Appendix 5.1.2.6A
Fish and Aquatic Resources
2011 - 2012 Baseline Report
(Part 1 of 2)

Fish and Aquatic Resources 2011-2012 Baseline Report
Appendix 5.1.2.6A

newgold™

Blackwater Gold Project





June 2013 / AMEC VE52277

Blackwater Gold Project

Final

Fish and Aquatic Resources
2011-2012 Baseline Report

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ACRONYMS

Abbreviations and Units	Definition
%	percent
°C	degrees Celsius
µg	microgram
µg/cm^2	micrograms per centimetres squared
µm	micrometre
µS/cm	microSiemens per centimetre
AFS	Atomic Flourescence Spectrometry
Agency	Canadian Environmental Assessment Agency
Agra	Agra Earth & Environmental
ALS	ALS Environmental Services
AMEC	AMEC Environment & Infrastructure
ANOVA	analysis of variance
Avison	Avison Management Services Ltd.
BC	British Columbia
B-C	Bray-Curtis Similarity Index
BC CDC	British Columbia Conservation Data Centre
BC ILMP	British Columbia Integrated Land Management Bureau
BC MELP	British Columbia Ministry of Environment, Lands and Parks
BC MFLNRO	British Columbia Ministry of Forests, Lands and Natural Resource Operations
BC MOE	British Columbia Ministry of Environment
BC MOF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BEAST	Benthic Assessment of Sediment
Bio-Limno	Bio-Limno Laboratories Inc.
BMI	benthic macroinvertebrate
CABIN	Canadian Aquatic Biomonitoring Network
CALA	Canadian Association for Laboratory Accreditation
CanFor	Canadian Forestry Products Ltd.
Cbf	dominant cobbles, subdominant boulders and fines
Cbg	dominant cobbles, subdominant boulders and gravel
CCME	Canadian Council of Ministers of the Environment
cells/cm^2	cells per centimetres squared
CFIA	Canadian Food Inspection Agency
cm	centimetre

Abbreviations and Units	Definition
cm	centimetre
cm^2	centimetres squared
Cordillera	Cordillera Consulting
CPUE	catch-per-unit-effort
CV	coefficient of variation
CVAFS	Cold Vapour Atomic Fluorescence Spectrometry
D	Simpson's Diversity Index
$D_{1,2}$	Dominance Identity Index
DFO	Fisheries and Oceans Canada
D_l	shoreline development
DO	dissolved oxygen
D_p	index of precision
DQO	Data quality objective
D_s	Secchi depth
DWB	DWB Forestry Services Ltd.
EA	Environmental Assessment
EC	Environment Canada
EcoAnalysts	EcoAnalysts Inc.
EcoCat	Ecological Catalog
Ecofor	Ecofor Consultants Ltd.
EEM	Environmental Effects Monitoring
EF	backpack electrofishing
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FDIS	Fisheries Data Information System
Fg	dominant fines, subdominant gravels
FHAP	Fish Habitat Assessment Procedures
FI	Food Ingestion rate
FIDQ	Fisheries Inventory Data Query
FISS	Fisheries Inventory Summary System
FoD	frequency of detection
FRGB	2005 Fraser River - Georgia Basin Model
FSR	Forest Service Road
FWA	Freshwater Watershed Atlas
g	gram
Gbf	Dominant gravels, subdominant boulders and fines
Gf	dominant gravels, subdominant fines
GIS	Geographic Information System

Abbreviations and Units	Definition
Golder	Golder Associates Ltd.
GPS	Global Positioning System
GSI	gonadosomatic index
H'	Shannon's diversity index
ha	Hectare
HADD	harmful alteration, disruption, or destruction
HBI	Hilsenhoff biotic index
HDMS	Hybrid Multidimensional Scaling
HN	hoop netting
HR-ICP-MS	High Resolution-Inductively Coupled Plasma-Mass Spectroscopy
HSI	hepatosomatic index
ICP-MS	Inductively Coupled Plasma-Mass Spectroscopy
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrophotometry
ID	identification
ILP	Interim Locational Point
ITIS	Integrated Taxonomic Information System
J	Pielou's Evenness index
k	light extinction coefficient
kg	kilogram
km	kilometre
km^2	kilometres squared
Knight Piésold	Knight Piésold Ltd.
kV	kiloVolt
LiDAR	Light Detection and Ranging
LRDW	Land and Resource Data Warehouse
LRMP	Land and Resource Management Plan
LSA	Local Study Area
LWD	large woody debris
m	metre
m/s	metres per second
m^2	metres squared
m^3	cubic metres
masl	metres above sea level
MDL	Method detection limit
mg	milligram
mg/kg wwt	milligrams per kilogram wet weight
mg/L	milligrams per litre

Abbreviations and Units	Definition
mL	millilitre
mM	millimolar
mm	millimetre
MMER	*Metal Mining Effluent Regulations*
MN	minnow trapping
n	number of samples
n.d.	no data
n/a	not applicable/available
NABS	North American Benthological Society
NAD	North American datum
NC	not calculated
NCD	non-continuous drainage
ND	not detected
North/South	North/South Consultants Inc.
NTU	Nephelometric turbidity unit
NVC	no visible channel
O:E	observed and expected taxa
OBBN	Ontario benthos biomonitoring network
PAST	Paleontological Statistics publicly available “free-ware” statistics software
PCA	Principal component analysis
PCR	Polymerase chain reaction
Project (the)	proposed Blackwater Gold Project
proponent (the)	New Gold Inc.
QA/QC	Quality Assurance/Quality Control
R^1	coefficient of determination
RCA	Reference Condition Approach
Rho	Spearman’s rho, a rank correlation coefficient
RISC	Resource Inventory Standards Committee
RIVPACS	River Invertebrate Prediction and Classification System
RPD	relative percent difference
RSA	Regional Study Area
S	taxa richness
SD	standard deviation
SE	standard error
S_{Eff}	sorting efficiency
SOP	Standard Operating Procedure

Abbreviations and Units	Definition
SWD	small woody debris
TDI	Tolerable Daily Intake
TK	Traditional knowledge
TRG	Tissue Residue Guideline
Triton	Triton Environmental Consultants Ltd.
TSF	Tailings Storage Facility
TU	Traditional use
UBC	University of British Columbia
US	United States
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
WSC	Water Survey of Canada
wt	wet
wwt	wet weight
YOY	young-of-the-year
$Z_{1\%}$	euphotic depth
Z_{avg}	mean depth
Z_{max}	maximum depth
Z_r	relative depth

EXECUTIVE SUMMARY

This report describes the fish, fish habitat, and aquatic resources in streams and lakes near New Gold Inc.'s (proponent) proposed Blackwater Gold Project (Project). The proposed Project is located on the Nechako Plateau, approximately 110 kilometres (km) southwest of Vanderhoof in central British Columbia (BC). The report describes the results of field surveys conducted in 2011 and 2012.

The overall objectives of the baseline studies were to:

- Characterize fish communities and aquatic resources in streams and lakes potentially affected by the Project to identify potential interactions and opportunities for mitigation, and to support an application for an Environmental Assessment (EA) Certificate;
- Provide baseline data that will support future environmental effects monitoring programs; and
- Quantify fish habitat (and its quality or productive capacity) potentially affected by the Project so that a fish habitat compensation plan can be developed to meet Fisheries and Oceans Canada's "no-net-loss" guiding principle.

Baseline studies focused on the Local Study Area (LSA), which surrounds the proposed mine site. The LSA contains five watersheds. The Davidson Creek Watershed will be the location of the greatest intensity of sampling and survey work because most mine infrastructure will be built in that watershed. Davidson Creek flows from the slope of Mount Davidson north-east to lower Chedakuz Creek. North of Davidson Creek and roughly parallel to it, is Turtle Creek, which also flows to lower Chedakuz Creek. South of Davidson Creek is Creek 661, which flows north-east into middle Chedakuz Creek upstream of Tatelkuz Lake. Between Davidson Creek and Creek 661 watersheds is the Tatelkuz Lake Tributaries Watershed, which drains to Tatelkuz Lake. The Creek 705 Watershed drains the south-east side of Mount Davidson and flows into Fawnie Creek.

The LSA contains one large lake – Tatelkuz Lake – and four headwater lakes: Lake 01682LNRS in the Davidson Creek Watershed; lakes 01538UEUT and 01428UEUT in the Creek 705 Watershed; and Snake Lake in the Tatelkuz Lake Tributaries Watershed.

The Regional Study Area (RSA) encompasses the whole of the Chedakuz Creek Watershed and part of the Fawnie Creek Watershed. It includes Kuyakuz Lake and all tributaries to that lake, middle Chedakuz Creek between Kuyakuz Lake and Tatelkuz Lake, and all tributaries to that stretch of the creek, lower Chedakuz Creek downstream to the confluence of Turtle Creek, and upper Fawnie Creek Watershed, including Top Lake and Laidman Lake.

The Project infrastructure also includes a 133 km-long, 230-kilovolt (kV) transmission line that will run from the mine site to BC Hydro's Glenannon Substation near Fraser Lake, and a

194-km long access road, which will follow a network of Forest Service Roads (FSRs) originating at the community of Engen, approximately 20 km west of Vanderhoof. Streams crossed by both corridors were surveyed for fish and fish habitat in 2012.

A literature review and data gap analysis was conducted early in 2011, and a baseline study plan was developed to fill those data gaps. The results of the studies conducted in 2011 and 2012 are summarized here. They are reported in greater detail in the main text of the report and its appendices. The results begin with stream temperatures and then proceed up the aquatic food chain from periphyton to benthic macroinvertebrates (BMI) in streams, and from phytoplankton, to zooplankton and BMI in lakes. The quantity and quality of fish habitat is described and then fish species diversity, population structure, relative abundance, and biological characteristics.

Temperature data loggers were installed at five stream sites in the LSA in spring 2011 and at an additional three sites in spring 2012. Stream temperatures were also recorded at five hydrometric sites, for a total of 13 data loggers operating by the end of 2012. Their records showed that in both years, mean daily temperatures rose from near 0°C in early April to a maximum of between 10°C and 22°C in mid-July and then fell to near 0°C in early November. In all seasons, mean daily stream temperatures exhibited a gradient of decreasing temperature with increasing elevation. Summer stream temperatures were higher in 2012 than in 2011.

Stream temperatures in the LSA and RSA fall below the BC Ministry of Environment (BC MOE) optimal temperature ranges for life history stages of rainbow trout (*Oncorhynchus mykiss*) and kokanee (*Oncorhynchus nerka*), the two most common fish species in the LSA and RSA. Hence, low temperatures rather than high temperatures limit aquatic biological processes in the LSA and RSA.

In 2011 and 2012, samples of periphyton and BMI were collected from 12 stream sites in the LSA and 2 reference stream sites outside the LSA. The purpose was to characterize the density, biomass, and taxonomic diversity of the lower trophic levels of stream ecosystems. Periphyton is a complex mix of algae, bacteria, and protozoans attached as a biofilm to submerged surfaces. It is the primary photosynthetic community in streams, and an important food source for BMI. One hundred and sixty samples of periphyton (80 for biomass and 80 for taxonomic analysis) were collected in 2011 and 2012.

Mean periphyton density and biomass (as indexed by chlorophyll *a* concentration) both showed substantial variation among sites, but different spatial distributions. The reason was differences in taxonomic composition. One site in lower Chedakuz Creek in 2011 had a mean biomass that approached the BC guideline for the protection of aquatic life in streams (10 $\mu g/cm^2$). This site is located adjacent to livestock pasture, so the high biomass probably reflects high nutrient concentrations from land run-off.

