
| Oligochaeta | 77 | 80 | 54 | 48 | 0 | 0 | 525 | 265 |
| Acarina | 71 | 42 | 39 | 51 | 4 | 6 | 34 | 29 |
| Coleoptera | 262 | 128 | 316 | 123 | 570 | 206 | 88 | 67 |
| Collembola | 525 | 256 | 637 | 243 | 1,140 | 412 | 176 | 135 |
| Chironomidae | 798 | 376 | 1,047 | 924 | 308 | 66 | 441 | 360 |
| Other Diptera | 163 | 46 | 215 | 144 | 18 | 6 | 209 | 98 |
| Ephemeroptera | 2,222 | 1,632 | 1,669 | 945 | 1,369 | 357 | 2,766 | 1,381 |
| Plecoptera | 3,056 | 2,054 | 1,523 | 620 | 1,419 | 817 | 2,241 | 698 |
| Trichoptera | 424 | 247 | 45 | 5 | 183 | 28 | 157 | 81 |
| Nematoda | 13 | 12 | 22 | 20 | 4 | 6 | 62 | 99 |
| Platyhelminthes | 2 | 5 | 146 | 63 | 18 | 6 | 353 | 94 |
| Total Abundance | 7,613 | 4,367 | 5,712 | 2,301 | 5,032 | 1479 | 7,052 | 2,793 |
| **Other Indices** | | | | | | | | |
| Taxa Richness | 45 | 7 | 42 | 3 | 34 | 6 | 42 | 4 |
| Simpson's Diversity Index | 0.860 | 0.040 | 0.907 | 0.010 | 0.904 | 0.010 | 0.910 | 0.008 |
| Evenness Index | 0.240 | 0.018 | 0.259 | 0.007 | 0.278 | 0.015 | 0.259 | 0.007 |
| Family Biotic Index | 3.43 | 0.43 | 3.98 | 0.64 | 3.60 | 0.41 | 3.61 | 0.14 |
| % EPT | 69 | 15 | 58 | 7 | 59 | 10 | 73 | 3 |

Notes: Refer to
for sampling locations.

**Figure 3.5 Benthic invertebrate community composition in Blairmore and Gold watersheds, October 2014.**




Benthic invertebrate samples were also collected from two locations on the Crowsnest River, downstream (CRR-W01) and upstream Crowsnest River (CRR-W02) (relative to the Blairmore Creek/Crowsnest River confluence). Metrics presenting benthic invertebrates community abundance and composition are summarized in Table 3.8 and Figure 3.6 and the complete dataset obtained from these two locations is presented in Appendix A2. Total mean abundance/density was almost double at the Crowsnest River downstream location (15,265 individuals/$m^2$) than at the upstream location (7,841 individuals/$m^2$). Similar to results from the LSA, high standard deviations in abundance at both locations indicate high within-location variability.

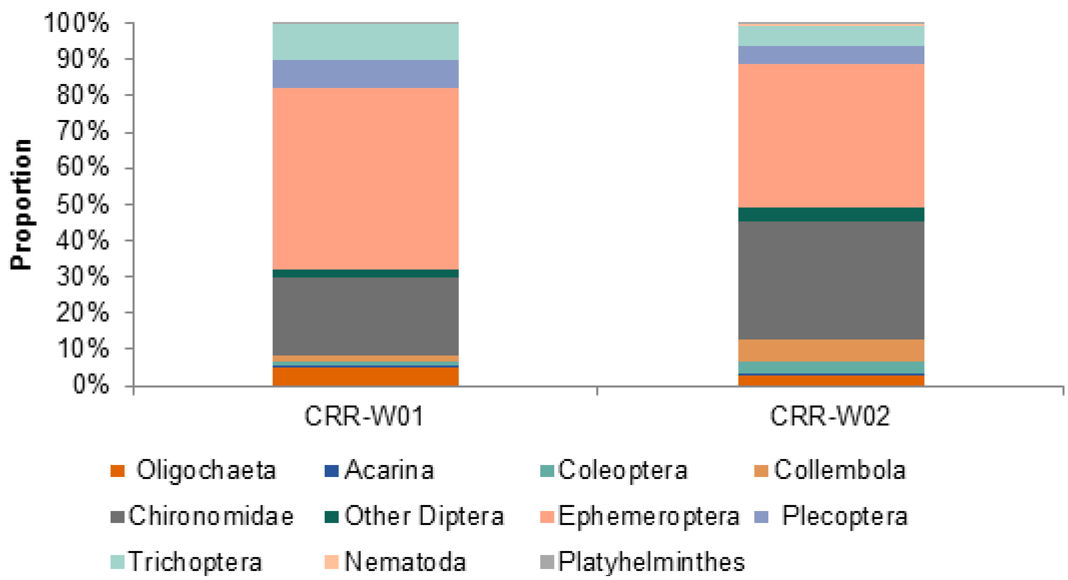
Ephemeroptera was the most dominant taxonomic group accounting for 50% and 39% of total abundance in the downstream and upstream Crowsnest River locations, respectively, followed by Chironomidae and Trichoptera, which comprised 22% and 32% and 10% and 6% of the total abundance at the downstream and upstream locations, respectively. The pollution-sensitive EPT taxa comprised 69% of the total abundance at the upstream location and 50% of the total abundance at the downstream location.

Mean taxa richness was higher in the upstream location (42 taxa) than in the downstream location (36 taxa). Simpson's diversity index and evenness index were similar at both locations (Diversity: 0.78, Evenness 0.21). Values of the Family Biotic Index indicate "good" water quality at the downstream location on the Crowsnest River and "fair" water quality at the upstream location on the Crowsnest River (Resh et al. 1996).

**Table 3.8 Baseline conditions for the benthic invertebrate community on the Crowsnest River upstream and downstream of Blaimore Creek confluence, October 2014.**

| Variables | CRR-W01 (N=5) | | CRR-W02 (N=5) | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| **Abundance/Density (number/m$^2$)** | | | | |
| Oligochaeta | 402 | 416 | 445 | 185 |
| Acarina | 39 | 28 | 95 | 52 |
| Coleoptera | 67 | 12 | 480 | 252 |
| Collembola | 133 | 24 | 959 | 504 |
| Chironomidae | 1,716 | 832 | 4,933 | 3,279 |
| OtherDiptera | 174 | 100 | 594 | 214 |
| Ephemeroptera | 3,927 | 1,054 | 6,024 | 3,165 |
| Plecoptera | 581 | 199 | 755 | 305 |
| Trichoptera | 770 | 353 | 845 | 618 |
| Nematoda | 24 | 19 | 101 | 81 |
| Platyhelminthes | 9 | 14 | 34 | 43 |
| Total Abundance | 7,841 | 2,419 | 15,265 | 3,060 |
| **Other Indices** | | | | |
| Taxa Richness | 45 | 2 | 51 | 3 |
| Simpson's Diversity Index | 0.771 | 0.037 | 0.788 | 0.093 |
| Evenness Index | 0.215 | 0.009 | 0.211 | 0.022 |
| Family Biotic Index | 4.74 | 0.44 | 5.37 | 0.79 |
| %EPT | 69 | 8 | 50 | 21 |

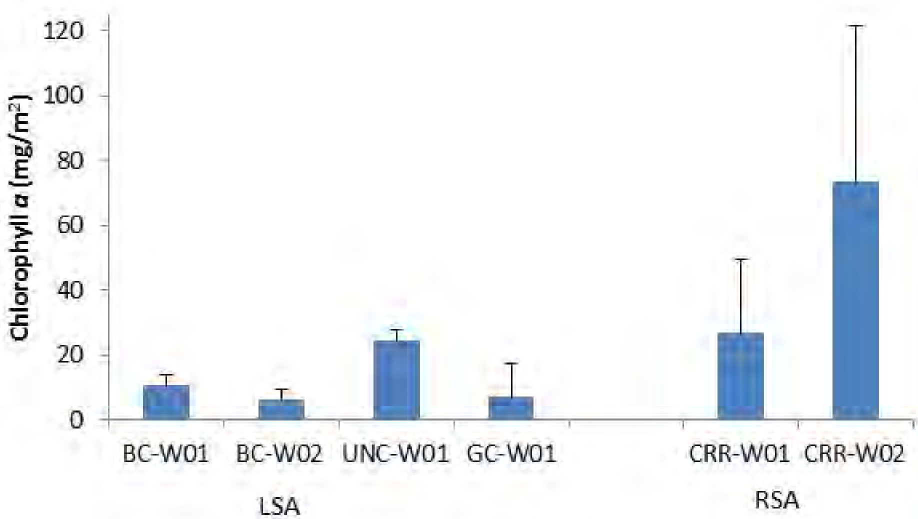
**Figure 3.6 Benthic invertebrate community composition in the Crowsnest River upstream and downstream of the Blairmore Creek confluence, October 2014.**



#### 3.2.2.2 Lower Trophic Levels – Periphyton

Periphyton[7] was sampled in the LSA at the same locations as the benthic invertebrate communities were sampled (Figure 3.7, Appendix A1 provides a description of the field methods used for sampling periphyton). Levels of periphyton chlorophyll *a* in the LSA ranged from 6.1 mg/m$^2$ to 24.6 mg/m$^2$ with the lowest and highest levels measured at the upstream location on Blairmore Creek (BC-W02) and the sampling location on the unnamed tributary to Blairmore Creek (UNC-W01), respectively (Figure 3.7). Chlorophyll *a* levels were 7.05 mg/m$^2$ and 10.5 mg/m$^2$ at the sampling location on Gold Creek (GC-W01) and the upstream sampling location on Blairmore Creek (BC-W01), respectively. Water quality conditions (Hatfield 2015) indicate higher levels of phosphorous in the unnamed tributary to Blairmore Creek (UNC-W01) than elsewhere in the LSA, suggesting the higher periphyton growth at that location may be a result of higher nutrient concentrations. A combination of small substrate particle size, increased forest cover and lower nutrient levels are the likely result of decreased biomass at the Blairmore upstream and Gold Creek locations.

**Figure 3.7 Chlorophyll *a* concentrations colonized on substrates in Blairmore Creek, Gold Creek and Crowsnest River, October 2014.**




Periphyton was sampled in the Crowsnest River at the same locations as the benthic invertebrate communities were sampled (Figure 3.7, Appendix A1 provides a description of the field methods used for sampling periphyton).

At 73.5 mg/m$^2$, chlorophyll *a* concentrations measured at the Crowsnest River upstream location (CRR-W02) were higher than at all other measured locations (Figure 3.7). This site is located on a larger, faster moving channel with larger substrate (i.e., boulders) which, compared to gravel and cobble in smaller streams provide greater surface area for establishment and growth of periphyton. Increased nutrient availability from human settlements may also contribute to increased periphyton abundance biomass in the Crowsnest River; nutrient concentrations measured in the RSA have been generally higher than in the LSA (Hatfield 2015).

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[7] Periphyton is benthic algae that adheres to the substrate of streams and lakes and is an important food source for many benthic invertebrates. It is measured in terms of chlorophyll *a* concentration and is used as an indicator of primary productivity. Several factors including substrate composition, flow, water quality, and light influence the abundance of periphyton.