Only two sites, lower Davidson Creek (BI-01) and lower Creek 705 (BI-09), were sampled in both 2011 and 2012. Mean periphyton densities were higher in 2012 than in 2011 at both

sites, suggesting that growing conditions for periphyton were more favourable in 2012 than in 2011. This was likely due to higher water temperatures in 2012 than in 2011. Between-year variation in solar radiation may have played a role, but there has not been sufficient solar radiation data recorded from the Project area to test if there was lower cumulative radiation in 2011 than in 2012.

In both 2011 and 2012, most periphyton communities were dominated by diatoms and cyanobacteria. Diatoms were predominant at 10 of the 14 sites and cyanobacteria at the other four sites. Relatively high proportions of cyanobacteria in streams are generally associated with high nutrient concentrations.

Motile diatom species – species in the genera *Nitzschia, Navicula, Gyrosigma*, and *Surirella* – which serve as indicators of siltation, were present in the periphyton samples collected from the LSA. However, on average, motile diatoms comprised less than 50% of the total diatoms at all stream sampling sites in 2011, which does not indicate a high degree of siltation from past land use activities (e.g., logging) at these stream sampling sites. For the two sites sampled in both years, motile diatom species made up greater proportions of the periphyton community in 2012 than in 2011, indicating greater siltation in 2012 than in 2011.

Benthic macroinvertebrates (BMI) are a diverse group of animals living on or in the substrates of streams, wetlands, and lakes. They include protozoans, flatworms, nematodes, aquatic worms, crustaceans (i.e., ostracods, isopods, and amphipods), molluscs (i.e., snails and clams), and larvae of aquatic insects (i.e., mayflies, dragonflies, and blackflies). Many BMI feed on periphyton and so provide a link between primary production and fish. Fish species in the LSA and RSA do not feed directly on algae but instead feed on the larger, more energy-rich BMIs (and other fish).

The main objectives of sampling BMI in streams were to characterize BMI communities in the LSA and RSA and to collect the baseline information necessary to apply the Reference Condition Approach. That is, to compare the BMI community in the LSA and RSA to an appropriate undisturbed, reference condition – either the Fraser Georgia Basin Model 2005 or the Skeena Model 2010. This is the standard approach recommended by the Canadian Aquatic Biomonitoring Network (CABIN).

One hundred and fifteen BMI samples were collected with kick nets from late August to early September in 2011 and 2012 at the same stream sites and dates as were periphyton. Taxonomic analysis of those samples showed that Blackwater BMI communities vary significantly across years, across sites and within sites. Among-site variation is most pronounced, followed by interannual variation, while within-site variation is lowest.

Blackwater BMI communities closely reflect site conditions related to altitude, productivity (i.e., periphyton density and biomass), stream size, and the amount of silt in the stream. Accordingly, Blackwater sites break down into five statistically distinct BMI groups (A to E). Over half of the sites belong in one group (A) associated with moderate altitude, larger substrate, fast flows, and medium productivity. Another group of three sites are associated

with small, high altitude streams with low productivity (B). The remaining sites are unique and include lower Chedakuz and Lower Turtle Creek, which show signs of nutrient enrichment.

Blackwater stream BMI communities most closely resemble the Skeena Model 2010 reference condition rather than the Fraser Georgia Basin Model 2005.

Phytoplankton is a group of single-celled plants that live suspended in the water column of lakes. They are the dominant photosynthesizing organisms in lakes, and so form the base of the food chain. For that reason, their density (cells/m^3), biomass (µg/m^3 chlorophyll *a*), and taxonomic composition are used as measures of lake productivity. Phytoplankton was sampled with a van Dorn bottle in three headwater lakes in September 2012. A total of 25 biomass samples and 35 taxonomy samples were collected. Mean phytoplankton cell density and biomass were highest in Lake 01682LNRS (the headwater lake of Davidson Creek) and lowest in Lake 01538UEUT (one of two headwater lakes in the Creek 705 Watershed). Mean densities and biomasses were similar among depths in each of the three lakes.

Chrysophyta (i.e., golden algae and diatoms) was the predominant taxa in lakes 01428UEUT and 01538UEUT and in the surface and deep samples from Lake 01682UEUT, but Cryophyta was the predominant taxa below the thermocline of Lake 01628UEUT. Green algae (Chlorophyta) were present in all of the lakes, but never made up more than 29% of total the total number of cells in a sample. This species is a preferred food for higher aquatic organisms, so grazing may be one reason for its lack of numerical dominance. Blue-green algae (cyanobacteria) were not abundant in any of the samples, and dinoflagellates and euglenoids were uncommon to rare. Blue-green algae and dinoflagellates typically dominate the algal community in poor water quality environments, indicating that these lakes have good water quality. This conclusion was confirmed by the results of water quality sampling program – all nutrient concentrations in lake water samples were below guidelines for BC waters.

Phytoplankton species diversity was similar among lakes. There was a decrease in phytoplankton species diversity through the water column at Lake 01682LNRS, reflective of decreasing light levels with increased depth, but there were no vertical trends in diversity throughout lakes 01428UEUT and 01538UEUT, which are both shallower than Lake 01682LNRS.

Zooplankton is a group of invertebrates that live suspended in the water column of lakes. They feed on phytoplankton (and each other) and, in turn, are prey for many fish species, including rainbow trout and kokanee. Their density (organisms/m^3), biomass (i.e., mg/m^3), and taxonomic composition are used as measures of lake productivity and ecosystem health.

Zooplankton communities in the three headwater lakes were sampled at the same locations and dates as phytoplankton communities. A total of 15 samples were collected from the three lakes using 0.5 m-diameter plankton net with an 80 µm mesh size. Mean zooplankton density and biomass were highest in Lake 01428UEUT and lowest in Lake 01682LNRS. Both density and biomass were similar between Lake 01538UEUT and Lake 01682LNRS.

Lake 01428UEUT has the lowest Secchi depth (mean = 3.5 m) (i.e., highest turbidity), followed by Lake 01538UEUT (4.8 m) and Lake 01682LNRS (5.6 m). This suggests that zooplankton abundance in these headwater lakes is driven by lake morphometry and transparency. That is, shallow, turbid lakes composed mainly of littoral zone produce the most dense populations of zooplankton, and deep, clear lakes with lower percent littoral zone produce less dense populations.

Rotifers were the predominant taxon by density in all three lakes. In Lake 01428UEUT, copepods were the second most common taxon, and in Lake 01538UEUT ciliophors were the second most common group. Zooplankton species richness ranged from 9 to 16 taxa and mean richness was similar among lakes. Mean diversity index was highest for Lake 01682LNRS and lowest at Lake 01428UEUT – the opposite trend for density and biomass.

A total of 15 samples of BMI were collected with kick-nets from the littoral zones of three headwater lakes in September 2012, following the protocol of the Ontario Benthos Biomonitoring Network (the CABIN protocol applies only to stream BMI communities). Another 15 BMI samples were collected with an Ekman dredge from profundal habitat in the three lakes. All 30 samples were analyzed for taxonomic composition. Littoral BMI communities differed significantly among the three lakes, and individual replicates within lakes grouped together. Community structure was negatively correlated with Secchi depth – a similar finding to that of zooplankton. Lower water clarity in Lake 01428UEUT indicates higher productivity, which was reflected in Lake 0148UEUT's relatively abundant and rich littoral BMI community. (Similar results were found for zooplankton density and biomass). This lake also had the highest proportion of Ephemeroptera, Plecoptera, and Trichoptera (EPT) and the lowest percentage of Chironomids relative to the other two lakes.

Like the littoral BMI communities, profundal BMIs differed significantly among lakes. Lake 01428UEUT's profundal community was richer taxonomically, had higher or comparable abundance of most species compared to the other two lakes, and was dominated by *Pisidium* fingernail clams and Chironomids of the genus *Procladius*.

Variation among profundal BMI communities was negatively correlated with conductivity and positively correlated with dissolved oxygen (DO) concentration. Lake 01682NLRS had the highest levels of conductivity and the lowest DO concentrations (most likely because of its greater depth). Profundal zones of lakes 01428UEUT and 01538UEUT were more similar in terms of these two variables.

A total of 17 BMI samples were analyzed for concentrations of 41 total metals: 14 samples of stream BMI from each of 14 sites and three samples of littoral BMI from the three headwater lakes. The data were pooled and subjected to principal component analysis (PCA) to identify the major trends in the data matrix. PCA extracted three principal components that explained a total of 75% of the total variance.

The first component, PC1, explained 47% of the variance and was a "size" component – an index of the concentration of heavy metals in BMI tissue. There was no substantial variation

in PC1 among watersheds and among BMI taxonomic groups (A to E). Since BMI are fixed to the substrate, this indicates that the concentrations of metals in water and sediment to which BMI communities are exposed may not be substantially different among the watersheds of the LSA. The lack of difference in PC1 scores among the five taxonomic groups indicates that concentrations of metals in BMI tissue are not influenced by differences in the physical characteristics of habitat that drives taxonomic composition.

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

The second component, PC2, explained 19% of the variance and was significantly and positively correlated with 20 metals, of which arsenic had the highest correlation. PC2 scores showed no clear spatial trends nor did they show any trends with taxonomic group (A to E).

The third component, PC3, explained 9% of the variance and was most highly negatively correlated with potassium. PC3 scores decreased in a downstream direction in Davidson Creek, Turtle, Creek, and Creek 705, and, to a lesser extent, in Creek 661. Since PC3 was interpreted as the absence of potassium, these trends indicate trends of increasing potassium with downstream distance.

Surveys of stream fish habitat were conducted in 2011 and 2012 to identify, characterize, and quantify the available habitat for fish within the LSA, and at stream crossings along the transmission line corridor and the road access corridor. Two survey methods were used depending on stream size and location: Fish Habitat Assessment Procedures (FHAP) and Reconnaissance (1:20,000) Fish and Fish Habitat Inventories. The intensity of habitat surveying was highest in the proposed mine footprint and lower outside the footprint.

Level 1 FHAP surveys were completed at 32 sites in August 2011 and 2012, focusing on the mainstems of the streams that are located within or downstream of the Project mine site. These included reaches of Davidson Creek that are within the proposed mine site, as well as two major tributaries to Davidson Creek that are within the proposed mine site (creeks 688328 and 704454), Turtle Creek, Creek 661, and Chedakuz Creek.

Reconnaissance 1:20,000 fish habitat inventories were completed at a total of 113 stream sites, including 43 sites in all mainstem reaches of Davidson Creek, Turtle Creek, Creek 661, Creek 688328, Creek 704454, and Chedakuz Creek where FHAP surveys were conducted, plus an additional 42 sites in tributaries to Davidson Creek, 5 sites in the Creek 700 drainage (of the Turtle Creek Watershed), 14 sites in the Creek 661 Watershed, seven sites in the Creek 705 Watershed, and 13 sites in the Tatelkuz Lake Tributaries Watershed.

Reconnaissance 1:20,000 protocols were also used to assess additional sites surveyed during kokanee surveys in August and September of 2012. Four of five sites fell outside of

the five main watersheds, but within the Chedakuz Creek drainage. One site was part of the Tatelkuz Lake Tributaries Watershed.

The fish habitat data collected in 2011 and 2012 was combined with available data collected from reconnaissance 1:20,000 fish and fish habitat inventories conducted between 1997 and 2006 for the main drainages within the LSA. One hundred and seven sampling sites from this historical dataset were relevant to the main drainages of the LSA. This combined database allowed detailed habitat descriptions of all major streams in all watersheds of the LSA and some areas of the RSA. This included general watershed descriptions, identification of reach breaks, measurement of stream gradients, and habitat classification maps.

These habitat data showed a system typical of central BC interior – steep, sub-alpine headwater tributaries of poor quality habitat draining to lower gradient reaches of higher quality habitat that flow into large, overwintering lakes (e.g., Tatelkuz Lake).

Helicopter overflights of the LSA conducted in March 2012 and March 2013 (unpublished data) showed that the lower section (Reach 1) and the upper section (Reaches 10 to 12 plus Lake 01628LNRS) of Davidson Creek were covered with ice in both winters. Tributaries to the upper and middle sections of Davidson Creek were also covered with ice. However, in 2013 the middle section (Reaches 2 to 9) of Davidson Creek showed long areas of open water. These were probably caused by groundwater inflows. Lower Chedakuz Creek is the only stream in the LSA that remains open during winter.

In March 2012, 13 stream sites were visited to assess their potential as over-wintering fish habitat. Sites in Davidson Creek, Turtle Creek, Creek 661, Creek 705, and the Tatelkuz Lake Tributaries Watershed were chosen based on the presence of residual pools and beaver ponds. Sites were rated for over-wintering habitat quality based on the mean DO concentration and the optimal and lethal DO concentrations for rainbow trout reported in the scientific literature. Sites in the lower reaches of creeks tended to have good overwintering habitat (e.g., Davidson Creek mainstem, ponded section of Reach 1 of Turtle Creek, Reach 2 of Creek 705), but other sites at higher elevations were rated as poor (e.g., Creek 428073 in the Davidson Creek Watershed, Reach 2 of Turtle Creek, Reach 1 of Creek 571602 of the Tatelkuz Lake Tributaries Watershed, and Snake Lake of the Tatelkuz Lake Tributaries Watershed).

Due to a mean ice cover of 0.5 m and the shallow depth of water under the ice (mean = 0.4 m), the total volume of overwintering habitat available to fish in streams is low compared to the volume that is assumed to be available in lakes (e.g., Tatelkuz Lake and Lake 01628LNRS).

In August and September 2012, fish habitat was surveyed in streams that will be crossed by the proposed transmission line corridor and the road access corridor using reconnaissance 1:20,000 methods. A total of 245 sites were surveyed: 137 sites along the transmission line; 98 sites along existing roads; and 10 sites associated with proposed roads. Stream

crossings are located in the Cheslatta, Chilako, Euchinko, Francois/Fraser, Knewstubb (Nechako Reservoir), and Nechako (middle and upper) watersheds.

In 2011, bathymetric surveys were conducted for the three headwater lakes that were sampled for phytoplankton, zooplankton and BMI (Lakes 01682LNRS, 01538UEUT, and 01428UEUT). The maps were used to calculate total surface area, littoral area (<6 m deep), profundal area (>6 m), perimeter, maximum depth, mean depth, and lake volume. Physical limnology data were collected from all three headwater lakes in August 2011 and September 2012 and from Tatelkuz Lake, Kuyakuz Lake, and Snake Lake at several dates in 2012. In all six lakes one or more vertical profiles of water temperature and DO concentration were measured.

Secchi depth and the distribution and quality of littoral habitat (i.e., type of substrate and areas of emergent vegetation) were measured in the three headwater lakes in the summer of 2011. In March 2012, habitat surveys were conducted in three of the four headwater lakes to assess their over-wintering habitat potential, based on mean DO concentration and water depth.

In March 2012, three headwater lakes were visited in order to assess their potential as over-wintering fish habitat. Habitat quality in Lake 01682LNRS was poor below 4.0 m due to the presence of low DO concentrations, but fair to good above a depth of 4.0 m. Snake Lake was assigned a poor rating because of shallow depth and low DO concentrations. In contrast, overwintering habitat in Lake 01538UEUT was rated as good at all depths.

Five survey programs were used to sample fish in the LSA and RSA in 2011 and 2012:

- Spring rainbow trout spawning survey in June 2011 with eight sets of paired hoop nets (upstream and downstream) installed in four watersheds of the LSA;
- Summer stream inventories in July and August 2011 and August to October 2012 using one-pass backpack electrofishing, minnow traps, and angling at a total of 76 sites in four watersheds of the LSA;
- Summer lake inventory in August 2011 and September 2012 using gillnets, minnow traps, shoreline backpack electrofishing, and angling in four headwater lakes in three watersheds of the LSA;
- Survey in August and September 2012 of fish and fish habitat at stream sites that will be crossed by the Project transmission line and road access corridors using backpack electrofishing and minnow traps; and
- Fall mountain whitefish spawning survey in 2012 using hoop nets, one-pass backpack electrofishing, and seine nets in four watersheds of the LSA.

The objectives of those five programs were, first, to measure species richness, relative abundance, spatial distribution, and biological characteristics. The second objective was to use those data to identify the number of breeding populations, the locations of their critical habitat, and their migration routes. Since rainbow trout was the predominant species in streams and headwater lakes, it was the primary target of investigation. Kokanee, which

spends its life mainly in lakes, but is the single most numerous species in the LSA and RSA, was the secondary target. Too few fish of other species were captured to provide much information on their life history or critical habitat.

With the exception of a few fish that escaped before processing, all fish captured at each site were counted, identified to species, measured for length and weight, and scales were taken for age determination. During the rainbow trout spawning season in June 2011, sex and maturity of rainbow trout were determined by lightly squeezing fish and looking for eggs or milt. Tissue samples were snipped from the fins of approximately 30 rainbow trout and kokanee from each watershed for microsatellite DNA analysis. Fish were then released live in the same location they were captured.

Incidental mortalities caused by capture and handling were dissected for otoliths, liver weights, gonad weights, and tissue samples for measurement of metals concentrations. Some selected specimens of rainbow trout were sacrificed to increase tissue sample sizes. A total of 102 rainbow trout were used to provide 218 tissue samples for metals analysis: 76 whole-body samples; 83 muscle samples; and 59 liver samples.

Substantial fishing effort was expended in 2011 and 2012: 35,057 m of stream surveys (mainly of kokanee spawners); 88,941 second of electrofishing, 6,285 trap-hours of minnow trapping; 4,998 hours of hoop netting; 99 hours of gillnetting; 487 m^2 of beach seining; and 8 rod-hours of angling.

Nine species of fish were captured in the LSA and RSA in 2011 and 2012 (**Table ES 1**). This included streams that will be crossed by the transmission line corridor and the access road corridor. None of these species are endangered, threatened, or vulnerable.

Table ES 1: Fish Species Sampled in the Blackwater Project Area, 2010-2011

Common Name	Scientific Name
Kokanee	*Oncorhynchus nerka*
Rainbow trout	*Oncorhynchus mykiss*
Lake chub	*Couesius plumbeus*
Longnose sucker	*Catostomus catostomus*
Brassy minnow	*Hybognathus hankinsoni*
Mountain whitefish	*Prosopium williamsoni*
Burbot	*Lota lota*
Longnose dace	*Rhinichthyes cataractae*
White sucker	*Catostomus commersonii*

In this report, catch, effort, CPUE, and biological characteristics of kokanee and rainbow trout were aggregated and presented on a population basis because modern resource management and conservation biology use breeding populations as the basic unit of

management. Three populations of kokanee and seven populations of rainbow trout and were identified, based on four sources of information:

- Genetic relatedness based on microsatellite DNA analyses;
- Proximity to overwintering habitat;
- Presence or absence of barriers to fish passage; and
- Fish sampling data, specifically densities of young-of-year fish that indicated the location of spawning areas.

These populations and their proposed seasonal migration routes are working hypotheses to be tested by future sampling and survey work.

Species of fish other than rainbow trout and kokanee could not be assigned to populations with confidence because of insufficient data – those species combined made up only 1.642% of the total number of fish counted in 2011 and 2012.

Kokanee, the landlocked form of sockeye salmon, was the most common species counted, making up 85.559% of the total count of 28,034 fish, but only because of the large numbers counted during spawning surveys conducted in August and September 2011 and 2012. During the rest of the year, kokanee sequester themselves in Tatelkuz and Kuyakuz lakes. Kokanee are not present in the four headwater lakes of the LSA.

Microsatellite DNA analysis of 262 samples of kokanee tissue collected in 2012 from eight areas within the Chedakuz Creek and Fawnie Creek watersheds and one from the Kootenay Lake drainage of the Columbia River system showed three broad groupings within the LSA and RSA, one of which is present in Kuyakuz Lake and its tributaries, and two of which are present in Tatelkuz Lake and its tributaries. The Fawnie Creek population groups with one of the Chedakuz Creek populations despite substantial spatial separation.

The Kuyakuz Lake kokanee population spends the majority of its life in Kuyakuz Lake. In the fall, spawners emerge from the lake to spawn in tributaries to Kuyakuz Lake, as well as in the mainstem of middle Chedakuz Creek downstream of Kuyakuz Lake. Eggs incubate in those tributaries over winter and the fry emerge in spring and migrate downstream and upstream to Kuyakuz Lake.

There are assumed to be two kokanee populations in Tatelkuz Lake: one that spawns in August in Davidson Creek, Creek 661, and Creek 522107; and a second population that spawns in September in lower Chedakuz Creek just downstream of the outlet of Tatelkuz Lake and in Creek 601947. Temperature differences in the spawning grounds maintain the separation of the two populations – water temperatures are always higher in Chedakuz Creek than in higher-elevation tributaries such as Davidson Creek and Creek 661. Embryos incubate in streams over winter and the fry emerge in spring and migrate downstream to Tatelkuz Lake (or upstream in the case of those emerging from gravel in lower Chedakuz Creek).

Biological data on kokanee was limited compared to the biological data available for rainbow trout because kokanee were sampled only during their spawning migration, and only length and weight were recorded to avoid inflicting handling stress. In general, lethal sampling was rare, so limited information was collected on age, sex, sexual maturity, gonad weight, liver weight, or tissue metal concentrations. Kokanee from Tatelkuz Lake and its tributaries have smaller mean length, weight, and condition than kokanee from Kuyakuz Lake and its tributaries.

Rainbow trout was the second most common fish species of the LSA and RSA (12.799% of total counts), and the predominant species in streams. Rainbow trout are present in Tatelkuz and Kuyakuz lakes and in the headwater lake of Davidson Creek (Lake 01682LNRS) and the two headwater lakes of Creek 705 (Lake 01538UEUT and Lake 01428UEUT). Rainbow trout are not present in Snake Lake because of low DO concentrations during winter.

Microsatellite DNA analysis of rainbow trout tissue samples showed four broad groupings corresponding to four watersheds: Davidson Creek; Creek 705; Turtle Creek; and Creek 661(Taylor 2012). There are believed to be seven populations of rainbow trout in the LSA and RSA: two in Davidson Creek, one each in Turtle Creek and Creek 661, and three in Creek 705.

In Davidson Creek, rainbow trout were divided into two populations, Davidson Creek and Davidson Headwater, based on the location of overwintering and spawning/rearing habitat and the presence of a partial barrier to fish passage. The Davidson Creek population contains the majority of trout that use the watershed. The adults use overwintering habitat in Tatelkuz Lake. In the spring, they migrate out of the lake into Chedakuz Creek and then up into the lower and middle reaches of Davidson Creek (Reaches 1 to 10 and tributaries) to spawn. They do not migrate further upstream into Reaches 11 and 12 because of the presence of a tall, steep cascade in lower Reach 11 that acts as a partial barrier to upstream fish passage. After spawning they return to Tatelkuz Lake. The fry and 1 to 2 year-old juveniles rear in middle and lower Davidson Creek and their tributaries before eventually migrating down into Chedakuz Creek and Tatelkuz Lake to overwinter.

The Davidson Headwater population of rainbow trout occupies much less area than the Davidson Creek population. Adults overwinter in headwater Lake 01682LNRS at the top of the watershed. In the spring, they migrate out of the lake through the single lake outlet and spawn in Reaches 12 and 11 of Davidson Creek and then return to the lake. The presence of the cascade in Reach 11 probably deters most members of this population from descending further downstream, although there is almost certainly some downstream dispersal of adults and juveniles. Juveniles rear in these two reaches before eventually migrating upstream into Lake 01682LNRS to overwinter. The high density of juvenile rainbow trout observed in the outlet of Lake 01682LNRS in 2011 supports this division of populations.