## 3.3 2016 FISH AND AQUATIC RESOURCE BASELINE AND ASSESSMENT PROGRAM

For the 2016 fisheries and aquatic program, a number of technical studies aimed to further characterize fisheries and aquatic baseline conditions were identified to further support the assessment of potential effects as a result of the Project. These include:

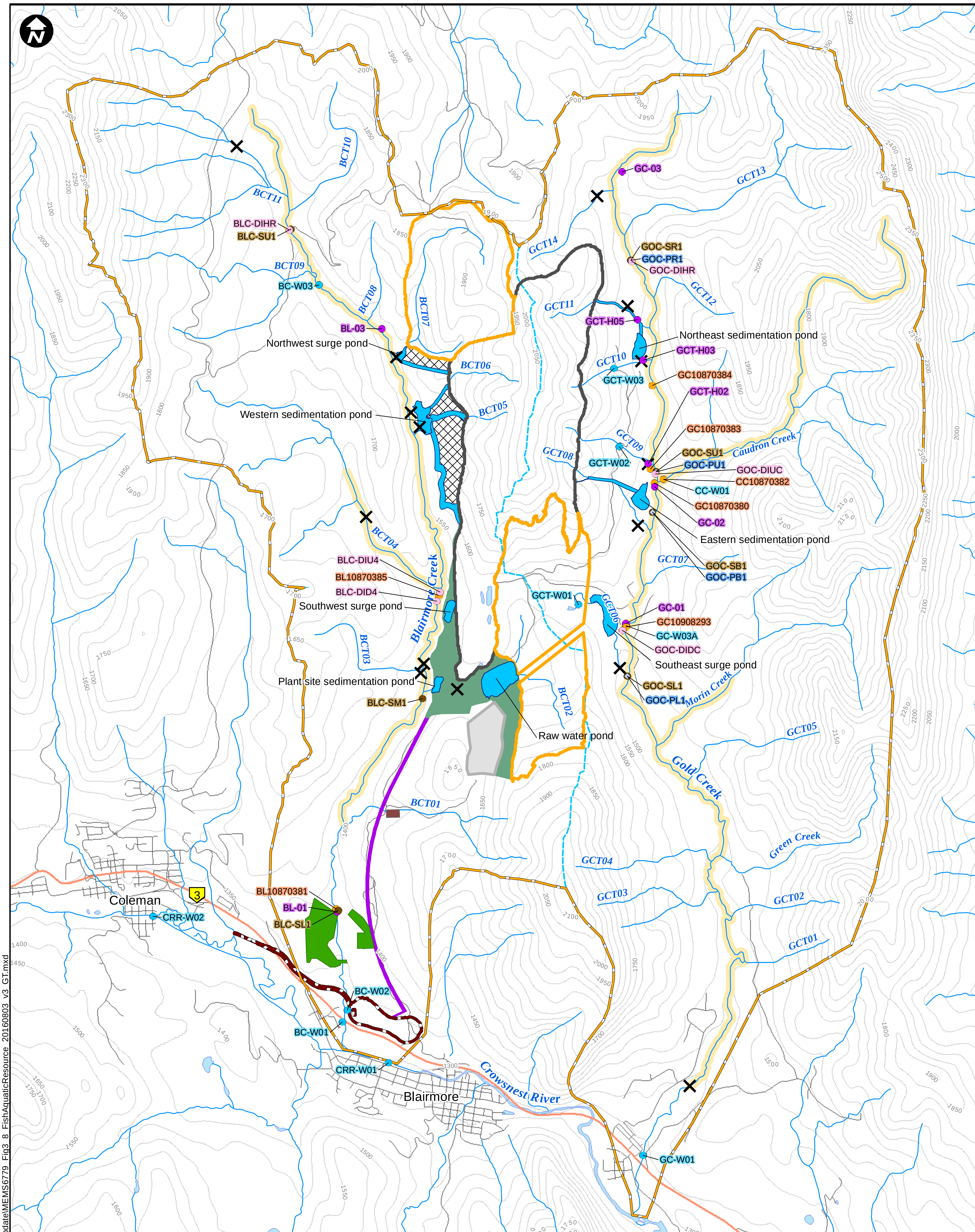
### *Fisheries Resources*

- Fish Habitat (to characterize the quality, distribution, quantity and limiting habitat in key watercourses potentially affected by the Project);
- Fish Biology (to determine/confirm fish presence, population/community composition, distribution and habitat use, population abundance/estimates, baseline fish health); and
- Instream Flow (in support of conducting an instream flow study to characterize potential positive and/or adverse effects of Project-related flow change and quantify potential alterations of flow change on critical fish/aquatic habitat).

### *Aquatics Resources (Water Quality Focus)*

- Surface Water Quality;
- Aquatic Sediments; and
- Tissue Residues (fish and lower trophic levels).

The fish and aquatic resources data will be collected using a suite of widely accepted standard methods over multiple seasons to facilitate key analyses. Once all 2016 seasonal fish population data has been collected a final analysis to characterize the fish composition, distribution, relative abundance, and general life history information of fish resources within Blairmore Creek and Gold Creek will be provided in the final Aquatic Ecology Effects Assessment report, which will be provided in Q1 2017. A description of each program is provided in the following subsections.




## LEGEND

- Benthic Sampling
- Periphyton Sampling
- Sediment Sampling
- Hydrometric Stations
- Water Temperature Data Logger
- 2016 Water Quality Sampling
- Habitat mapping (FHAP) and Fluvial Geomorph Area
- Barrier to fish passage
- Primary Highway
- Road
- 50 m Contour
- Watershed Boundary
- Watercourse
- Waterbody
- Local Study Area
- Railway Loop
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area

**PROJECT**

RIVERSDALE RESOURCES

**GRASSY MOUNTAIN COAL PROJECT**

Hatfield CONSULTANTS

**TITLE**

**SUMMARY OF FISH AND AQUATIC RESOURCE SAMPLING LOCATIONS, 2016**

**NOTES**

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

0 1 2 4
Kilometres

PROJECT: 6779
DRAWN BY: GT
CHECKED BY: CB
DATE: AUGUST 03, 2016

**FIGURE**

**3.8**

Document Path: K:\Data\Project\MEMS7779A_MXD\AquaticEcologyEIAUpdate\MEMS6779_Fig3_8_FishAquaticResource_20160803_v3_GT.mxd

### 3.3.1 Fisheries Resources

#### 3.3.1.1 Fish Habitat

Fish habitat assessments are required to describe the quality, abundance and distribution of fish habitats in the Project LSA. Habitat surveys were completed in previous 2014 and 2015 field seasons; the additional 2016 surveys will streamline the habitat surveys to ensure the data is characterized to the appropriate standard for estimating changes in physical habitat associated with potential flow alterations (i.e., IFN) from the associated mining activities.

The collection of fish habitat in the field will use a modified version of British Columbia's *Fish Habitat Assessment Procedures* (Johnston and Slaney 1996) as described in Lewis et al. (2004), specifically aimed at water withdrawal/alteration projects. The data will be organized into different spatial scales to facilitate analysis. Three scales of analysis are identified: macrohabitat (reach scale), mesohabitat (hydraulic unit scale), and microhabitat (site-specific scale).

Habitat assessments will also be completed on identified key tributaries of both Gold (i.e., Caudron, Morin, Green creeks including other identified unnamed tributaries that may be potentially affected by the Project) and Blairmore Creek at BCT04. Any identified obstructions or barriers to upstream fish movement from previous 2014 and 2015 field surveys will be re-evaluated to confirm their barrier type and status.

The detailed fish habitat information will be compiled so that an assessment of existing conditions can be performed in addition to an assessment of the extent to which potential water alterations will affect fish habitat.

#### 3.3.1.2 Fish Biology

The objective of the fish biology sampling program is to supplement historical baseline data with the collection of more up-to-date fish information in both the Gold Creek and Blairmore Creek watersheds to:

- confirm fish presence and absence throughout the Project LSA;
- describe fish distribution in terms of space and time;
- characterize fish population and/or community structure to understand fish species and life stages present;
- enumerate fish population abundance indicator(s) (CPUE, CPUA, density, population estimates etc.); and
- better understand life-history timing with particular emphasis on migration and seasonal/preferred habitat use.

Fish data will be generated using a suite of widely accepted standard collection methods over multiple seasons to facilitate key analyses. This will include direct visual observation by way of snorkeling (overwintering & spawner surveys). Since March 2016, snorkel surveys have been utilized in both Gold Creek and Blairmore Creek to gather fish information with respect to overwintering fish presence/absence, habitat use, abundance and distribution as well as spawn timing, spawning habitat use/preference and distribution. This passive method of data collection will continue throughout the remainder of the 2016 field programs where practical; however, to effectively address provincial and federal regulatory expectations, and to generate a more robust baseline to assess for potential effects, active fish capture methods (e.g., electrofishing) are necessary. A provincial fish research licence (FRL) (#16-2611 FRL) was issued for the Project on July 25, 2016, and a SARA fish research permit (16-PCAA-00026 SARA Section 73 Permit for Incidental Harm) was issued for the Project on July 27, 2016.

The proposed active fish sampling program will specifically target the following fish baseline studies:

i. WSCT sub-adult and adult population assessment;

ii. WSCT recruitment and juvenile population assessment;

iii. WSCT tributary use and distribution survey; and

iv. Tissue Residue/Fish health (discussed further below).

### *WSCT Sub-Adult and Adult Population Assessment*

The objective of the WSCT sub-adult and adult population assessment is to estimate the abundance of WSCT (> 150 mm) in the mainstem of Gold Creek and Blairmore Creek above known migration barriers utilizing a combined capture-recapture and snorkel survey approach. This approach was adopted from Cope et al. (2013), where it has been applied to WSCT population monitoring in the upper Fording River watershed. This approach will reduce excessive stress to fish by reducing active sampling while still generating important baseline information. The survey period will occur between July 31 and August 25, 2016. The capture of WSCT will be targeted towards fish >153 mm fork length using a combination of electrofishing and angling. Electrofishing will be the primary means of targeting sub-adult and adult WSCT from targeted mesohabitats where we anticipate to find them actively rearing/holding, thus sampling area may vary. A one-pass electrofishing sample will be deployed at each targeted mesohabitat. The number of fish to be marked >153 mm will ultimately depend on the number of fish encountered above the targeted size threshold. We have selected the >153 mm fork length to account for smaller sized sub-adult/adult WSCT that inhabit the upper reaches of both Gold Creek and Blairmore Creek (C. Bettles, pers. obs., 2016). Fish will be anaesthetized in a 40 L bath of river water containing 2.0 ml clove oil yielding bath concentrations of 50 mg/l. Clove oil is a safe, inexpensive, and effective anesthetic suitable for fish handling procedures in the field. The lowest effective dose of clove oil is recommended as time to recovery of equilibrium and fear response in salmonids has been shown to increase exponentially with exposure time (Keene et al. 1998). Because of its low solubility in water, the clove oil will first be dissolved in 10-ml of ethanol (95%) before being added to river water.

Fish will be double marked using a combination of a Visible Implant Elastomer (VIE) and body mark (i.e., fin clip). An analysis of marking/tagging options is summarized below. Given the increased turbidity in Blairmore Creek, tagging by fin clip, alone, would likely result in higher incidence of captured (recovered) fish being counted as ‘unmarked’. The inclusion of the VIE tag will ensure that fish are more accurately assigned to ‘marked’ or ‘unmarked’ captures. An additional benefit for including the fin clip mark is to archive tissue samples for future genetic investigations of WSCT including ongoing species integrity (i.e., hybridization) or more detailed population structure analyses. The clip also provides a physical mark indicating it has previously been sampled if encountered during future sampling programs and should typically last longer than the VIE. Fin clips will be collected from a portion of the upper caudal lobe from fish captured on each mark run and will be stored in 2-ml Nalgene® cryogenic vials (or similar) and preserved in 95% ethanol.

All marked fish will be released within the mesohabitat unit in which they were captured. Approximately 3-5 days post-marking, the same sections of watercourse will be surveyed using snorkel surveys where surveyor(s) will record the number of fish marked and those fish with no marks. Fish less than the 153 mm fork length cut-off will be recorded for completeness although they will not be included in the population estimate calculations.

Given suitable watershed conditions, snorkel counts have been proven to be a reliable and efficient means of obtaining indices or relative abundance for WSCT throughout their range including the East Kootenay's (e.g., Baxter 2004, 2005, 2006a, 2006b, Baxter and Hagen 2003). However, it is possible that snorkel counts will be underestimates of true abundance as individuals are routinely missed due to impacts of visibility, fish behavior and stream channel complexity. To address possible observer challenges, fish are marked within the section (reach) of stream for which the estimate will be conducted and population estimate generated.