The Turtle Creek Watershed is not lake-headed nor does it have barriers to fish passage. Therefore, a single population of rainbow trout is assumed to use that watershed. The Turtle Creek population of rainbow trout overwinters in Tatelkuz Lake. In the spring, the adults migrate out of the lake into Chedakuz Creek and then up into Turtle Creek, as well as into Creek 700, a major tributary that flows into Reach 5 of Turtle Creek. They return to Tatelkuz Lake, but juveniles rear in Turtle Creek before eventually descending to Chedakuz Creek and moving upstream into Tatelkuz Lake to overwinter.

Creek 661 is headed by a shallow pond that is unlikely to provide overwintering habitat. It also has no barriers to upstream migration. Therefore, it was assumed to support a single population of rainbow trout. Similar to the Davidson Creek and Turtle Creek populations, the Creek 661 population is believed to overwinter in Tatelkuz Lake and migrate up Creek 661 to spawn.

Creek 705 Watershed is assumed to support three separate populations of rainbow trout, 705 Headwater North, 705 Headwater South, and Creek 705, because it contains two headwater lakes and provides spawning and rearing habitat for trout that ascend to the lower and middle reaches of Creek 705 from Fawnie Creek.

The 705 Headwater North population overwinters in headwater Lake 01428UEUT. Water from that lake flows down Creek 606013 to a confluence in the middle of Reach 4 of Creek 705. In the spring, adults migrate out of the inlet and outlet of Lake 01428UEUT to spawn in Creek 606013 and its tributaries and then return to the lake. Juveniles remain in Creek 606013 and its tributaries to rear. Juveniles were observed in both inlet and outlet reaches of Lake 01428UEUT in 2011. The downstream extent of this population is set at the confluence of Creek 606013 and Creek 705.

The 705 Headwater South population overwinters in headwater Lake 01538UEUT, which is also classified as Reach 7 of Creek 705. In the spring, adults migrate out of its outlet to spawn in Reaches 4, 5 and 6 of Creek 705 and its tributaries and then return to the lake. Juveniles remain in the upper reaches of Creek 705 and its tributaries to rear. Juveniles were observed in the outlet reaches of Lake 01538UEUT in 2011. The downstream extent of this population is set at Reach 4 of Creek 705.

The Creek 705 population is made up of fish that overwinter in an undetermined location in the Fawnie Creek Watershed. In the spring, they migrate upstream through Fawnie Creek and then into Reaches 1 to 4 of Creek 705 where they spawn and then return to Fawnie Creek. Juveniles rear in the mainstem and tributaries of the lower and middle reaches of Creek 705 until they mature and migrate downstream into Fawnie Creek. The spatial extent of this population is from the confluence of Creek 705 and Fawnie Creek upstream to the confluence of Creek 705 and Creek 606013.

A total of 2,023 fish were captured in hoop nets in June 2011, of which 1,997 (or 98.7%) were rainbow trout. Total hoop nets catches of rainbow trout in June 2011 were highest in

Creek 705, followed by Turtle Creek, Creek 661, and Davidson Creek. This is an index of relative abundance of rainbow trout spawners in those watersheds.

In all four watersheds, total downstream catches of rainbow trout in hoop nets were higher than upstream catches because the nets could not be installed before the spawning migration began due to an unusually high freshet. Although rainbow trout are reported in the scientific literature to begin their spawning migration at a water temperature of 5°C, those in the LSA and RSA were migrating at temperatures lower than 5°C, and may have begun their migrations while some streams were still covered in ice.

Upstream migrants were observed earlier than downstream migrants at seven of the eight hoop nets. The exception was upper Davidson Creek. This supports the existence of a second population of rainbow trout that overwinters in Lake 01628LNRS and spawns in Reaches 10 and 11 and in lower reaches as well, although they would have to descend a cascade to enter middle Davidson Creek and probably would not be able to return to their overwintering lake after spawning, but continue downstream to Tatelkuz Lake.

The difference in dates at which 50% cumulative catches of rainbow trout occurred for the paired upstream and downstream hoop nets was defined as “stream residence time.” It ranged from 3 to 10 days with a mean of 5 days (n = 8, SE = 1 day).

All rainbow trout that were captured and processed in hoop nets were given a unique fin clip. A total of 152 clipped rainbow trout were recaptured in hoop nets late in June 2011. Ninety two percent were recaptured at the same site where they were originally clipped, only moving in the opposite direction. The other 8% were captured at different sites in the same watershed. These results indicate fidelity by rainbow trout to their spawning grounds because there were no recaptures outside of a watershed. This supports the idea that each watershed in the LSA and RSA is used by at least one distinct population of rainbow trout.

Comparison of the total number of rainbow trout that were clipped at each hoop net site with the number of clipped trout from each site that were recaptured at the same site showed that recaptures ranged from a low of 1.4% for the Upper Davison Creek site to a high of 44.4% for the Creek 700 site. This means that between 56% and 99% of all marked fish were never recaptured. The main reason so many marked fish were never recaptured was that the system was not closed to emigration. Fish that were moving downstream to their overwintering lake had left the sampling area and would not be expected to return for at least one year. This was especially true for the June 2011 study because the hoop nets were installed after the migration had begun and most of the counts were of fish moving downstream after spawning.

A second reason for low recaptures of fin-clipped rainbow trout was that some remained upstream of the hoop nets until the nets were removed, and then migrated downstream later in the year. Even if the mean residence time in a spawning creek is relatively short, late arrivals would still have been upstream of the nets when the nets were removed.

A third reason was that some fish died during spawning and/or the migration to and from the spawning site. This is possible because spawning is a stressful event, and the fish were exposed to predators that may have aggregated on the spawning run.

A total of 1,589 fish were captured by backpack electrofishing in 2011 and 2012, of which 1,323 (or 83.3%) were rainbow trout. In general, electrofishing CPUE and density were low in all of the watersheds of the LSA. Over 70% of the 78 values of electrofishing CPUE were below 1.0 fish/100 s, and over 75% of the values of fish density were below 5.0 fish/100 m^2. Minnow trapping CPUE was also low; over 75% of the 37 values of minnow trapping CPUE were below 1.0 fish/trap-hour.

With few exceptions, the rainbow trout sampled in streams of the LSA in August and September of 2011 and 2012 were juveniles between the ages of 0 and 3 years. Most were less than 100 mm long. Adults returned to their lakes of residence after spawning ended in late June. Hence, the rainbow trout CPUE and minnow trapping CPUE is an index of the abundance and density of juvenile rainbow trout during their summer rearing period.

Rainbow trout electrofishing CPUE and density both showed decreasing trends with upstream distance in Davidson Creek, Creek 661 and Turtle Creek. This reflected lower quality rearing habitat in tributaries and upstream reaches of creeks. The highest quantity and quality of rearing habitat was generally located in the lower reaches of all creeks.

Pooling electrofishing CPUE of rainbow trout by population over both the 2011 and 2011 surveys showed that both the Creek 705 mainstem population and the Creek 705 Headwaters South population had the highest CPUE, followed by the Creek 705 Headwaters North population, the Davidson Creek Headwaters population, and the Creek 661 population. The Davidson Creek mainstem and the Turtle Creek population both had the lowest CPUE.

Comparing these results with the rank order of populations or watersheds based on total downstream hoop net CPUE showed that the Creek 705 mainstem population had both the highest electrofishing CPUE and the highest downstream hoop net CPUE, and that the Davidson Creek population had both the lowest electrofishing CPUE and the lowest downstream hoop net CPUE.

A total of 213 fish were captured by gillnets installed in the four headwater lakes in 2011 and 2012, of which 124 (or 58.2%) were rainbow trout and 86 (or 40.4%) were lake chub. All the lake chub were captured in Snake Lake, which does not support any other fish species.

Lake 01428UEUT had the highest rainbow trout gillnet CPUE (mean = 96.0 fish/100 m^2/day, n = 3, SE = 14.2), followed by Lake 01682LNRS (mean = 35.5 fish/100 m^2/day, n = 2, SE = 19.6), and Lake 01538UEUT (mean = 30.0 fish/100 m^2/day, n = 5, SE = 8.2). This rank order follows the same rank order of mean zooplankton density and biomass, but it does not follow the rank order of phytoplankton density and biomass.

On average, the Creek 705 population of rainbow trout has the longest, heaviest, and oldest specimens, but with the lowest mean condition factor. The Davidson Creek population has the shortest mean length, but the highest mean condition. The Turtle Creek population has the lowest mean weight. Age ranges between 0 and 8 years for most populations, with the exception of the 705 Headwaters South population that has an age range of 3 to 9 years. With the exception of growth, these differences in mean biological characteristics are largely the result of differences in the seasonal distribution of sampling effort and gear type.

Plots of mean length on age show that growth of rainbow trout is slower in the three headwater populations than in the other four populations that are derived from migrants from Tatelkuz Lake. Asymptotic length (L_∞) ranges from 261 to 436 mm for the three headwater lakes and from 575 to 1,148 mm for the other four populations. The most likely reasons are resource limitation in small headwater lakes, lower water temperatures in headwater systems, and, perhaps, lower nutrient concentrations.

Despite lower growth rates, mean condition is the same or higher in headwater lakes than in the other four populations, indicating that rainbow trout in the headwater lakes are as healthy as fish in the other populations, and supporting the idea that growth differences may reflect temperature differences as well as differences in food quantity.

Sex ratios for rainbow trout in the LSA ranged from a low of 0.2 for the 705 Headwaters North population to a maximum of 5.0 for the Davidson Headwaters population. The mean sex ratio for all populations combined was 0.7. The wide variation in sex ratio is most likely a function of sample size. In general, the larger the sample size, the closer the ratio approached the value of 1.0 expected for a stable population.

The length at 50% maturity of rainbow trout ranged from 100 to 300 mm among populations, with a pooled estimate over all populations of 150 mm. No fish were mature at lengths below 100 mm. For all populations pooled, all fish were 95% mature at a length of 300 mm.

The results of rainbow trout stomach contents analysis support the idea that rainbow trout are opportunistic feeders, consuming the most common prey available from both benthic and pelagic habitat, and that their diet also shifts as they grow in size, and are better able to exploit multiple niches. Dipterans dominated the diet of small trout in Creek 661 (<100 mm long) and Davidson Creek (<120 mm), but terrestrial insects were found only in the diet of larger fish from Turtle Creek (>180 mm), indicating that prey selection changes with body size. Davidson Creek trout had more prey items and more taxonomic diversity than did the Creek 661 trout, but this conclusion was based on low sample size – only four stomachs were sampled from Creek 661.

For the lake populations, there was a clear relationship between rainbow trout diet and habitat. Daphnids are the most abundant prey item for rainbow trout from Lake 01538UEUT, and daphnids are pelagic organisms that migrate vertically in the water column (Green 1997). In contrast, benthic gammarids are the dominant prey item for rainbow trout from Lake 01428UEUT. The surface area of Lake 01538UEUT is 52% littoral and 48% pelagic,

but the area of Lake 01428UEUT is 97% littoral and 3% pelagic. Feeding on zooplankton is common when other forms of prey are not available.

A total of 218 fish tissue samples were analyzed for concentrations of 41 total metals, methylmercury, lipids, and percent moisture. There were three types of tissue samples: whole-body, muscle, and liver.