The Maximum Likelihood Pooled-Peterson Estimate will be used to calculate the population abundance. It will be computed by pooling the captured-sample, the 'recovery' (of marked) sample, and the number of recaptures over all sections sampled in the 'designated' habitat within each watercourse. The term "recovered" or "recovery" is used for fish that are sighted through snorkel surveys and not physically handled. The key assumption of the pooled-Petersen method is that either; (a) the probability of marking is equal in all sections (b) the probability of recovery is equal in all sections (c) complete mixing of marked and unmarked fish across all sections. It is unlikely that fish from all sections mix completely across each watercourse (so condition (c) above may not be met), but the assumption of equal marking or equal recovery rates may be approximately satisfied because the effort and methods on all sections will generally be the same.

If the number of recovered fish is small over all sampled sections, an adjusted estimate (called the Chapman correction) will be used as the estimator.

### *Marking/Tagging Considerations: Analysis of Options*

A wide variety of tagging or marking methods can be can be used to create a known subset of fish populations. Marks are defined as anything recognizable that is external, internal, or incorporated into the integument of a fish, while a tag is usually defined as something attached externally or internally to a fish which contains specific identification information. Whereas no "perfect" tag exists, it is important to evaluate how each tag aligns with the study objectives.

A suite of tags/marks were considered and evaluated against the study objectives of the sub-adult and adult population assessment. These tags/marks included: body mark (i.e., fin clip), natural marks, anchor tags (e.g., floy tags), and visible implant elastomer (VIE). Table 3.9 provides a summary of each of the four tag/mark techniques.

### Table 3.9 Options analysis of tag/mark techniques considered for the WSCT sub-adult and adult population assessment.

| Tag/Mark Option | Strengths | Weaknesses |
|---|---|---|
| **Body Mark (fin clip)** | ▪ Ability to collect non-lethal DNA samples<br>▪ Low cost<br>▪ Quick to sample in the field<br>▪ Requires minimal equipment | ▪ Difficult to recognize clips in the field depending on water visibility<br>▪ Regeneration of tissues can add uncertainty to longer-term studies<br>▪ Open wound can result thus increase risk to infection<br>▪ Limited study application |
| **Natural Mark** | ▪ Morphological or meristic marks are generally unique to fish. | ▪ Attempted on WSCT (e.g., Gifford and Mayhood 2014), but further testing is required to confirm effectiveness |
| **Anchor Tag (floy tag)** | ▪ Visible from shoreline and under UV light<br>▪ Enable identification without recapture and without increasing mortality<br>▪ Identifiable at night<br>▪ High retention rates<br>▪ May be applied to very small fish-Minimal impact on fish survival, growth, and behavior<br>▪ Low capital and material costs<br>▪ Fast to apply<br>▪ Well-established technique applied to various fish size classes<br>▪ Used extensively in WSCT fish population assessment and monitoring programs | ▪ Limited coding capacity (can increase by using several colors, body locations, etc.)<br>▪ Can be difficult to detect in ambient light if growth is considerable and pigmented tissue is laid down over the tag<br>▪ May be hard to notice by casual observers<br>▪ Could potentially make fish more observable to predators |
| **VIE** | ▪ Tags are widely used b/c they have little effect on growth, survival, and behavior of fish (Phillips and Fries 2009)<br>▪ Multiple tag locations and colors can create unique identifications<br>▪ Tags visible under UV light even during daytime sampling<br>▪ Used effectively in cutthroat trout Mark-Recapture studies (Bonneau et al. 1995) | ▪ Retention time varies by tag location, species, tag color as tag material degrades or covered over by new tissue growth (Bolland et al. 2009) |

The tag/mark techniques listed above is not an exhaustive list of all available options; however, the above techniques were selected for consideration because of their application with WSCT, other Cutthroat Trout sub-species or salmonids (e.g., RNTR).

Floy tags are one of the primary tagging techniques used for monitoring WSCT populations in southeast British Columbia and have been applied for years on varying different drainages inhabiting the species. Based on discussions with regulators for this Project, the proposed use of floy tags at this time is not desirable, thus was dropped from further consideration.

VIE has been widely used as an effective mark in fish population studies, including WSCT. Depending on how the VIE is marked on individual fish, it has been proven effective at identifying marked WSCT through snorkel surveys (Bonneau et al. 1995) during daytime surveys. The use of a syringe requires increased handling of fish, but can be limited if the applicator is experienced and minimizes the number of VIE marks.

Using natural meristic marks was considered as it has the lowest invasive risk to fish of any of the considered tags/marks. However, its use specifically in identifying WSCT is still in its infant stages, thus its accuracy in mark-recapture studies is still unproven. Further studies are required to refine the approach. Based on this, the use of natural meristic tags was excluded from further consideration.

The use of body marks (fin clips) is one of the simplest and oldest forms of marking fish. They are quick to execute thus minimizing the handling time/stress on fish. Fin clips have been used as marks in other WSCT population studies (e.g., Alberta Conservation Association) and provide the added benefit of archiving tissue samples for future genetic analyses.

Based on the study objectives of the sub-adult and adult population assessment as well as consideration of the strengths and weaknesses of the select mark/tag options evaluated, Benga will apply a ‘double mark’ utilized VIE and fin clip. The rationale for taking this approach is two-fold: (1) generate current and future data through fin clips. Archiving tissue samples for future genetic analyses will be important in the ongoing monitoring of persistence and sustainability of WSCT in both Blairmore and Gold creeks; and (2) given the potential for improperly assigning fin clipped individuals (e.g., relatively poor visibility in Blairmore Creek), the VIE acts as a double check to ensure more accurate identification thus more valid population abundance estimates. Furthermore, the use of UV light to identify VIE tags increases the accuracy rate of properly identifying marked fish. The proposed double marking methodology has been discussed with the AER and DFO fish biologists as part of FRL and SARA permit requests, and approvals for this method are captured in both of the regulatory issued research licence/permit documents.

### *WSCT Recruitment and Juvenile Population Assessment*

The objective of the WSCT juvenile population assessment is to: (1) collect information on fry and juvenile presence/absence distribution in key mesohabitats (i.e., pool, glide, run, riffle) and (2) calculate density estimates of WSCT fry (0+) and juvenile (1+ - one year old age class, 2+ - two year old age class).

The spatial scale of the assessment will include the mainstems of both Gold Creek and Blairmore Creek within each watercourse’s ‘designated’ habitat.

Sampling will predominantly utilize single-pass backpack electrofishing methods and will follow established sampling criteria described in *Standard for Sampling Small-Bodied Fish in Alberta* (2013a) and *Standard for Sampling of Small Streams in Alberta* (2013b) guidance documents. Sampling will occur at approximately 6-10 locations per watercourse.

Nested within each location will be three sites encompassing pool, riffle, glide, run and/or side-channel habitats; each site will be approximately 300 m in length. Sampling of habitats will also take into consideration fish information needs (e.g., known spawning areas) for the Instream Flow Needs Study including refinement/validation of site-specific Habitat Suitability Curves. To minimize sample variance an experienced crew will be employed on each watercourse and the same crews will be utilized for all sampling.

Electrofishing will commence at the end of July/early August, 2016 based on data compiled with respect to the 2016 spawning window for Gold Creek and Blairmore Creek as well as monitoring of the local hydrograph. Surveys will be initiated in lower reaches where fry emergence has most likely concluded and to allow for any delayed emergence in upper reaches/headwaters. If no fry are observed at the onset of the program, sampling will be delayed until such time fry are visually active.

At each location, three sites of approximately 100 $m^2$ each will be individually sampled for fish densities. A Smith-Root LR-24 DC Backpack electrofisher (or similar) will be used for three successive single-passes within each closed sample unit. Catch results will then be used to estimate the number of fry (0+ age class) and juveniles (1+ and 2+ age classes) within the enclosure area. Estimates and their 95% confidence interval will be reported as a standard numerical density (number fish/100 $m^2$) for each site. Capture, effort (area and electrofishing time for each single-pass) and life-history data (e.g., fork length, weight) will be recorded.

Estimates of juvenile fish density (number of fish/100 $m^2$) will be determined using closed, maximum-likelihood estimates (Kruse et al. 1998, Van Deventer and Platts 1990).

#### *WSCT Tributary Use and Distribution Survey*

Tributary streams to both Blairmore Creek and Gold Creek were evaluated and characterized in the 2015 field surveys. Based on further evaluation of the previous data coupled with additional field information gathered during 2016 field surveys completed to date, a select number of tributaries require fish sampling to document fish presence, distribution, and habitat use (if fish are present). These tributaries include: Gold Creek tributaries (GCT13, GCT10, Caudron Creek, Morin Creek, Green Creek); Blairmore Creek tributaries (BCT04, BCT02). Fish sampling in each target tributary will use either opportunistic or single-pass electrofishing technique (Bateman et al. 2005). Opportunistic sampling will occur in those tributaries that are not directly affected by the proposed mine to better understand how they contribute to the sustainability of WSCT in each watershed. A combination of opportunistic and single-pass sampling will be deployed in those tributaries likely to be directly affected by the proposed mine (e.g., GCT10, BCT02). The objective for these two tributaries is to: (1) understand their fish bearing status; (2) if fish are present characterize their distribution (Bateman et al. 2005); and (3) estimate fish density as per described above.

### 3.3.1.3 Instream Flow Needs Study

The primary objectives of the IFN study are to characterize potential effects of flow change, and quantify potential effects of flow change on fish/aquatic habitat and how it relates to “Serious Harm” in the context of fisheries productivity. The study has been designed to provide a quantitative analysis of anticipated effects by predicting hydraulic conditions important for fish (i.e., stream depth, width, and water velocity) during different phases of the Project and by comparing the subsequent changes in habitat quality to baseline conditions. The IFN study is multidisciplinary in nature; it will incorporate data from the fish biology and fish habitat programs (described above) as well as other baseline field programs related to hydrology, water quality, fluvial geomorphology, lower trophic organisms, and riparian/stream ecology.

A combination of the British Columbia Instream Flow Methodology (BCIFM; Lewis et al. 2004) with habitat simulation modeling (e.g., PHABSIM, RHABSIM, SEFA or alternative) will be used for the assessment. These methods are similar to, and supported by, the habitat component of the Instream Flow Incremental Methodology (IFIM). Both methods assume that habitat for fish (and other aquatic species) changes as a function of flow and that predictive models can be developed to describe this relationship for a given stream. The BCIFM is a stratified-random approach to fish habitat measurement. The selection of transect sites is critical; transects will be established with primary focus on WSCT critical habitat (i.e., spawning, incubation, rearing, overwintering etc.) and associated life stage(s).

Generally, the key steps involved will include the following:

i. Quantify the habitat unit composition of each Macrohabitat reach by delineating the reach into pool (slow), riffle (fast, turbulent), and glide/run (fast, non-turbulent) mesohabitats, expressed in linear distance (m) of channel occupied by the mesohabitat within the reach. This is completed the methods applied through Johnston and Slaney's (1996) Level 1 assessment (as described above).

ii. Identify an adequate number of transect sites per reach. The number required will depend on heterogeneity of habitats within the reach. A minimum of five transects will be established per mesohabitat unit type. The number and location of transects sites will be guided by professional judgement.

iii. For each transect, microhabitat characteristics (depth, velocity, substrate, and cover) will be measured at a minimum of three flow levels spanning the (ideal) range of 5% to 40% naturalized mean annual discharge (NMAD); however, a greater number of flow levels may be collected in each system.

Additional physical and biological data are typically required to execute a defensible IFN. These include:

- Hydrology;
- Hydrogeology;
- Fluvial geomorphology;
- Surface water temperature; and
- Drift benthic invertebrates.

Baseline data specific to these technical areas will be collected in support of executing the IFN. Of note, water chemistry data collected for the project will be considered as part of the IFN studies.

Hydrometric stations have been re- and newly-established in both Blairmore (re-established, N=2) and Gold (re-established, N=1; newly established, N=2) creeks where the baseline will be refined using continuous local hydrology data (~1 year). The baseline characterization of surface hydrology for the LSA and RSA will conform to MOE (2012) and Lewis et al. (2004) for the purposes of the IFN. Newly established hydrometric station installed in Gold Creek have been specifically established upstream towards the headwaters of Gold Creek and just downstream of Gold Creek's main tributary, Caudron Creek aimed to characterize the water inputs along the west banks of Gold Creek that are potentially to be altered by the proposed mine. Hydrometric station data will be supplemented with microhabitat discharge measurements at transects positioned in key mesohabitats in the area of Gold Creek where surface and groundwater inputs will potentially be altered by the proposed mine. Furthermore, groundwater findings generated from the groundwater numerical model developed for the mine will be evaluated.

A fluvial geomorphology assessment will be conducted with the objective to describe natural channel conditions, whether previous land and water uses have altered channel conditions, and to what extent the proposed water alterations (i.e., proposed decrease flow in Gold Creek and proposed increase flows in Blairmore Creek) will alter baseline channel morphology. The geomorphology assessment will describe the watershed physical characteristics, physical channel condition, influences of water and land use on channel processes, and the potential effects of the proposed flow alterations on present and future conditions.

Understanding annual stream temperature fluctuations in Blairmore Creek and Gold Creek watersheds is paramount for characterizing critical habitat and potential limiting factor(s), as well as predicting effects of the Project, on fish production. For the temperature assessment, continuous (automated) recording thermographs were installed in March 2016 at multiple sites on both Gold Creek and Blairmore Creek mainstems and set to collect water temperature every 30 minutes. Calibration and installation of thermographs followed standard operating procedures outlined by Washington State Department of Ecology (Ward 2011). Additionally, established hydrometric stations also collected water temperature data.

Macroinvertebrates and their habitats are often considered in instream flow assessments in an effort to preserve food sources for fish, because many fish species, in particular all stream-rearing salmonids, depend on drift of invertebrates from upstream areas. Abundance and distribution of macroinvertebrates in the drift will be characterized through the use of drift samplers, which are vertically fixed nets that collect invertebrates suspended in the water column. Samplers are held in place with vertical stakes pounded into the substrate (e.g., quarter-inch diameter steel rod for removable sets, rebar, T-bar, or angle iron for permanent stakes that are left in the stream). Three sample locations will be targeted on each of Blairmore and Gold creeks; upper-, mid- and lower- reaches. Five replicates per site will be sampled. Sites will be sampled twice during the main growing season once in July and once in September, at low to moderate flows.

Once all seasonal benthic macroinvertebrate data has been collected a final analysis to characterize benthic macroinvertebrate metrics within Blairmore Creek and Gold Creek will be provided in the final Aquatic Ecology Effects Assessment.

### 3.3.2 Aquatic Resources

#### 3.3.2.1 Surface Water Quality

Water quality sampling in 2016 will target sites established in previous 2014 and 2015 field seasons to further enhance the current baseline. The short-term target was winter (March) 2016 to enhance the winter surface water quality baseline dataset. The same field protocols and QA/QC applied during the preceding field seasons were used to ensure consistency and minimize sampling bias. An additional target was to establish an appropriate reference site. Caudron Creek was selected as a reference surface water quality site given its water quantity importance to Gold Creek as well as being uninfluenced by the proposed mine given its location (east side of Gold Creek) in the LSA.

#### 3.3.2.2 Aquatic Sediments

The objective of the sediment sampling program is to characterize baseline sediment chemistry at key locations in the vicinity of the proposed mine site, with emphasis in those areas targeted for mine effluent discharge or run-off water over the course of the mine life.

Sampling locations for aquatic sediments will be coordinated with existing established locations for water quality, tissue residue, benthic invertebrates, and fish habitat to provide opportunity to examine relationships between these components of the aquatic environment; however, fine bottom sediments may not be widespread, particularly in steeper-gradient areas. While integration of these components is preferred, sampling locations for sediments will be located where fine sediments are identified.

Variables for laboratory analyses of aquatic sediments (reported as dry weight) will include the following:

i. Particle size distribution;

ii. Total organic carbon (TOC);

iii. Polycyclic aromatic hydrocarbons (PAH);

iv. Nutrients (where applicable);

v. Moisture content; and

vi. Total Metals.

#### 3.3.2.3 Tissue Residue

Similar to sediments, tissues can absorb metal or organic contaminants discharged by operational or post-closure mines. Contaminants may be taken up directly from the water column via facilitated diffusion (e.g., inorganic metals) or, in the case of organic selenium and methyl-mercury, may be taken up via dietary sources, stored in fat and proteins, and biomagnified up the food chain.

Regardless of the mode of uptake, the quantification of tissue contaminant levels is a necessary part of any baseline program, providing reference for future contaminant accumulation in aquatic organisms. Significant change from baseline concentrations may trigger additional impact assessment and/or the implementation of contingency mitigation measures that should have been developed as part of the mine review process.

Given the sensitivities around WSCT and the limited fish species diversity in both Blairmore and Gold creeks, we are proposing to utilize non-native BKTR in lower Blairmore Creek as the sentinel fish species. With the exception of reproductive timing (i.e., WSCT in the spring and BKTR in the fall), both species exhibit similar life-history strategies, particularly where BKTR have been introduced into native WSCT range (Shepard 2010). Benthic invertebrate samples (from previously collected Hess/Surber samples or proposed drift samples) will be included for characterization as part of the tissue residue program.

Tissue specimens will be collected during the summer as part of the fish biology sampling program. Periphyton samples will be collected from select locations in both Blairmore Creek and Gold Creek following the methodology described in MOE (2012). Sampling of periphyton will be collected in June 2016 at select established locations in both Blairmore Creek and Gold Creek mainstems. Benthic invertebrate samples collected from previous field programs and/or those collected during the proposed 2016 drift sampling program (part of the instream flow study) will be included for tissue analysis.

Fish tissue samples will be targeted at locations downstream from the mine's proposed effluent discharge location. Given BKTR have not, historically, been documented and RNTR appear to be sparse in upper Blairmore Creek, another watercourse with known BKTR in the vicinity of the LSA, but uninfluenced by the Project (i.e., lower Gold Creek or an alternative), will be targeted. Additionally, every effort will be made to associate sampling effort in the vicinity of aquatic sediment and surface water quality stations, where feasible.

Tissue residue samples for both fish and periphyton will follow sampling protocols outlined in the Water and Air Baseline Monitoring Guidance Document for Mining Proponents and Operators (BC MOE 2012).

### 3.3.3 2016 Field Schedule

Table 3.10 outlines the schedule for executing the 2016 field programs. As some field programs/activities have already been peformed, Figure 3.7 provides a visual overview of the 2016 sampling locations. As additional field programs are ongoing, the final synthesis and analysis of the data will be provided in the Aquatic Ecology addendum in Q1, July 2017. Exact dates of when field work will occur is subject to seasonal sensitivities, site-specific (i.e., discharge) conditions, and timely issuance of scientific fish collection permit approvals, thus are subject to change slightly.

**Table 3.10 Proposed 2016 field timing for executing fish and aquatic resource field programs.**

| Program | Activity | Timeline (2016) |
|---|---|---|
| Fish Resources | Fish Baseline Field Surveys | March, May/June, July/August, October |
| | Fish Habitat Field Surveys (includes IFN needs), including temperature data logger install/retrieve | March, June, September, October/November |
| Fish Resources | Fluvial Geomorphology Assessment | May, June, July |
| Fish Resources | Drift Benthic Surveys | July, September |
| Fish Resources | Hydrometric Station Establishment | March, May |
| Aquatic Resources | Water: Physical & Chemical | March, May, August, October |
| Aquatic Resources | Aquatic Sediments | June |
| Aquatic Resources | Tissue Residue | July, August (fish, aquatics) |
| Habitat Offsetting | Reconnaissance Survey | June-August |

# 4.0 ASSESSMENT OF POTENTIAL EFFECTS

The primary impacts of mine development on fish resources are almost always mediated through effects to their habitat. These effects include alteration to sediment deposition and scour processes in streams, stream crossings (roads, pipelines, and powerlines), stream diversions, changes to stream flows, effluent discharge, and complete habitat loss under the project footprint. In particular, the effects of waste rock storage areas, and project footprint components (Table 1.2) typically require more robust assessment, as they are likely to pose the most significant risks to fish and fish habitat. Fish populations respond to perturbations in numerous ways, including increased stress, disease, mortality and decreased growth, inability to reproduce, survival, recruitment, and production. The assessment of potential aquatic effects for this project is driven by the bullets listed in the AER and CEAA Terms of References summarized in Table 1.1 and Table 1.2.

The core components of the aquatic effects assessment will focus on the potential direct habitat losses to select watercourses as a result of the project footprint, alterations to stream flow in select tributaries and mainstem watercourses, effluent discharge (i.e., potential changes in water quality) and how these project activities interact with the select VCs. At this time, a complete impact assessment cannot be completed for these core components as all the required data that comprises the 2016 field program has not yet been collected. Once this data is collected and fully analyzed (via laboratory analysis, project footprint verification, and IFN model simulations), a final impact assessment and significance evaluation will be provided in the Aquatic Resources addendum (to be issued in Q1 2017).

The following subsections provide an overview of the potential effects that could be associated with each phase of the Project and a summary of how each potential effect will be assessed.

## 4.1 OVERVIEW OF POTENTIAL DESIGN IMPACTS ON AQUATIC RESOURCES

The Project mine plan has been developed to minimize or prevent direct physical impacts to available, suitable fish habitat in both Blairmore Creek and Gold Creek mainstems. Based on the proximity of the Project footprint there is the potential for the direct removal of portions of specific upper headwater tributaries of both Blairmore Creek and Gold Creek. The activities associated with the construction, operations, and reclamation phases that may have the potential to affect aquatic resources are summarized in Table 4.1.

**Table 4.1 Project activities with potential to affect aquatic resources.**

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

### 4.1.1 Overview Mine Plan Design Mitigations

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. The following outlines the key components that will be implemented in the mine plan to protect the aquatic environment and mitigate for any potential Project effects to fish and aquatic resources. Full details of the following components are provided in full in Section C.5.3 of the application.

#### 4.1.1.1 Selenium Treatment

The removal of selenium from water, as a result of exposure of waste rock, can be achieved running the water through an anoxic (free of oxygen and electrochemically reducing) environment, such as large backfilled mining pit areas. Under reducing conditions, selenium can precipitate or adsorb to mineral particles. Benga will manage the saturated backfill areas, which will occur as part of the Project mine phasing, as reducing zones to remove selenium from mine contact water. Nitrate will be removed from the mine water by a similar process.

The removal of selenium in saturated backfill zones has been observed to occur naturally in backfilled pits at active or closed mines. The removal process is well understood and the principle/process of the saturated backfilled zones is the foundation of the majority of active selenium water treatment plants.

Full details on the potential effects of selenium on the aquatic environment are provided in the Water Quality report (CR#5).

#### 4.1.1.2 Grassy Mountain Surface Drainage, Diversion and Water Management

The collection of surface runoff water and the management of pit water are required for the removal of total suspended solids (TSS). Management and mitigation of the selenium content of water precipitating through the excavated rock placed in the ex-pit rock disposal areas is also of primary concern. The main objective is to control selenium and TSS levels to meet wastewater guidelines and objectives.

A series of collection ditches, sumps, pumps and settling ponds will be established to manage all surface water on the mine site. Surface runoff from mining areas and haul roads is collected and directed to settling ponds for treatment or will be pumped to the raw water pond for storage and use in the coal cleaning process. Water collected at the toes of disposal areas is expected to contain elevated levels of selenium. It is understood that water will be directed initially to surge ponds before being directed to saturated zones for selenium attenuation and surface runoff from disturbed areas will be controlled. Full details of this water management facility planning are provided in Section C.5.3.2.