A principal component analysis (PCA) of the rainbow trout tissue metals data set extracted three components that explained 66% of the total variance. The first component, PC1, explained 36.2% of the total variance and was significantly positively correlated with 22 heavy metals. It was not significantly negatively correlated with any metal, nor was it significantly correlated with fish length or weight or with calcium and potassium – both key structural metals. This component was interpreted as representing the magnitude of heavy metal concentrations. A plot of mean PC1 scores on watersheds or lakes for each of the three tissue types showed that muscle tissue has the lowest scores for all watersheds or lakes, that liver has the highest scores in almost all localities, and that whole-body samples have scores only slightly lower than liver. There is little variation among watersheds and lakes in mean PC1 scores within tissue types. Creek 661 has the highest mean PC1 score for liver and muscle tissues and the second highest for whole-body.

PC2 explained 18.9% of the total variance of the data set. It was significantly negatively correlated with calcium (a major structural metal), strontium (an analogue of calcium), and magnesium (also a structural metal), and significantly positively correlated with copper and mercury, thallium and selenium – all highly toxic metals for fish and all that would be expected to be captured by liver tissue. PC2 was not significantly correlated with fish length or weight. This component was interpreted as representing tissue type.

A plot of PC2 scores on PC1 scores for all samples showed that the two components clearly separated the three types of tissue. It not only showed that liver samples had the highest PC2 scores, followed by muscle samples and whole-body samples, it showed that liver and whole-body samples fall within similar ranges of PC1 scores, but that muscle samples have substantially lower PC1 scores. Hence, PC1 not only represents heavy metal concentrations due to environmental exposure, but heavy metal concentrations on a tissue-specific basis.

The third component, PC3, explained 10.6% of the total variance and was highly significantly positively correlated with fish length and weight. This component was interpreted as representing fish body size.

Only one of the 218 tissue samples collected in 2011 and 2012 exceeded Health Canada's mercury guideline of 0.5 mg/kg wwt – a liver sample taken from a trout captured from Lake 01682LNRS. The liver had a total mercury concentration of 0.518 mg/kg wwt, and the fish was 344 mm long, weighed 463 g, and was 5 year old, based on otolith age determination.

A total of 13 tissue samples (or 6% of the total) were analyzed for methyl-mercury concentrations. Methyl-mercury concentrations were highly positively correlated with total

mercury concentrations in each sample for which both were measured. A linear regression of methyl-mercury concentration on total mercury concentration was highly significant and explained 87% of the variance in methyl-mercury concentration. The regression slope indicates that, on average, methyl-mercury makes up 55% of the concentration of total mercury.

A site-specific methyl-mercury guideline of 0.062 mg/L was calculated by determining the species of fish-eating birds that resides or visits the Project area that has the highest potential consumption rate of fish. Using that site-specific methyl-mercury guideline, only two tissue samples from a single rainbow trout would classify as exceedences. Fish sample number 16-011, captured from Lake 01682LNRS, the headwater lake of the Davidson Creek Watershed, on 19 September 2012, had a methyl-mercury concentration of 0.1360 mg/kg wwt for the muscle sample, and 0.1330 mg/kg wwt for the liver sample. The concentration of the whole-body sample was less than the guideline.

No significant correlation was found between total selenium concentration and fish length for liver tissue, but highly significant and negative linear regressions were found for both muscle and whole-body tissues. There are two possible explanations for these results: (1) adult rainbow trout transfer (or depurate) total selenium from muscle and liver tissue into their eggs and milt; and (2) selenium concentrations are lower in large adult rainbow trout collected from lentic habitat (i.e., lakes) than in small, juvenile rainbow trout collected from lotic (i.e., stream) habitat. However, these two hypotheses cannot be tested with available daa because all juveniles were sampled from stream habitat and and all adults were sampled from lake habitat, i.e., the effects of habitat and sexual maturation are confounded.

The draft BC MOE total selenium whole-body tissue guideline for protection of aquatic life of 4 µg/kg dry weight (or 1 g/kg wet weight assuming a percent moisture content of ~73%) was exceeded by eight whole-body samples (or 11% of the total number of whole-body samples), none of the muscle samples, and 59 of the liver samples (or 100% of the liver samples).

Mean total metal concentrations measured from whole-body samples were compared with those measured from whole-body samples of rainbow trout that were collected for the Chu Molybdenum Project in the northeastern corner of the Blackwater RSA in 2009. Blackwater samples had lower heavy metal concentrations than samples from the Chu Molybdenum Project area.

One hundred and seventy samples of rainbow trout tissue that were collected from seven localities in or near the LSA and RSA in 2011 – four within the Chedakuz Creek Watershed and three from the adjacent Fawnie Creek Watershed – were assayed at ten microsatellite DNA loci. The numbers of alleles and heterozygosity observed in these samples (2.5 to 4.5 and 0.33 to 0.50) were typical of rainbow trout sampled from other areas of the British Columbia interior and over a similar geographic scale. Samples clustered into four broad groupings: Davidson Creek; Creek 661; Turtle Creek and Creek 700 in the Turtle Creek Watershed; and Lakes 01428UEUT, 01538UEUT, and Creek 705 in the Creek 705 Watershed.

Approximately 7% of the total variation in allele frequencies was attributable to differences between the Chedakuz Creek and Fawnie Creek watersheds, 5% to localities within drainages, and 88% to variation within localities. Most of the samples were genetically distinct from one another and are probably largely independent from one another, although some movement likely does occur occasionally between localities that are currently interconnected.

As the Chedakuz Creek (Davidson/Turtle/Creek 700) and Fawnie Creek (Lakes 01538UEUT and 01428UEUT/Creek 705) watersheds flow in opposite directions across a major drainage divide, the genetic similarity between some fish in these watersheds suggests that these watersheds may have in the past, or in exceptionally high water years, been connected allowing fish to move between the two.

The proportion of the total variation in microsatellite allele frequencies of rainbow trout in the Project area that is attributable to differences among populations is consistent with previous results once differences in the geographic scale of coverage and physical connectivity are accounted for. In other words, the rainbow trout populations in the Project area are not particularly unique in terms of genetic diversity.

1.0 INTRODUCTION

1.1 Scope of Work

This baseline report describes the fish, fish habitat, and aquatic resources in streams and lakes near New Gold Inc.'s (proponent) proposed Blackwater Gold Project (Project). The proposed Project is located on the Nechako Plateau of central British Columbia (BC), approximately 110 kilometres (km) southwest of Vanderhoof (straight-line distance) and 160 km southwest of the city of Prince George (**Figure 1.2-1** and **Figure 1.2-2**). The report was based on field surveys conducted near the Project in 2011 and 2012.

The Project has the potential to alter stream flows, lake levels, water quantity and quality, and fish habitat quantity and quality. As such, the Project may be subject to the requirements of the *Metal Mining Effluent Regulations* (*MMER*) (Government of Canada 2002) and the federal *Fisheries Act* (Government of Canada 1985, 2012). The *MMER* requires mine proponents to monitor the chemical characteristics and toxicity of mine discharges and the downstream receiving environment as part of an environmental effects monitoring (EEM) program.

Non-compliance with water quality discharge criteria or standards will potentially result in the contravention of section 36 of the *Fisheries Act,* which prohibits the "deposit of a deleterious substance" into Canadian waters. Alteration of stream flows, lake levels, and fish habitat may result in the contravention of section 35 of the *Fisheries Act,* which prohibits the harmful alteration, disruption, or destruction (HADD) of fish habitat.

On 29 June 2012, the federal government amended the *Fisheries Act* through Bill C-38. The first set of amendments took effect immediately and altered subsection 35(1) to add the word "activity" to the definition of Harmful Alteration, Disruption, or Destruction (HADD) of fish habitat. The second set of amendments, which are expected to come into force later in 2013, alter the definition of a HADD, change the enforcement regime, and allow delegation of responsibilities to other levels of government. Until the new regulatory regime is in place, and its protocols and outcomes are understood, New Gold will follow the policy of No Net Loss as laid out in Fisheries and Oceans Canada's (DFO) Policy for Management of Fish Habitat (DFO 1986).

1.2 Objectives

Due to the Project's potential to adversely affect fish and fish habitat, and its potential to invoke the *Fisheries Act*, the overall objectives of the baseline studies were to:

- Characterize fish communities and aquatic resources in streams and lakes that may be affected by the Project so to identify potential interactions and opportunities for mitigation, and to support an application for an Environmental Assessment (EA) Certificate;
- Provide baseline data that will support future EEM programs; and
- Quantify fish habitat (and its quality and productive capacity) potentially affected by the Project so that a fish habitat compensation plan can be developed to meet DFO's No Net Loss guiding principle (DFO 1986).

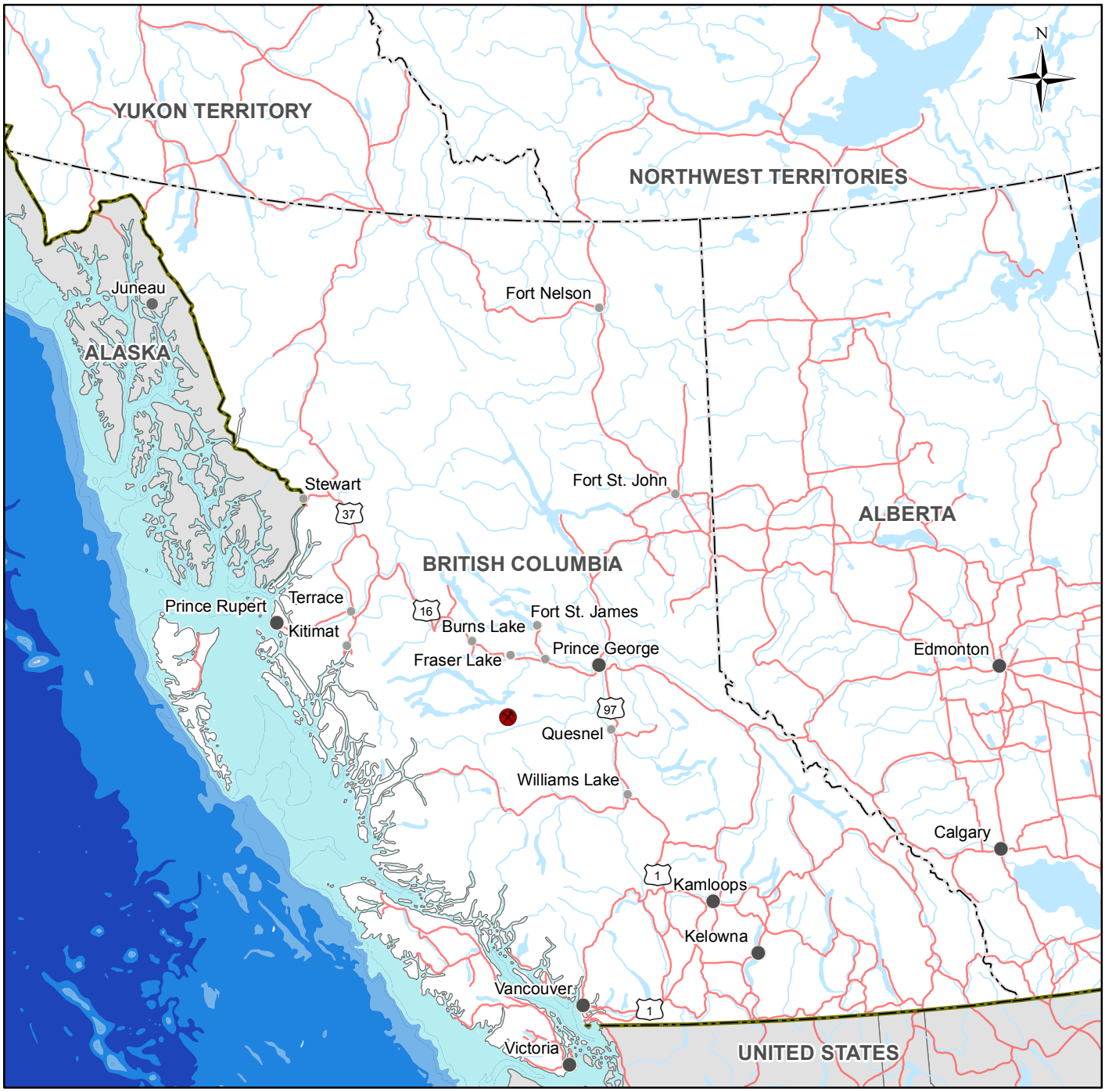
This report focuses on fish, fish habitat, and aquatic resources in the Project study area. "Fish" includes fish species diversity, absolute and relative abundances, locations and timing of seasonal migrations, biological characteristics such as length, weight, age, growth, sex, sex ratio, length at 50% and 100% sexual maturation, diet, tissue metal concentrations, and genetic relationships among populations as determined by microsatellite DNA analyses.