#### 4.1.1.3 Water Capture and Release (Sediment Ponds)

It is understood that the source of the water directed to the sediment ponds will be from surface runoff and groundwater interception from the pit and will not be exposed to selenium enrichment, thus will likely not require selenium management efforts. This water may contain suspended solids that will require removal prior to release to the environment. Sediment ponds are to be designed as wet ponds with permanent pools. It is understood that outflows from the ponds up to the water quality design flood will occur via discharge pipes through the embankments, which will have inverts at the levels of the permanent pools. Pond capacities and discharge pipes have been sized to provide the required retention for the water quality design flood. The five settling/release ponds are described in more detail in Section C.5.3.3 of the application.

#### 4.1.1.4 Water Capture and Management

The following is a high level understanding of the mine design features related to the capture of mine process water and the various management treatment mitigation options that will be implemented.

##### *Surge Ponds*

Water from external wasterock areas will be directed to the selenium management surge ponds which have been strategically located to accept water that will impacted by the external rock disposal areas. These surge ponds will not release water and will require additional management that includes storage and transfer of water. These ponds are also shown on Figures C.5.3-1 to C.5.3-5 in Section C.5.3.5 of the application.

### *Saturated Zones for Selenium Attenuation*

As mentioned, selenium impacted water will be directed to a number of selenium attenuation zones located within mined out and backfilled portions of the open pit. These zones are areas within the open pit where selenium impacted water will be directed to occupy the void spaces in the deposited overburden. As discussed in Section C.5.3.1, in the absence of oxygen these zones will cause the selenium to drop out of solution, a full description of the various attenuation zones and phasing for the Project is provided in C.5.3.4.2.

### *Groundwater Seepage Capture*

A groundwater monitoring plan will be implemented for the Project as described in CR#3. As part of the monitoring plan, groundwater monitoring around expit wasterock disposal areas will occur. When or if monitoring indicates that selenium impacted water has percolated through the wasterock piles and is not being captured within the surface water drainage ditches to the surge ponds, deep groundwater seepage capture wells will be installed. This deeper groundwater will then be directed towards the attenuation zones for selenium treatment. The potential changes in groundwater baseflow on the surface water creeks has been captured in the groundwater assessment and the water balance models.

### *Metals Treatment Facility*

The water model developed for the Project has indicated the potential for some metals parameters (e.g., cobalt and cadmium) may occur at the discharge of the saturated zones at levels above the water quality guidelines. Monitoring of the discharge from the saturated backfill area during operations will confirm if water treatment is required and the timing of such treatment. In the event a treatment process is required, Benga will implement the development of a water treatment facility to ensure that any direct discharge of process water to the receiving creeks meets provincial and federal guidelines.

## 4.1.1.5 End-of-Mine Lake

Final mining will occur in the very north-east corner of the Project's open pit. The final pit will result in a self-sustaining end pit lake (EPL) (Hydrogeology CR#3). The EPL will not be designed to maintain any fish populations; however, to ensure water quality within the EPL meets all provincial and federal guidelines, and is not a risk to humans, wildlife, or to the aquatic environment, no in-pit backfilling will be allowed inside the lake's drainage area in order to minimize the amount of selenium affected water from entering the lake. To ensure that lake does not become into contact with mine waste rock areas or attenuation zones treating selenium, horizontal drainage holes will be drilled at the 1700 m elevation in the lake area to the east to allow the lake water to decant and report east into Gold Creek. This decanting to Gold Creek will only occur at final closure. Details of the EPL are provided in Figure C.5.3-7.

### 4.1.2 Project Specific Potential Effects on Fish and Aquatic Resources

#### 4.1.2.1 Changes in Flow

At present, direct design (footprint) effects (i.e., physical mining activities) are expected to occur to the mainsteams of either Blairmore Creek or Gold Creek. However, the current mine plan footprint may directly affect four tributaries to Blairmore Creek (Project nomenclature: BCT02; BCT05; BCT06; and BCT07), and six tributaries to Gold Creek (Project nomenclature: GCT06; GCT08; GCT09; GCT10; GCT11; and GCT14). The significance evaluation of these direct footprint effects will be provided in an addendum to the Aquatic Ecology Effects Assessment in Q1 2017.

To characterize the potential effects of predicted flow alterations on fish and aquatic habitat in the context of "Serious Harm", a project IFN study is currently being conducted. As described in section 3.3.1.3, the IFN study has been designed to provide a quantitative analysis of anticipated effects by predicting hydraulic conditions important for fish (i.e., stream depth, width, and water velocity) during different phases of the Project and by comparing the subsequent changes in flow to key indicators or effect pathways. Once sufficient data has been collected for the IFN, the assessment will proceed, predicted effects (pre-mitigation) will be generated and summarized, appropriate mitigation will be applied, and final significance evaluation will be provided in an addendum to the Aquatic Ecology Effects Assessment in Q1 2017. Depending on the outcome, the need for habitat offsetting will be discussed in the assessment.

#### 4.1.2.2 Changes in Water Quality

As the mine progresses through operations there's the potential for changes to sediment and water quality parameters that may have chronic or lethal (acute) effects on aquatic biota if they have the potential to enter the aquatic ecosystem. Water quality effects on the Aquatic Health VC has been assessed in the Water Quality asssessment (CR#5). Additional information collection on fish (fish tissue residue) and aquatic resources (water quality and sediment quality) forms part of the 2016 sampling program (Section 3.3.2 of this report) and data has been included in CR#5. The fish tissue residue results will be included as supplementary data to CR#5 as part of the Aquatic Ecology Effects Assessment, which will be provided in Q1 2017.

#### 4.1.2.3 Changes in Angling Pressure

A majority of the Project infrastructure is located on land currently owned by Benga, with the remaining on crownland. The main access road connecting the CHPP area with Highway 3 will follow the route of the proposed overland conveyor, which will transport the clean steelmaking coal product to the rail load out where it will be loaded into train cars. Mine pit and waste rock storage area haul roads, along with water management facility roads will branch out from the CHPP area. These roads will vary in location over the course of the mine life. Public use of these roads will be prohibited by Benga during the construction and operation phases for public safety reasons. At closure, the haul roads will be reclaimed as part of the Conservation and Reclamation Plan (C&R Plan). As part of the C&R Plan, access to some of the water management facilities (specifically the surge ponds) will still be required for a number of years after the end of mining (EOM). These roads as well as the main access road will be on Benga private land and will be closed to the public. At final closure, all water management facility structures will be reclaimed, as well as the associated access roads. The main access road will also be reclaimed from the CHPP area to the Golf and Country Club.

Benga has also been consulting with recreational users such as the Crowsnest Pass Quad Squad, the United Riders of Crowsnest and the Crow Snow Riders in order to gain further understanding on recreational use of the proposed mining area. A majority of the known trails in the area are along the north and west sides of the proposed development. Benga will continue to work with these groups in order to develop measures to mitigate potential impacts of the Project on outdoor recreation in the area. In addition, at the completion of mining, the area will be reclaimed to a land use equivalent to what existed prior to development including recreational use.

As the public will not be allowed to use any private mine related roads, and with Benga's commitment to adopt an employee policy where angling is not allowed. Angling pressure on local fish populations is not anticipated to be a concern. A final significance evaluation will be provided along in the final Aquatic Ecology Effects Assessment report in Q1 2017.

# 5.0 CUMULATIVE EFFECTS ASSESSMENT

Of the proposed projects forming the Planned Development Case:

- 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.

The list of proposed projects included as part of any Cumulative Effects Assessment (CEA) will be re-evaluated as the assessment of effects proceeds. Once a tabulation of residual effects is generated and after mitigation has been applied, the need for conducting a CEA on Aquatic Resources will be confirmed. If residual effects remain post-mitigation, the Aquatic Ecology Effects Assessment issued in Q1 2017 will include an assessment and discussion of cumulative effects.

# 6.0 POTENTIAL MONITORING

Monitoring plans for the Project will be finalized at the end of 2016 once all significance evaluations have been compiled; however, the framework for monitoring could potentially include (but not limited to):

- implementation of a water quality monitoring program for the life of the project, which will include regular compliance monitoring of sedimentation ponds, which will include but not limited to monitoring of flows and total suspended solids (TSS);
- effects monitoring for surface water quality in natural watercourses, both upstream and downstream of Project activities on both Blairmore Creek and Gold Creek;
- development and implementation of a benthic invertebrate biomonitoring program to assess the effectiveness of the surface water management;
- design and implementation of a monitoring program to monitor sedimentation and stream "embeddedness" patterns in Blairmore Creek and Gold Creek to assess the effectiveness of surface water management;
- at the EOM, the evaluation of the end pit lake system through a monitoring program to assess water quantity and water quality; and
- specific monitoring requirements for Blairmore Creek and Gold Creek based on results of the IFN study, as necessary.

If deemed necessary as a result of the outcome(s) from the Aquatic Ecology Effects Assessment a habitat offset plan will be developed. The offset planning will consider the results of the impact assessment findings (e.g. IFN results) to aid in the determination of quantity and nature of required offsets, identification of locations where offsets could be implemented, and the development a habitat offset plan. The offset plan would initially be considered conceptual and would be finalized in consultation with the AER and DFO. Once agreed upon, the associated approvals and authorizations from regulatory agencies would be applied for. The implementation of the offsets and monitoring to assess effectiveness of the plan would be determined as part of the plan development and approval/authorization terms and conditions. It is expected that the final implementation plan would be prepared with regulators and stakeholders prior to Project approval at the Project permitting level.

# 7.0 SUMMARY

Benga has been collecting fish and aquatic baseline data for the Project in 2014 to 2015 and are continuing with additional baseline data collection in 2016 in both Blairmore Creek and Gold Creek. The information collected in 2014 and 2015 provides some baseline background data; however, additional data collection in 2016 will provide the foundation of a more detailed and comprehensive aquatic effects assessment for Blaimore Creek and Gold Creek watersheds.

This more focused assessment will support previously collected fish and aquatic resources data, and will also use data generated from the hydrogeological assessment (CR#3), the hydrology assessment (CR#4), and the water quality assessment (CR#5) to fully address the AER TOR and CEAA guidelines developed for the Project.

As part of ongoing discussions with the AER, CEAA, DFO, and DFO SARA specialists, it was agreed that as seasonal data is required for the complete 2016 data collection to complete the IFN study, the more comprehensive and completed Aquatic Ecology Effects Assessment will be provided to the AER and CEAA as an addendum to the EIA in Q1, 2017.

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# APPENDICES

# Appendix A1

# Methods for Conducting Baseline Field Programs for Aquatic Ecology Component, 2014-2015

# A1.0 DESCRIPTION OF FIELD METHODS FOR AQUATIC ECOLOGY BASELINE FIELD PROGRAMS

## A1.1 INTRODUCTION

This Appendix describes the field methods used in the baseline field programs for Aquatic Ecology conducted in support of this Application. The baseline field programs that were conducted are summarized in Table A1.1 and Figure A1.1; each program is described in detail below.

### Table A1.1 Summary of baseline field programs conducted for the Aquatic Ecology component of this Application.

| Date | Description of Field Program |
|---|---|
| August 2014 | ▪ Aquatic habitat assessments and fish inventories at two locations on Blairmore Creek[1]<br>▪ Aquatic habitat assessments at 17 locations on tributaries of Blairmore Creek and fish inventories at eight of these locations[1] |
| October 2014 | ▪ Benthic invertebrate and periphyton surveys at four locations in the Blairmore Creek watershed (LSA) and two locations on the Crowsnest River (RSA) |
| February 2015 | ▪ Assessment of winter flow conditions at one location on each of five of the six tributaries of Gold Creek that originate within the Project footprint[2] |
| June 2015 | ▪ Aquatic habitat assessments at one location on each of the six tributaries of Gold Creek that originate within the Project footprint<br>▪ Aquatic habitat assessments at three tributaries of Blairmore Creek that originate within the Project footprint |
| August 2015 | ▪ Watercourse habitat surveys of:<br>o Gold Creek mainstem from the downstream delineation of critical habitat for westslope cutthroat trout to the upper reaches of Gold Creek, upstream of the Project footprint<br>o the lower reaches of six tributaries of Gold Creek that originate within the Project footprint |

[1] A total of 170 samples of genetic material from fish captured at five sites were collected and submitted to AESRD for genetic testing. Electrofishing could not be conducted at seven of the locations due to either insufficient water depth or lack of a defined channel, Electrofishing was not conducted at one location (BCT10) due to proximity BC-02 and it was assumed that the genetic results from one site could be applied to the adjacent site.

[2] One of the six tributaries (GCT14) could not be accessed in February 2015 due to deep snow conditions.

## A1.2 AUGUST 2014 AQUATIC HABITAT ASSESSMENTS AND FISH INVENTORIES IN BLAIRMORE CREEK WATERSHED

Aquatic habitat assessments and fish inventories were conducted in the Blairmore Creek watershed at the locations listed in Table A1.2 and identified in Figure A1.1.

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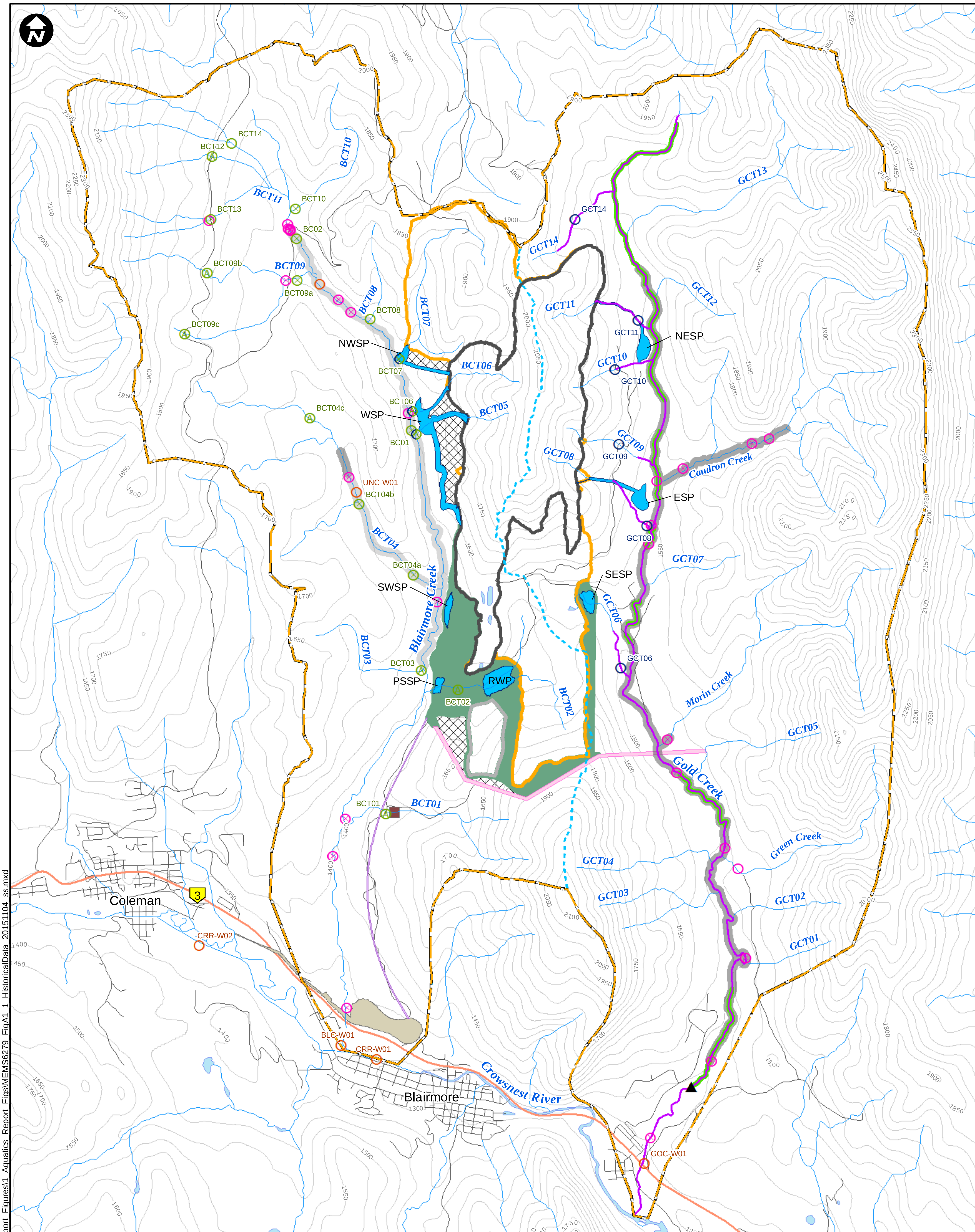


## LEGEND

- June 2015 Aquatic Habitat Assessment
- August 2014 Fish Inventory and Habitat Assessment Location (attempted)
- August 2014 Fish Inventory and Habitat Assessment Location (no fish caught)
- August 2014 Fish Inventory and Habitat Assessment Location (fish caught)
- FWMIS Historical Sampling Location (no fish caught)
- FWMIS Historical Sampling Location (fish caught)
- October 2014 Benthic and Periphyton Survey Location
- Barrier
- August 2015 Reach Habitat Assessment Surveys
- Reaches surveyed in August 2015 in which fish were observed
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT Population (95% to 99% pure)
- Primary Highway
- Road
- 50 m Contour
- Watershed Boundary
- Watercourse
- Waterbody
- Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Proposed Pipeline ROW
- Access and Conveyor
- Railway Loop
- Non-Disturbed Area

**PROJECT**

RIVERSDALE RESOURCES

**GRASSY MOUNTAIN COAL PROJECT**

MILLENNIUM EMS Solutions Ltd.

**TITLE**

**SUMMARY OF HISTORICAL INFORMATION AND LOCATIONS OF FIELD PROGRAMS CONDUCTED IN SUPPORT OF THIS APPLICATION**

**NOTES**

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

0 1 2 4
Kilometres

PROJECT: 6279
DRAWN BY: SB (EDITED SS)
CHECKED BY: PM
DATE: NOVEMBER 4, 2015

**FIGURE**

**A1.1**

Document Path: K:\Data\Project\MEMS6279-NVI_MXD\2015_Baseline_Report_Figures\1_Aquatics_Report_Figs\MEMS6279_FigA1_1_HistoricalData_20151104_ss.mxd

**Table A1.2 Locations of aquatic habitat assessments and fish inventories in Blairmore Creek watershed, August 2014.**

| Site Name | UTM Easting | UTM Northing | Habitat Assessment | Fish Inventory |
|---|---|---|---|---|
| BC01 | 684541 | 5507209 | √ | √ |
| BC02 | 682981 | 5509810 | √ | √ |
| BCT01 | 684213 | 5502010 | √ | × |
| BCT02 | 685189 | 5503691 | √ | × |
| BCT03 | 684694 | 5503910 | √ | × |
| BCT04a | 684579 | 5505248 | √ | √ |
| BCT04b | 683848 | 5506212 | √ | √ |
| BCT04c | 683222 | 5507459 | √ | × |
| BCT05 | 684636 | 5507128 | √ | × |
| BCT06 | 684563 | 5507445 | √ | × |
| BCT07 | 684371 | 5508212 | √ | √ |
| BCT08 | 684020 | 5508709 | √ | √ |
| BCT09a | 683006 | 5509253 | √ | √ |
| BCT09b | 681761 | 5509331 | √ | × |
| BCT09c | 681482 | 5508527 | √ | × |
| BCT10 | 682994 | 5510178 | √ | √ |
| BCT12 | 681853 | 5510942 | √ | × |
| BCT13 | 681838 | 5510087 | √ | √ |
| BCT14 | 682118 | 5511115 | √ | √ |

Note: “x” denotes a site that was targeted for fish inventories but fish inventories were not conducted due to insufficient flow or lack of a defined channel.

### A1.2.1 Aquatic Habitat Assessments

Aquatic habitat information was collected at the locations indicated in Table A1.2 and Figure A1.1. If conditions permitted, the target length of watercourse on which to conduct the aquatic habitat assessments was 300 m at each location. Habitat assessment information that was collected consisted of substrate and stream cover, channel morphology, wetted and channel width; maximum depth (widths (±0.10 m) and depths (±0.01 m) were measured with an Eslon fiberglass tape); overhead and instream cover, substrate (dominant and subdominant particle size), and any signs of disturbance.

Photographs of each site were taken and notes regarding any barriers were made. Potential barriers were photographed, marked with GPS coordinates and evaluated using professional judgment as to whether they were a permanent or seasonal barrier. Any barriers encountered while travelling between sampling locations were also noted.

### A1.2.2 Fish Inventories

Fish inventories were conducted in August 2014 at ten locations in the Blairmore Creek watershed at locations upstream from Blairmore Falls (Table A1.2, Figure A1.1). Sample locations were based on streams visible on a 1:50,000 NTS map and were chosen to maximize the coverage within the watershed and the Project footprint.

A Fisheries Research License (14-2724 FRL) was obtained from AESRD prior to fish inventory activities. Each fish inventory site indicated in Table A1.2 was visited and a determination made if fish capture via backpack electrofishing was possible (i.e., sufficient water depth >0.10 m, defined channel). If conditions permitted, the target length of watercourse to sample was 300 m at each location. In addition to aquatic habitat information described in Section A1.2.1 the following additional habitat information was obtained:

- *in situ* measurements of water temperature (±0.01°C), pH (±0.01 pH units), and specific conductivity (±0.01 µS/cm) were collected from just below the water surface using a hand-held Hanna multi-meter (model 98129). The concentration of dissolved oxygen (DO; ±0.1 mg/L) was measured using a Winkler titration kit (Lamotte 5860);
- Depth at 25%, 50% and 75% of the wetted width;
- Average velocity across the channel;
- Maximum depth of all pools found; and
- Slope of the channel.

In addition, the actual location of electrofishing at each site was taken using a Garmin GPS unit and digital range finder and accounted for sinuosity of the watercourse.

All captured fish were identified to species, and weighed with a digital Ohaus scale (±0.01 g) and measured for fork length with a fish measuring board (±1 mm). Fish identified as cutthroat trout were selected for collection of genetic samples for laboratory testing. As per the requirements of the FRL for genetic testing, and with additional instructions from AESRD (Coombs, Personal Communication, 2014), a 5 $mm^2$ piece of caudal fin was removed from each fish using a pair of surgical scissors and stored in absolute ethanol in a screw-top cryogenic vial. Each vial was labelled with the date, species, fork length and location of capture of the fish, and samples were submitted to AESRD for genetic analysis. All fish were released near their original point of capture. The target number of fish for genetic testing at each location was 30 individuals. A total of 170 samples of genetic material from five sites was collected and submitted to AESRD in October 2014. Not all sites were sampled for genetic material due to some of the sites being in close proximity to each other and not separated by a known or suspected barrier (e.g. BCT10 and BC02). In that case, it was assumed that the genetic sample from one site could be applied to the adjacent site and only fish community data was collected.

## A1.3 OCTOBER 2014 BENTHIC INVERTEBRATE AND PERIPHYTON SURVEYS

### A1.3.1 Benthic Invertebrate Communities

Benthic invertebrate communities and associated periphyton abundance were sampled on October 8 and 9, 2014 at a number of locations at which water quality samples were collected as part of the water quality baseline. Five samples were collected from each location listed in Table A1.3 and Figure A1.1, for a total of 30 samples. Four locations are in the Local Study Area (LSA), and two locations are in the Regional Study Area (Figure A1.1). Sampling methods followed those outlined in (Alberta Environment, 1990), (Environment Canada, 1993) and (Hatfield Consultants, 2014) using a Hess cylinder (0.093 $m^2$ and 210 µm mesh). Sampling areas were contained within 20 m upstream and downstream of the site coordinates (Table A1.3) and were not adjacent to any tributaries. Once collected, samples were transferred to 200 mL glass jars and immediately preserved in 95% ethanol.

Benthic invertebrate samples were sorted and identified to lowest practical level by Kilgour and Associates in Ottawa, Ontario. Samples were sieved in the laboratory using a 250 µm mesh to remove any remaining sediment.