"Fish habitat" includes the location, quantity, and quality of stream and lake habitat that supports all life stages of fish: migration, spawning, rearing, and overwintering. This includes measurements of stream gradient, width, depth, substrate type, etc., as well as lake bathymetry (i.e., surface area, volume, perimeter, etc.).

The report does not describe "fisheries," which are harvests of fish populations, because fisheries were not studied in 2011 and 2012. However, a brief historical review of the possible presence of recreational and Aboriginal fisheries in the LSA and RSA is part of the data gap analysis described in **Section 3.0**.

"Aquatic resources" include all components of aquatic ecosystems that support fish and fish habitat. These include stream temperatures, conductivities, pH and DO concentrations, the biomass, density and taxonomic composition of periphyton and benthic macroinvertebrates (BMI) in streams, physical limnology of lakes (i.e., vertical profiles of temperature, conductivity and DO), and the biomass, density and taxonomic composition of phytoplankton, zooplankton, and BMI in lakes.

This report does not describe stream flows, water quality, or sediment quality, nor does it describe the turnover times of lake water volumes. Hydrology is described in the *Blackwater Gold Project: 2013 Hydrometeorology Report* (Knight Piésold 2013), and water quality and sediment quality are described in the *Blackwater Gold Project: Water and Sediment Quality* (AMEC 2013a). The results of water balance modelling of streams and lakes in the Project area will be described in future reports.



Legend

- Blackwater Gold Project
- City
- Town
- Road
- Stream
- Waterbody
- Provincial Boundary
- International Boundary

Reference
Atlas of Canada scale 1:7,500,000

Scale: 1:9,000,000

0 50 100 200 300 400 500
Kilometres

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of Blackwater Project in British Columbia

DATE:	ANALYST:	**Figure** 1.2-1
April, 2013	AA	
JOB No: VE52095	QA/QC: IM	PDF FILE: Other-100-005_v7_project_location.pdf
GIS FILE: Other-100-005_v7.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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320000 360000 400000 440000

5960000 5920000 5880000

François Lake
Cheslatta Carrier
Danskin
CHESLATTA 1
Skin Tyee
Uncha Mountains Red Hills Park
Francois Lake Park
Uncha Lake
Takysie Creek
Binta Lake
BINTA LAKE 2
Cheslatta
KNAPP LAKE 6
BAPTISTE LOUIS 8
Cheslatta River
Cheslatta Lake
Knapp Creek
TARGE CREEK 15
ALEXIS THOMAS 1A
Cheslatta
HOLY CROSS LAKE 3
MURRAY LAKE 4
Bird Creek
Nechako Canyon Protected Area
Lucas Lake
Lucas Creek
Knewstubb Lake
Big Bend Creek
LEON 14
Natalkuz Lake (Nechako Reservoir)
Tetachuck River
Entiako River
Entiako Park
Entiako Lake
Tweedsmuir Park
Johnny Lake
Laidman Lake
Fawnie Creek
Moose Lake
ULKATCHO 6
TSETZI LAKE 11
TSACHLA LAKE 8
Tsacha Lake
Kushya
KUSHYA CREEK 12
KUSHYA CREEK 7
UPPER KLUSKUS LAKE 9
KLUSKUS 1
Blackwater River
Kluskus
CHIEF MORRIS 13
BISHOP BLUFFS 5
BISHOP BLUFFS 6
BISHOP BLUFFS 10
KLUSKUS 14
SUNDAYMAN'S MEADOW 3
YALADELASSLA 4
KLOYADINGLI 2
Kuyakuz Lake
Euchiniko Lakes
Kluskus-Blue FSR
Exploration Road
Proposed Fresh Water Pipeline
Proposed Mine Access Road
Top Lake
Chedakuz Creek
Tatelkuz Lake
TATELKUS LAKE 28
Kluskus-Ootsa FSR
Mills Ranch Reroute
Chedakuz Creek
Taluk Creek
Batnuni Lake
Euchiniko River
Nataniko Creek
Alexander Mackenzie Heritage Trail
Kluskoil Lake Park
EUCHINICO CREEK 19
TROUT LAKE JONNY 15
Nazko
EUCHINICO CREEK 17
EUCHINICO CREEK 18
TROUT LAKE ALEC 16
Euchiniko
Baezaeko
REDWATER CREEK 30
Nazko
Kluskus FSR
Meridian Road (Vanderhoof) Ecological Reserve
Finger Lake
Tatuk Lake
TATUK LAKE 7
Finger Tatuk Park
Chilako River Ecological Reserve
Chilako River
Endako
Stellako
Fraser Lake
FRASER LAKE 2
Nadleh Whuten
YENSISCHUCK 3
Fort Fraser
NAUTLEY 1
STELLAQUO 1
SEASPUNKUT 4
Stellako Reroute
Stellako WMA
Stellako
Fraser Lake
Engen
Nechako River
NOONLA 6
Vanderhoof
Stuart River Park
Stuart River
Weneez
Sinkut River
STONY CREEK 1
Tachick Lake
Saik'uz
CLUSTALACH 5
OLD COUNTRY MEADOW 4
Nulki
Nulki Lake
LAKETOWN 3
SINKUT LAKE 8
SACKANITECLA 2
Mapes
CORKSCREW CREEK 10
CORKSCREW CREEK 9
Corkscrew
Sinkut River
Cluculz Lake
Cluculz Creek
Khai
Smith Creek
Tahultzu Lake
Hallett Lake
Greer Creek
Targe Creek
Nechako River
N
16
27
35

Legend

- Populated Place
- Highway
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Railway
- Existing Transmission Line
- Alexander Mackenzie Heritage Trail
- Stream
- Waterbody
- Parks and Protected Areas
- Indian Reserve

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Transmission Line Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip Extent
- Proposed Mine Site

KEY MAP



Scale: 1:500,000

0 5 10 20
Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Proposed Mine Site Location with Mine Access Road, Transmission Line, and Fresh Water Pipeline

DATE:	ANALYST:	**Figure** 1.2-2
April, 2014	WR	
JOB No: VE52277	QA/QC: AP	PDF FILE: Other-100-028_v14_Overview.pdf
GIS FILE: Other-100-028_v14_Overview.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Section 2.0 of this report describes the study areas in which the baseline surveys were conducted. **Section 3.0** reviews the available historical data on fish, fish habitat, fisheries, and aquatic resources of the area near the Project, identifies data gaps, and describes a study design to fill those data gaps. That section also provides specific objectives of the baseline surveys in both 2011 and 2012. **Section 4.0** describes survey methods, and **Section 5.0** describes and discusses survey results. **Section 6.0** provides references for all documents cited in this report.

Methods in **Section 4.0** and results in **Sections 5.0** and **6.0** follow a trophic sequence. The physical component (i.e., stream temperature) are described first, followed by lower trophic components (i.e., periphyton and benthic macroinvertebrates in streams and phytoplankton and zooplankton in lakes), and upper trophic components (i.e., fish habitat, fish abundance and distribution, and fish population biology).

2.0 STUDY AREA

The Project is located on the Nechako Plateau of central BC (**Figure 1.2-2**). This region is located within the Omineca Region of the BC Ministry of Environment (BC MOE) and the Pacific Region of DFO. It is characterized by gently undulating highlands that are dissected by meltwater channels and glacial features. The proposed mine site is situated along the northern flanks of Mount Davidson at an elevation of 1,700 m above sea level (masl). Valleys around the Project have elevations between 940 and 1,010 masl.

The proposed mine site occupies a surface area of approximately 3,300 ha. Its center is at 53° 11'22.872"N and 124° 52'0.437"W (or 58930000 Northing and 375400 Easting), and is located in National Topographic System (NTS) sheet 93F/02 (**Figure 2.1-1**). The mine site is largely contained within the Davidson Creek Watershed, a tributary sub-watershed within the Chedakuz Creek Watershed. Davidson Creek flows from the outlet of headwater Lake 01682LNRS near the summit of Mount Davidson north-east to Chedakuz Creek immediately downstream of the exit of Chedakuz Creek from Tatelkuz Lake (**Plate 2.1-1** to **Plate 2.1-3**). Chedakuz Creek flows to the Nechako Reservoir, which was created in 1952 by construction of Kenney Dam across the Nechako River. (Nechako Reservoir contains multiple basins, including Natalkuz Lake and Knewstubb Lake, both of which are shown in **Figure 1.2-2**. Natalkuz Lake is shown in **Figure 2.1-1**. Hence, the Chedakuz Creek Watershed is now part of the Lower Nechako Reservoir Basin.

2.1 Local Study Area

Early in 2011, a Local Study Area (LSA) contained within a larger Regional Study Area (RSA) was defined for the Project. The Canadian Environmental Assessment Agency (CEAA) defines a LSA as the region in close proximity to the Project where direct effects of mine activities are anticipated (CEAA 2013). Direct effects include mortality of fish and loss of fish habitat, whereas indirect effects are those that are mediated by other disciplines such as water quality or hydrology.

Figure 2.1-1 shows the LSA for the three aquatic disciplines (hydrology; water quality; and fish, fish habitat, and aquatic resources). The boundaries of the LSA were selected following review of the location and size of the Project footprint and associated infrastructure, and consultation with hydrologists, water quality specialists, and aquatic biologists. They based their selection on an understanding of the potential direct effects of the Project on fish, and on a review of the life histories of fish known to be present in the area.

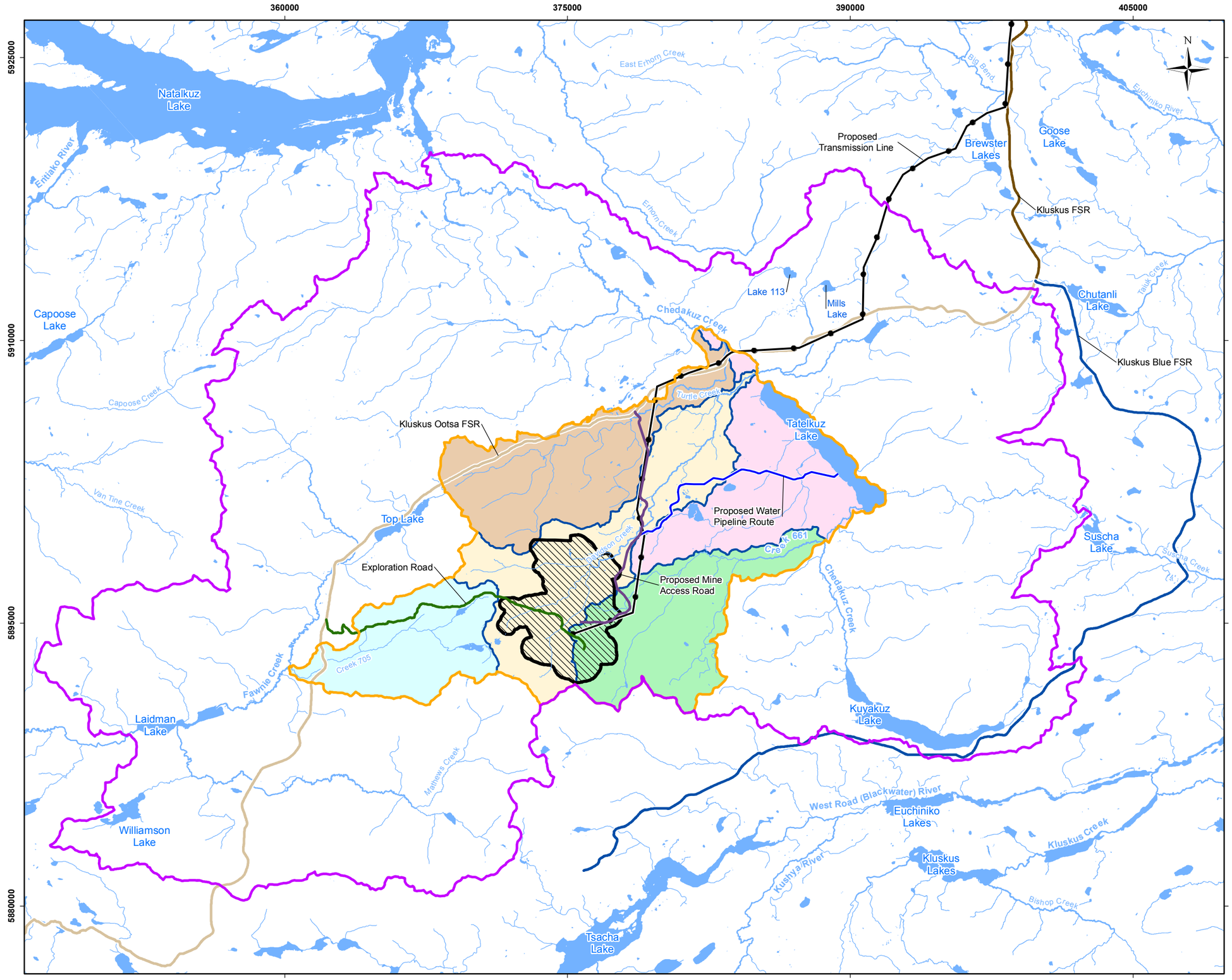
The Aquatics LSA includes the following streams and lakes (**Figure 2.1-1** and **Table 2.1-1**):

- Tatelkuz Lake (**Plate 2.1-3**);
- The portion of lower Chedakuz Creek (which flows from Tatelkuz Lake to the Nechako Reservoir) between Tatelkuz Lake and the confluence with Turtle Creek;
- The portion of middle Chedakuz Creek (which flows from Kuyakuz Lake (**Plate 2.1-8**) to Tatelkuz Lake) from the confluence with Creek 661 downstream to Tatelkuz Lake;
- Turtle Creek, which flows northeast into lower Chedakuz Creek (**Plate 2.1-4**). The main tributary of Turtle Creek is Creek 700, which drains to the west from the Project mine site;
- Davidson Creek, which also flows northeast into lower Chedakuz Creek, but upstream of the Turtle Creek confluence (**Plate 2.1-2**);
- Streams in the Tatelkuz Lake Tributaries Watershed that drain north-east into Tatelkuz Lake. This watershed is immediately south of Davidson Creek and consists of several creeks that flow into Tatelkuz Lake, the largest of which flows out of Snake Lake;
- Creek 661, which drains the north-east side of Mount Davidson from the Project mine site towards Chedakuz Creek upstream of Tatelkuz Lake; and
- Creek 705, which drains the southwest slope of Mount Davidson into Fawnie Creek, a tributary to the Entiako River. The Entiako River drains to the Nechako Reservoir (**Figure 1.2-2**).

Table 2.1-1: Main Drainages of the Aquatics LSA

Gazetted Name	Local Name	BC Freshwater Atlas Code	Tributary of
n/a	Turtle Creek	100-567134-610692-480511	Chedakuz Creek
n/a	Creek 700	100-567134-610692-480511-645840	Turtle Creek
Davidson Creek	Davidson Creek	100-567134-610692-522527	Chedakuz Creek
n/a	Tatelkuz Lake Tributaries	100-567134-610692-579340	Tatelkuz Lake
n/a	Creek 661	100-567134-610692-671007	Chedakuz Creek
n/a	Creek 705	100-567134-641477-543682-598692	Fawnie Creek

Notes: n/a = not applicable



Legend

- Existing Road
- Kluskus FSR
- Kluskus Blue FSR
- Kluskus Ootsa FSR
- Proposed Exploration Road
- Stream
- Waterbody
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Water Pipeline Route
- Proposed Mine Site

Catchments

- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Study Areas

- Mine Site Regional Study Area
- Mine Site Local Study Area

Scale:1:200,000

0 1 2 4 6 8 10

Kilometres

Reference

BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish and Aquatic Resource Study Areas

DATE:	ANALYST:	
April, 2013	MY	**Figure** 2.1-1
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-002_v8_aquatic_SA.pdf
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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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The LSA contains four headwater lakes: Lake 01682LNRS in the Davidson Creek Watershed (**Plate 2.1-1**), lakes 01538UEUT and 01428UEUT in the Creek 705 Watershed (**Plate 2.1-5** and **Plate 2.1-6**), and Snake Lake in the Tatelkuz Lake Tributaries Watershed (**Plate 2.1-7**).

Figure 2.1-2 to **Figure 2.1-6** show the names and locations of the lakes and of the many small tributary creeks of the five main watersheds of the LSA, which were surveyed for fish and fish habitat in 2011 and 2012 and historically. **Figure 2.1-7** shows the names and locations of the streams of the Chedakuz Creek Watershed that were surveyed in 2012.



Plate 2.1-1: Lake 01682LNRS, the Headwater Lake of Davidson Creek, 6 June 2011



Plate 2.1-2: Reach 3 of Davidson Creek, 18 August 2011



Plate 2.1-3: Tatelkuz Lake Facing South-East, 19 June 2011



Plate 2.1-4: Turtle Creek, 15 October 2011



Plate 2.1-5: Lake 01538UEUT, the Southern Headwater Lake of Creek 705, Facing West, 19 June 2011



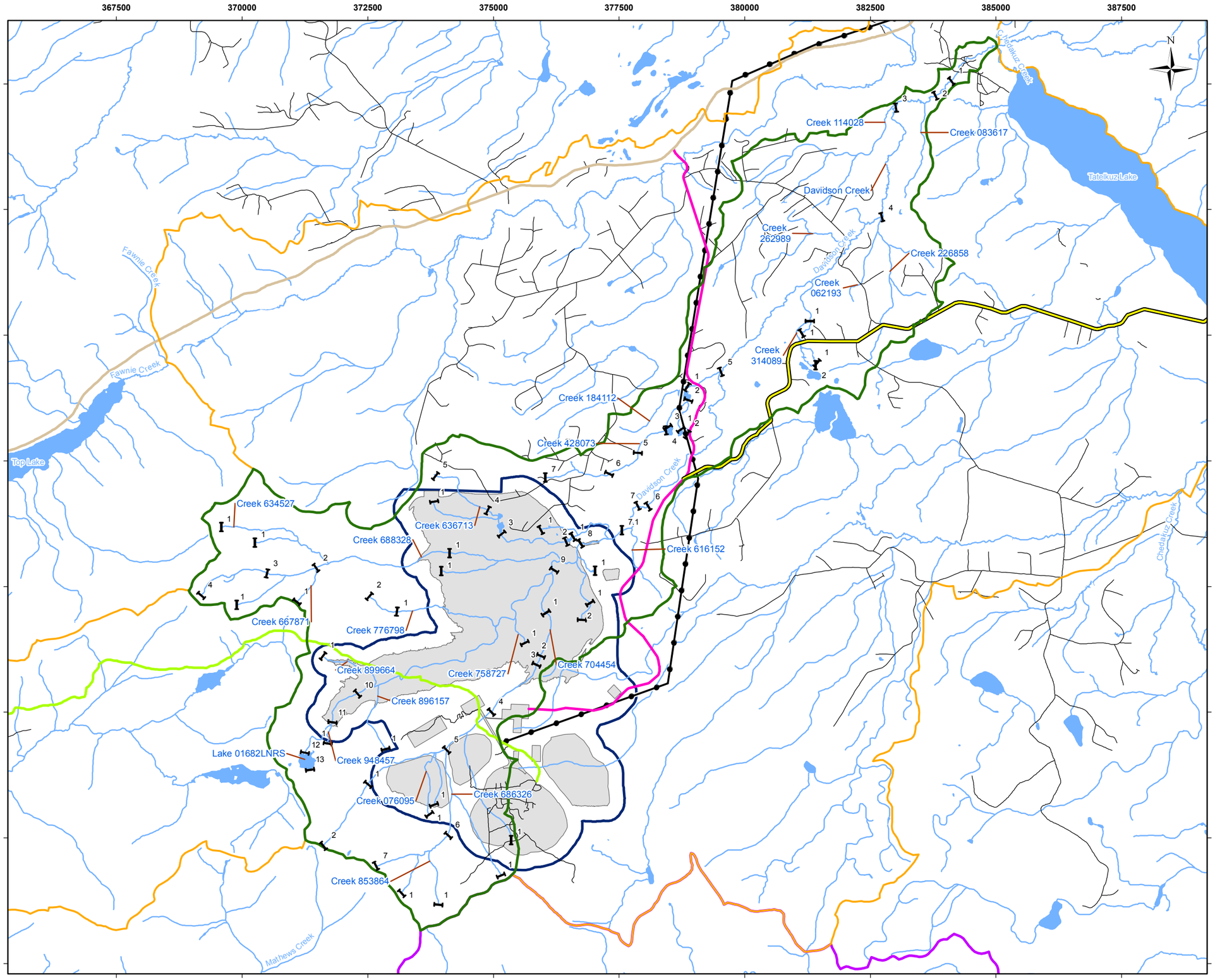
Plate 2.1-6: Lake 01428UEUT, the Northern Headwater Lake of Creek 705, Facing South, 6 June 2011



Plate 2.1-7: Snake Lake, the Headwater Lake of the Tatelkuz Lake Tributaries Watershed, 29 May 2012



Plate 2.1-8: Kuyakuz Lake with Middle CHEDAKUZ Creek in the Foreground, Summer 2012



Legend

- Reach Break
- Road
- Stream
- Waterbody
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area
- Regional Study Area