**Table A1.3 Locations of benthic invertebrate community and associated periphyton sampling.**

| Site Name | Description | UTM Easting | UTM Northing |
|---|---|---|---|
| **Local Study Area** | | | |
| UNC-W01 | Unnamed Tributary to Blairmore Creek | 683748 | 5507115 |
| BLC-W01 | Blairmore Creek (lower) | 683624 | 5499170 |
| BLC-W02 | Blairmore Creek (upper) | 683309 | 5509186 |
| GOC-W01 | Gold Creek (lower) | 687705 | 5497354 |
| **Regional Study Area** | | | |
| CRR-W01 | Crowsnest River (upstream of Blairmore Creek) | 684254 | 5498614 |
| CRR-W02 | Crowsnest River (downstream of Blairmore Creek) | 681055 | 5500602 |

### A1.3.2 Periphyton

Periphyton was collected from each location where benthic invertebrates were sampled (Table A1.3). Individual samples were collected from three randomly-selected rocks (>100 mm) collected from depths between 0.2 m to 0.4 m within erosional areas of each sampling site (Table A1.3) for a total of 18 samples. A measured area of 0.00385 $m^2$ was collected from rock surfaces using a blade and forceps. Due to the depth and velocity of the Crowsnest River, health and safety concerns meant that rocks were selected from the right-downstream side of the channel. Samples were stored in 5.0 mL, polypropylene, sterile cryogenic vials and immediately frozen in the dark until the time of analysis. ALS Laboratories (Calgary, Alberta) conducted the chlorophyll *a* analyses.

## A1.4 FEBRUARY 2015 WINTER FLOW SURVEYS IN PROJECT-AFFECTED TRIBUTARIES OF GOLD CREEK

In February 2015, the watercourses at the locations in the Gold Creek watershed noted in Table A1.4 (with the exception of GCT14, which could not be accessed due to deep snow pack) were assessed at a road crossing (Figure A1.1) where full water quality sampling was being conducted for the water quality baseline for the presence of flowing water, barriers to fish migration at the culverts under the road, and, where conditions allowed, *in situ* water quality measurements.

## A1.5 JUNE 2015 AQUATIC HABITAT ASSESSMENTS IN GOLD AND BLAIRMORE CREEK WATERSHEDS

Aquatic habitat assessments were conducted in June, 2015 on the six Project-affected tributaries of Gold Creek and three of the four Project-affected tributaries of Blairmore Creek (Table A1.4, Figure A1.1).

**Table A1.4 Aquatic Habitat Assessment Locations in Project-Affected Tributaries of Gold and Blairmore Creek, June 2015.**

| Site | UTM Easting | UTM Northing |
|---|---|---|
| GCT06 | 687355 | 5503970 |
| GCT08 | 687770 | 5505665 |
| GCT09 | 687370 | 5507030 |
| GCT10 | 687313 | 5508048 |
| GCT11 | 687629 | 5508713 |
| GCT14 | 686772 | 5510087 |
| BCT05 | 684636 | 5507128 |
| BCT06 | 684563 | 5507445 |
| BCT07 | 684371 | 5508212 |

Habitat assessment information that was collected consisted of substrate and stream cover, channel morphology, wetted and channel width; maximum depth (widths (±0.10 m) and depths (±0.01 m) were measured with an Eslon fiberglass tape); overhead and instream cover, substrate (dominant and subdominant particle size), and any signs of disturbance, *in situ* measurements of water quality, depth at 25%, 50% and 75% of the wetted width, average velocity across the channel, and slope of the channel.

Photographs of each site were taken and notes regarding any barriers were made. Potential barriers were photographed, marked with GPS coordinates and evaluated using professional judgment as to whether they were a permanent or seasonal barrier. Any barriers encountered while travelling between sampling locations were also noted.

## A1.6 AUGUST 2015 AQUATIC HABITAT SURVEYS OF GOLD CREEK AND PROJECT-AFFECTED TRIBUTARIES OF GOLD CREEK

In August 2015, aquatic habitat surveys were conducted of the Gold Creek mainstem from the barrier to above the confluence of GCT14, as well as of the six Project-affected tributaries of Gold Creek from their confluence with Gold Creek until either the stream gradient became too great for the watercourse to be good fish habitat or the steep terrain made additional surveys on the watercourse impossible (Figure A1.1).

Fish habitat sampling followed the methods outlined in Alberta Transportation's Fish Habitat Manual (Alberta Transportation, 2009) with the objective of creating a habitat map of each watercourse. The habitat map was supplemented with channel measurements at periodic intervals. The length of interval was determined by the size of the watercourse and frequency at which habitat changed. Measurements taken were:

- Channel and wetted width;
- Depth at 25%, 50% and 75% of the wetted width;
- Average velocity across the channel;
- Maximum depth of all pools found;
- Slope of the channel;
- Location and height of any suspected barriers to fish passage; and
- Substrate and cover.

Photos were taken where channel measurements were made and any areas of disturbance were noted on the habitat map or in the field note book.

# Appendix A2

# Benthic Invertebrate and Periphyton Data

**Table A5.1 Benthic Invertebrate Data.**

| Area | CRR | | | | | CRR | | | | | BLC | | | | | BLC | | | | | GOC | | | | | UNC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | W01 | W01 | W01 | W01 | W01 | W02 | W02 | W02 | W02 | W02 | W01 | W01 | W01 | W01 | W01 | W02 | W02 | W02 | W02 | W02 | W01 | W01 | W01 | W01 | W01 | W01 | W01 | W01 |
| replicate | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 3 | 4 | 5 |
| DATE | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.08 | 14.10.08 | 14.10.08 |
| % subsampled | 100 | 100 | 50 | 50 | 50 | 100 | 50 | 50 | 50 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 100 | 50 | 50 | 100 | 50 | 50 | 100 | 50 | 100 | 100 |
| TAXA LIST | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **ANNELIDA:OLIGOCHAETA** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ENCHYTRAEIDAE: | 12 | 26 | 11 | 5 | 51 | | | 2 | 19 | 11 | 3 | 3 | 1 | | | | | 3 | 1 | | | | | | | | | |
| LUMBRICIDAE (juveniles) | 3 | 1 | | | 1 | | | 1 | 2 | 3 | 2 | 1 | 2 | | | | | | | | | | | | | | | |
| *Eiseniella tetraedra* | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| LUMBRICULIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhynchelmis* | | | | | | | | | | | 7 | | 13 | | 1 | | | | | | 16 | 28 | 31 | 18 | 86 | | | |
| NAIDIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nais spp.* | 3 | | | 1 | 1 | 56 | 15 | 19 | 4 | | | | | | | | | | 1 | | | | | | | | | |
| TUBIFICIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Immature With Hairs | | | | | | 2 | | 4 | | 3 | 2 | 1 | | | | 11 | 4 | 1 | | | | | | | | | | |
| **ACARINA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ATURIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Aturus* | | | 2 | 1 | 1 | 2 | | 1 | 1 | 3 | | 2 | 1 | 1 | | | 1 | 6 | 2 | 1 | | | | | | | | |
| HYDRYPHANTIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Protzia* | | | | | | | 1 | | | 2 | | | | | | 1 | | | | | | | | | | | | |
| *Wandesia* | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| LEBERTIIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lebertia* | 4 | 1 | 2 | | | 5 | 3 | 6 | | 6 | | 6 | 8 | 9 | 4 | | | | | | 3 | | 1 | 2 | 2 | | | |
| PIONIDAE: | | | | | | | | | | | | 1 | | | | | | | | | | | | 1 | | | | |
| TORRENTICOLIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Testudacarus* | | 1 | | | | | | | | 2 | 1 | | | | | | | | | | | | | | | | | |
| **INSECTA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **COLEOPTERA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DYTISCIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Liodessus* | 1 | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| ELMIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Narpus concolor* | | | | | | | | 2 | 1 | 2 | 1 | | | | | | | | | | | | | | | | | |
| *Optioservus* | 5 | 5 | 4 | 3 | 3 | 19 | 27 | 29 | 9 | 66 | 21 | 18 | 45 | 15 | 21 | 22 | 49 | 12 | 22 | 15 | 3 | | 3 | 7 | 15 | 31 | 66 | 31 |
| **COLLEMBOLA:** | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | |
| SMINTHURIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Sminthurides* | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | |
| **DIPTERA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CERATOPOGONIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bezzia/Palpomyia* | | | | | | | | | | | 4 | 2 | | 1 | 4 | | | | 2 | | | | | | | | | |
| CHIRONOMIDAE:CHIRONOMINAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Microtendipes* | | | | | | 3 | | 2 | | | | | | | | | | | | | | | | | | | | |
| *Micropsectra* | | | | | 1 | 6 | 10 | 17 | 1 | 18 | 4 | 6 | 6 | 4 | 3 | | 39 | 3 | 8 | 12 | 1 | 1 | 1 | 1 | 6 | 2 | 1 | 3 |
| *Polypedilum* | 19 | 97 | 61 | 38 | 68 | 3 | 11 | 10 | 20 | 8 | 46 | 31 | 46 | 7 | | | | 5 | | | 1 | 4 | | 1 | | | | |
| *Rheotanytarsus* | 4 | | 7 | | 17 | 19 | 29 | 32 | 2 | 26 | 9 | 9 | 16 | 6 | | 6 | 130 | 9 | 4 | 47 | 1 | | | | | | | |
| *Stempellina* | | | | | | | | | | | | | | | | 1 | 16 | | | 5 | | | | | | | | |
| *Sublettea/Tanytarsus* | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| CHIRONOMIDAE:DIAMESINAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Diamesa* | | 9 | 3 | 12 | 2 | 161 | 48 | 44 | 26 | 413 | 7 | 11 | 5 | 2 | 1 | | | | 2 | | 12 | 4 | 6 | 19 | 1 | | 3 | 1 |
| *Pagastia* | | | | | | | 1 | 1 | | 8 | | | | | | | | | | | | | | | | | | |
| *Potthastia longimana* | | | | | | | | 2 | | | | | | | | | | | | | | | | | | | | |
| CHIROOMIDAE:ORTHOCLADIINAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Corynoneura* | | | | | | | | | | | | | | | | 2 | 2 | 1 | 1 | 1 | | | | 4 | | | | 1 |
| *Cricotopus* | | | | | | 114 | 48 | 110 | 8 | 281 | 5 | 12 | 28 | 32 | 16 | 1 | | 3 | 4 | 2 | 10 | 4 | | 4 | | 4 | 7 | 4 |
| *Eukiefferiella* | 18 | 19 | 14 | 34 | 27 | 9 | 10 | 27 | 30 | 211 | 4 | | | | | | | | | | | | | | | 8 | 12 | 10 |
| *Heterotrissocladius* | | | | | | | 1 | | | | | | | | 1 | | | | | | | | | | | | | |
| *Paraphaenocladius* | 2 | 4 | 3 | 3 | 5 | 3 | 1 | | 4 | | | | | | | | 23 | 5 | 3 | 5 | | | 1 | 1 | 1 | 1 | 3 | 2 |
| *Rheocricotopus* | | 2 | | 1 | 5 | | | | | | | | | | | | | | | | | 3 | | | 7 | 2 | | 1 |
| *Tvetenia* | | | | 4 | | | 1 | | | | 1 | | | | | | | | | | | 5 | 1 | 18 | 5 | | 4 | |
| CHIRONOMIDAE:PRODONOMINAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Boreochlus* | | | | | 1 | | | | | | 1 | | | | | | | 17 | | | | | | | | | | |
| CHIRONOMIDAE:TANYPODINAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ablabesmyia* | | | | | | | | | | | | | | | | 2 | 6 | 1 | | 2 | | | | | | | | |
| *Conchapelopia/Helopelopia* | 1 | 1 | 3 | 2 | | 3 | 2 | 5 | | | 7 | 7 | 22 | 10 | 6 | 1 | | | | | | | | | | | | |
| DOLICHOPODIDAE: | | 11 | 1 | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| EMPIDIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chelifera/Metachela* | | | | | | | | | | | 3 | 1 | 3 | 3 | 4 | | | | | | 3 | | 1 | | 1 | | 1 | |
| *Hemerodromia* | | | | | | 1 | | | | | 1 | | | 1 | | | | | | | | | | | | | | |
| *Oreogeton* | | | | 2 | 2 | 8 | 3 | 7 | | 5 | | | | | 1 | 1 | 1 | | 1 | | | | | | | | | |
| PELECORHYNCHIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Glutops* | | 3 | | | 1 | | | | | | | 2 | 1 | 1 | 1 | | | | | | 1 | | 2 | 4 | 1 | | | |
| PSYCHODIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pericoma* | | | | | | | 1 | | | | 2 | 4 | 7 | 2 | 2 | 1 | 29 | 6 | 18 | 5 | 8 | 7 | 7 | 8 | 8 | | | 1 |
| SIMULIIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Simulium* | | 1 | 1 | 3 | | | | | 4 | 2 | 6 | 2 | | | | | | | | | 1 | 1 | 2 | | 1 | | | |
| TIPULIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Antocha* | | 1 | 11 | 5 | 5 | 46 | 19 | 33 | 10 | 58 | 5 | 1 | 4 | 2 | 3 | | | | | | | | | 1 | | | | |
| *Dicranota* | 1 | 2 | | | | | | | | 1 | 1 | | | 1 | | 1 | 8 | 1 | 1 | 2 | | | 1 | | | 1 | | 1 |
| *Hexatoma* | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| *Pseudolimnophila* | | | | | | | | | | | | | | | | | 1 | 1 | | 1 | | | | | | | | |
| *Tipula* | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | | | | | | | | |

| Area | CRR | | | | | CRR | | | | | BLC | | | | | BLC | | | | | GOC | | | | | UNC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | W01 | W01 | W01 | W01 | W01 | W02 | W02 | W02 | W02 | W02 | W01 | W01 | W01 | W01 | W01 | W02 | W02 | W02 | W02 | W02 | W01 | W01 | W01 | W01 | W01 | W01 | W01 | W01 |
| replicate | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 3 | 4 | 5 |
| DATE | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.08 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.09 | 14.10.08 | 14.10.08 | 14.10.08 |
| % subsampled | 100 | 100 | 50 | 50 | 50 | 100 | 50 | 50 | 50 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 100 | 50 | 50 | 100 | 50 | 50 | 100 | 50 | 100 | 100 |
| TAXA LIST | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **EPHEMEROPTERA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AMELETIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ameletus* | | | | | | | | | | | | | | | | 1 | 8 | | 3 | 1 | 1 | | | 4 | | | | 5 |
| BAETIDAE:(early instars) | 196 | 246 | 211 | 170 | 183 | 296 | 339 | 192 | 434 | 183 | 285 | 139 | 153 | 54 | 13 | 54 | 119 | 24 | 77 | 45 | 39 | 24 | 9 | 52 | 24 | 18 | 53 | 38 |
| *Acentrella* | 1 | | 1 | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | |
| *Baetis* | 2 | 2 | 1 | 1 | 1 | 3 | 2 | 3 | 5 | 4 | 3 | 2 | 5 | | | | 1 | | | | 2 | 1 | | | 3 | | | |
| EPHEMERELLIDAE:(early instars) | 6 | 4 | 6 | 3 | 7 | 14 | 11 | 15 | 15 | 29 | 7 | 37 | 14 | 1 | 3 | 6 | | | | | 25 | 28 | 25 | 40 | 38 | 18 | 48 | 33 |
| *Caudatella* | | | | | | | | | 1 | | | | | | | | | | | | 1 | | | 4 | | | | |
| *Drunella doddsi* | 3 | 2 | 1 | 1 | 1 | | | | 5 | 1 | 1 | 2 | 1 | | | | | | | | 1 | 13 | 9 | 10 | 10 | | | |
| *Drunella grandis ingens* | | | 1 | 1 | | 2 | | | 2 | 1 | | | | 2 | 1 | | | | | | | | | | | | | |
| *Ephemerella* | | 1 | | 1 | 1 | | | | 1 | | | | 9 | 4 | 3 | 9 | 32 | 3 | 10 | 9 | | | | | | | 8 | 1 |
| *Seratella* | | | | | | 8 | 7 | 33 | 1 | | | | | | | | | | | | | | | | | | | |
| HEPTAGENIIDAE:(early instars) | 24 | 17 | 4 | 23 | 24 | 15 | 12 | 21 | 4 | 5 | 86 | 46 | 79 | 15 | 9 | 7 | 1 | 1 | 12 | | 13 | | | | | 3 | 35 | 33 |
| *Epeorus* | | | | | | | | | | | | | | | | | | | | | 1 | 16 | 4 | | 8 | | | |
| *Heptagenia* | | | | | | 1 | | 1 | 4 | | 3 | 19 | 14 | 2 | 2 | 2 | 25 | | 14 | 26 | 16 | 46 | 45 | 101 | 88 | 7 | 13 | 22 |
| *Rhithrogenia* | 13 | 1 | | 9 | 1 | 1 | 1 | | 3 | 2 | 18 | 1 | | | | | 1 | | 1 | | 6 | 17 | 29 | 28 | 40 | 7 | 1 | |
| LEPTOPHLEBIIDAE:(early instars) | | | | 1 | 1 | 1 | 1 | 1 | | 2 | | | | | | 3 | | | | | | | | | | | | |
| *Paraleptophlebia* | | | | | | 1 | | | | | | | | | | 9 | 80 | 2 | 17 | 31 | | | | | | | | |
| **PLECOPTERA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CAPNIIDAE:(early instars) | 6 | 7 | 1 | | 2 | | | 1 | 1 | 2 | 45 | 20 | 20 | 3 | 8 | 29 | 38 | 16 | 44 | 7 | 1 | 2 | 1 | 1 | 4 | 16 | 79 | 46 |
| *Isocapnia* | | | | | | 2 | 1 | | | | 3 | | | | | | | | | | | | | | | | | |
| CHLOROPERLIDAE:(early instars) | 5 | 3 | 1 | 1 | 3 | | | 6 | | | 4 | 4 | | 5 | 3 | 14 | 59 | 44 | 53 | 34 | 8 | 10 | 11 | 5 | 39 | 5 | 61 | 20 |
| *Alloperla* | | | | | | | | | | | | | 1 | 2 | 5 | 4 | 20 | 6 | 7 | 2 | 1 | 19 | 12 | 12 | 8 | 4 | 22 | 8 |
| *Hastaperla bevis* | 10 | 9 | 1 | 4 | | 1 | 13 | 22 | 16 | 13 | 18 | 32 | 70 | | 2 | | 7 | | 1 | | | | | | | | 1 | |
| LEUCTRIDAE:(early instars) | | | | | | | | | | | | | | | | | 2 | | 5 | 2 | | 1 | | | | | | |
| *Paraleuctra* | 6 | 6 | | | 1 | | | 2 | 4 | 1 | 13 | 8 | 5 | 1 | 5 | | 1 | 10 | | | | 2 | 5 | 2 | 16 | | 5 | 7 |
| NEMOURIDAE:(early instars) | 17 | | 12 | 13 | 19 | 5 | 5 | 2 | 3 | 1 | 161 | 277 | 325 | 124 | 25 | 3 | 1 | 4 | 25 | 1 | 57 | 64 | 5 | 98 | 43 | 10 | 33 | 15 |
| *Malenka* | 9 | | 2 | 7 | 5 | 1 | | | 6 | 7 | 49 | 48 | 55 | | | | 9 | 14 | 24 | 1 | 5 | 5 | | 4 | 2 | | | |
| *Zapada haysi* | | | | | | 2 | | | 1 | 5 | | | | | | 1 | 1 | | | 2 | 9 | 18 | 3 | 15 | 5 | | 5 | 6 |
| PELTOPERLIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Yoraperla* | | | | | | | | | | | | | | | | 4 | 3 | 7 | 8 | 4 | | | | | | | | |
| PERLIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | 3 | | | |
| *Acroneuria abnormis* | | | | | | | | | | | 1 | 3 | 17 | 1 | | | 1 | 4 | 2 | | | 1 | | 3 | 1 | | 7 | |
| *Calineuria californica* | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| *Hesperoperla pacifica* | | | 1 | 2 | 5 | 6 | 14 | 11 | 6 | 30 | 13 | | | | | | | | | | | | | | | | | |
| PERLODIDAE: | | | | | | | | | | | | | | | | | | | | | 4 | | | 9 | | | 2 | 2 |
| *Isoperla* | 5 | 3 | 4 | 5 | 3 | 5 | 4 | 3 | 7 | 14 | 7 | 10 | 25 | 1 | 2 | 2 | 7 | | 3 | 7 | 2 | 1 | 1 | | | 1 | | |
| *Megarcys* | | | | | | | | | | | | | | | | | | | | | 2 | | | 3 | | 1 | 3 | |
| TAENIOPTERYGIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Taenionema* | | | | | | | | | | | | | | | | | | | | | 2 | 28 | 49 | 6 | 97 | | | |
| **TRICHOPTERA:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BRACHYCENTRIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Brachycentrus* | 7 | 1 | 8 | 8 | 1 | 3 | 5 | 3 | 2 | 3 | 2 | | | | | | | | | | | | | | | | | |
| *Micrasema* | 1 | 13 | 2 | 4 | 1 | 32 | 7 | 26 | 4 | 22 | 6 | 31 | 46 | 24 | 7 | | | | | | | | | 1 | | 2 | 1 | 6 |
| GLOSSOSOMATIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Glossosoma* | | 1 | | | | | | | | 1 | | | | | | 1 | | | 1 | 1 | | | | | | | 3 | |
| HYDROPSYCHIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Arctopsyche grandis* | 17 | 5 | 16 | 33 | 15 | | 1 | 2 | 69 | 5 | 38 | 7 | 11 | 2 | | | | | | | | | | | | | | |
| *Hydropsyche* | 7 | 2 | 4 | 2 | 3 | 1 | | | 10 | 2 | 14 | | | | | | | | | | | 2 | 1 | | | | | |
| *Parapsyche elsis* | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 2 | 7 | 5 | | | |
| HYDROPTILIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Hydroptila* | | | | | | 6 | 1 | 6 | | 1 | | | | | | | | | | | | | | | | | | |
| LEPIDOSTOMATIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lepidostoma* | 13 | 11 | 12 | 3 | 2 | 13 | 2 | 1 | | | | | | | | | | | | | | | | | | 3 | | |
| RHYACOPHILIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhyacophila* | 8 | 8 | 9 | 6 | 3 | 7 | | 2 | 3 | 9 | 3 | 3 | 2 | | 1 | 3 | 5 | 2 | 3 | 1 | 5 | 7 | 3 | 6 | 6 | 5 | 10 | 7 |
| UEONIDAE: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Neothremma* | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 2 |
| **NEMATODA:** | | 1 | 2 | 1 | 2 | | 5 | 6 | 10 | 5 | 1 | 1 | 3 | | 1 | | 1 | 2 | 1 | 2 | 2 | 2 | | 11 | 1 | | 1 | |
| **PLATYHELMINTHES:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PLANARIIDAE: | 1 | 3 | | | | 1 | | 1 | 5 | 3 | | | 1 | | | 17 | 9 | 4 | 22 | 6 | 18 | 36 | 13 | 22 | 22 | 1 | 2 | 1 |
| TOTAL TAXA | 35 | 39 | 36 | 39 | 40 | 43 | 39 | 46 | 43 | 48 | 49 | 40 | 38 | 33 | 33 | 34 | 39 | 32 | 38 | 33 | 38 | 34 | 32 | 39 | 36 | 23 | 33 | 29 |
| TOTAL NUMBERS | 531 | 632 | 476 | 468 | 530 | 988 | 715 | 769 | 817 | 1586 | 1026 | 912 | 1167 | 442 | 264 | 322 | 843 | 270 | 508 | 336 | 333 | 503 | 337 | 587 | 703 | 196 | 597 | 412 |