N

Scale:1:75,000

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Kilometres

Reference

BC Government GeoBC Data Distribution

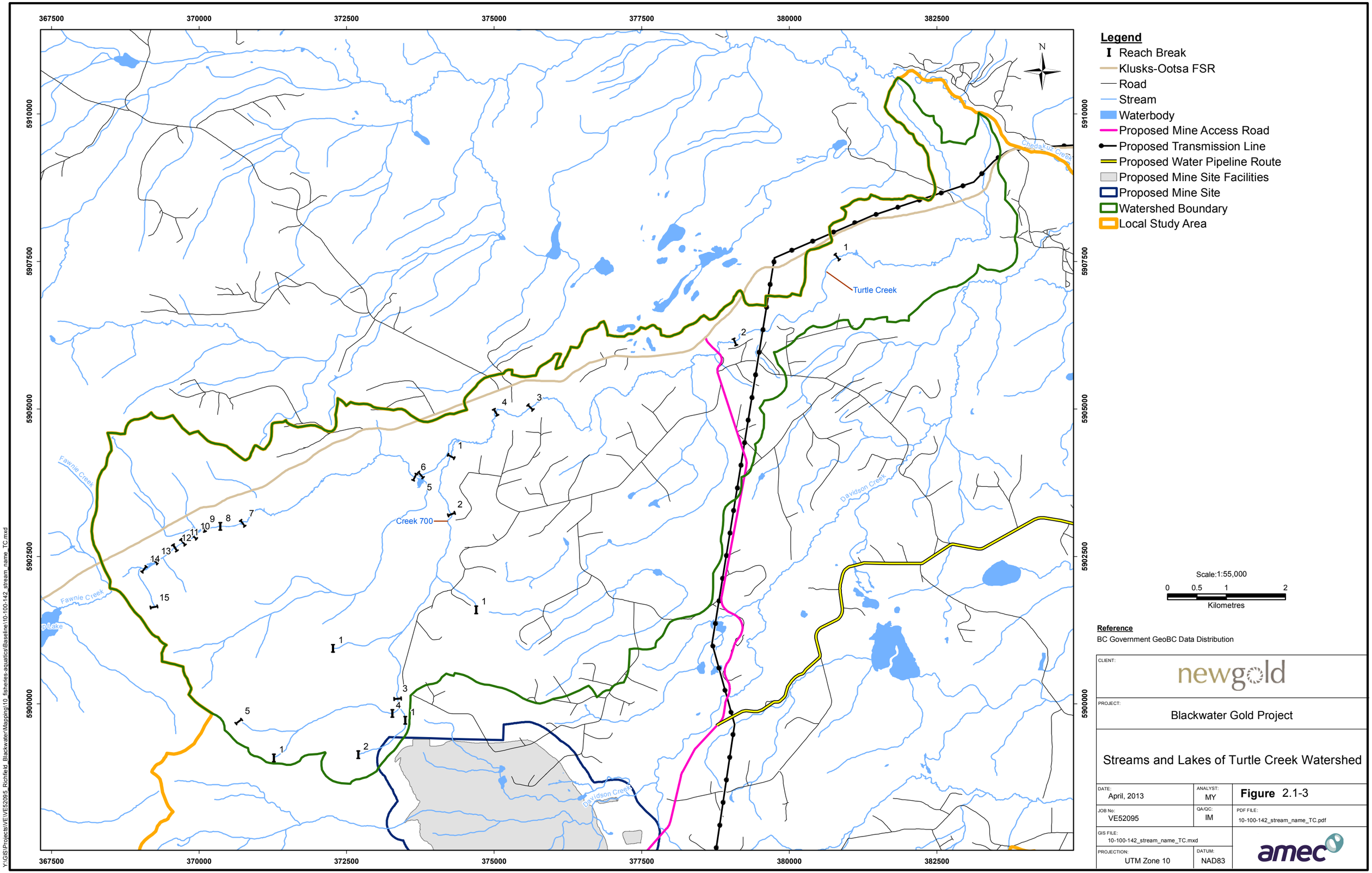
CLIENT: newgold

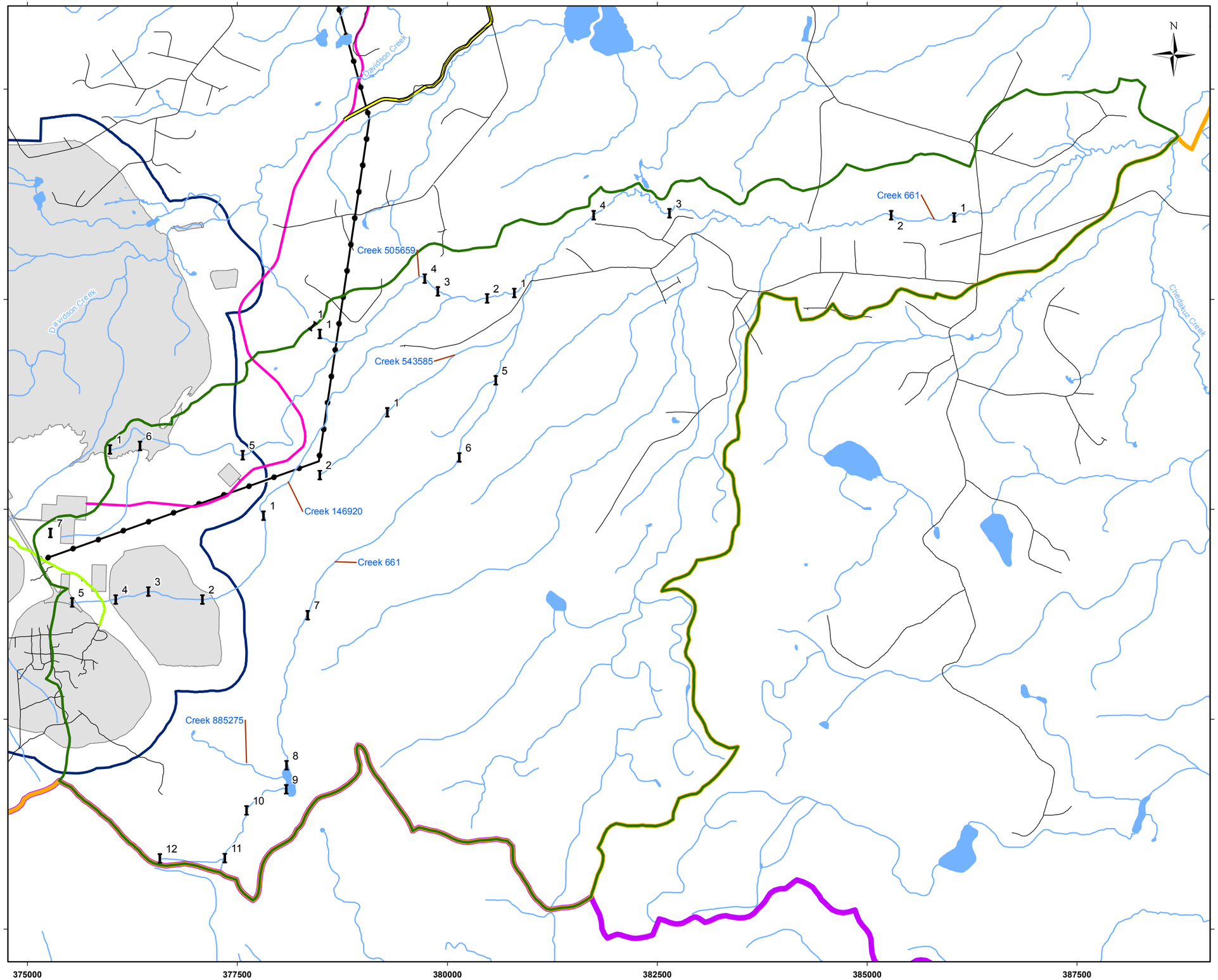
PROJECT: Blackwater Gold Project

Streams and Lakes of Davidson Creek Watershed

DATE:	ANALYST:	**Figure** 2.1-2
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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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367500
370000
372500
375000
377500
380000
382500
5910000
5907500
5905000
5902500
5900000
N
Chedakuz Creek
Turtle Creek
Davidson Creek
Fawnie Creek
Creek 700
Fawnie Creek
Davidson Creek
Legend
Reach Break
Klusks-Ootsa FSR
Road
Stream
Waterbody
Proposed Mine Access Road
Proposed Transmission Line
Proposed Water Pipeline Route
Proposed Mine Site Facilities
Proposed Mine Site
Watershed Boundary
Local Study Area
Scale:1:55,000
0 0.5 1 2
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Streams and Lakes of Turtle Creek Watershed
DATE:
April, 2013
ANALYST:
MY
Figure 2.1-3
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VE52095
QA/QC:
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DATUM:
NAD83
amec
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Legend

- Reach Break
- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area
- Regional Study Area

Scale:1:45,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

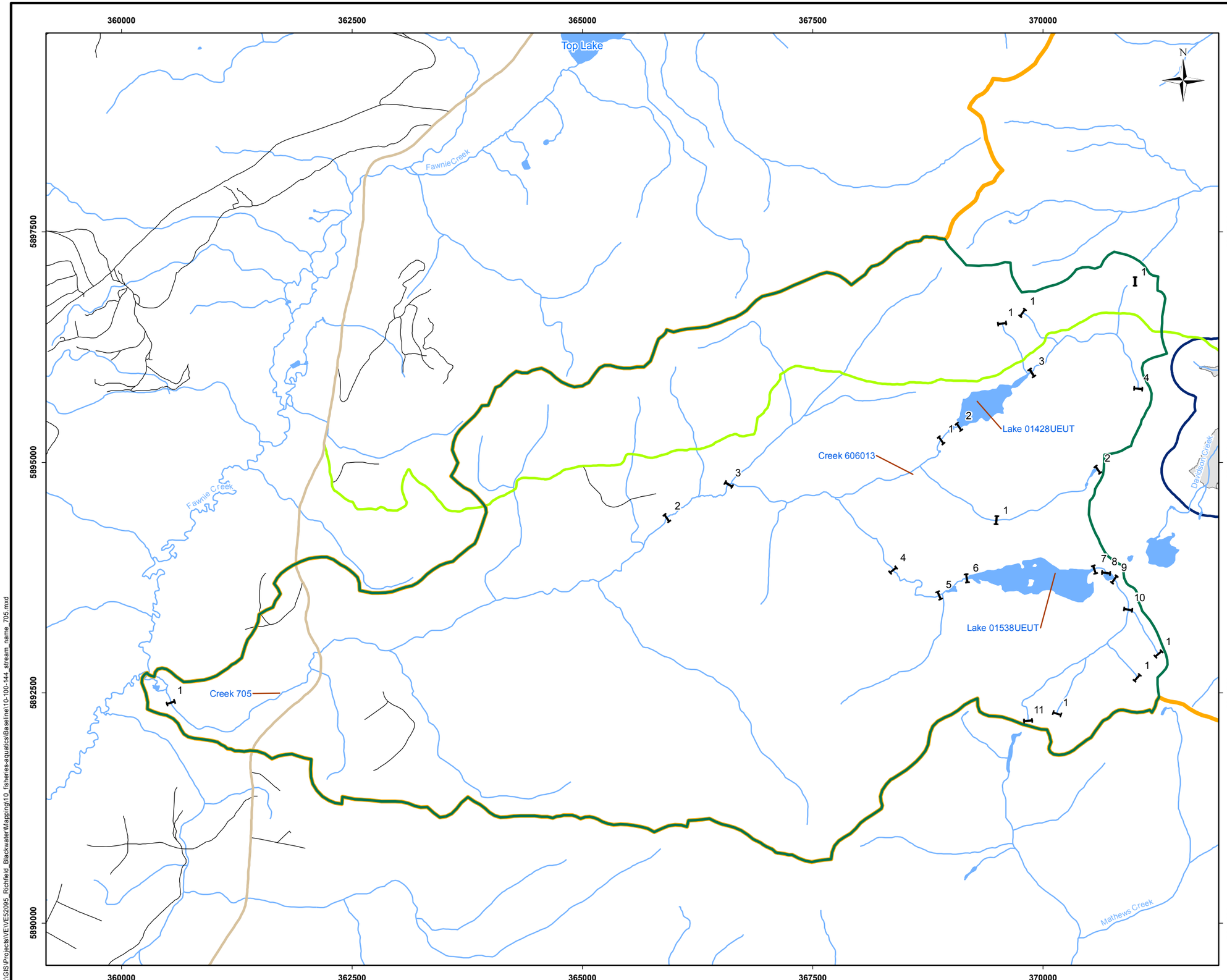
CLIENT: newgold

PROJECT: Blackwater Gold Project

Streams and Lakes of Creek 661 Watershed

DATE: April, 2013	ANALYST: MY	**Figure** 2.1-4
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Legend

- Reach Break
- Exploration Road
- Kluskus-Ootsa FSR
- Road
- Stream
- Waterbody
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area

Scale:1:40,000

0 0.5 1 2

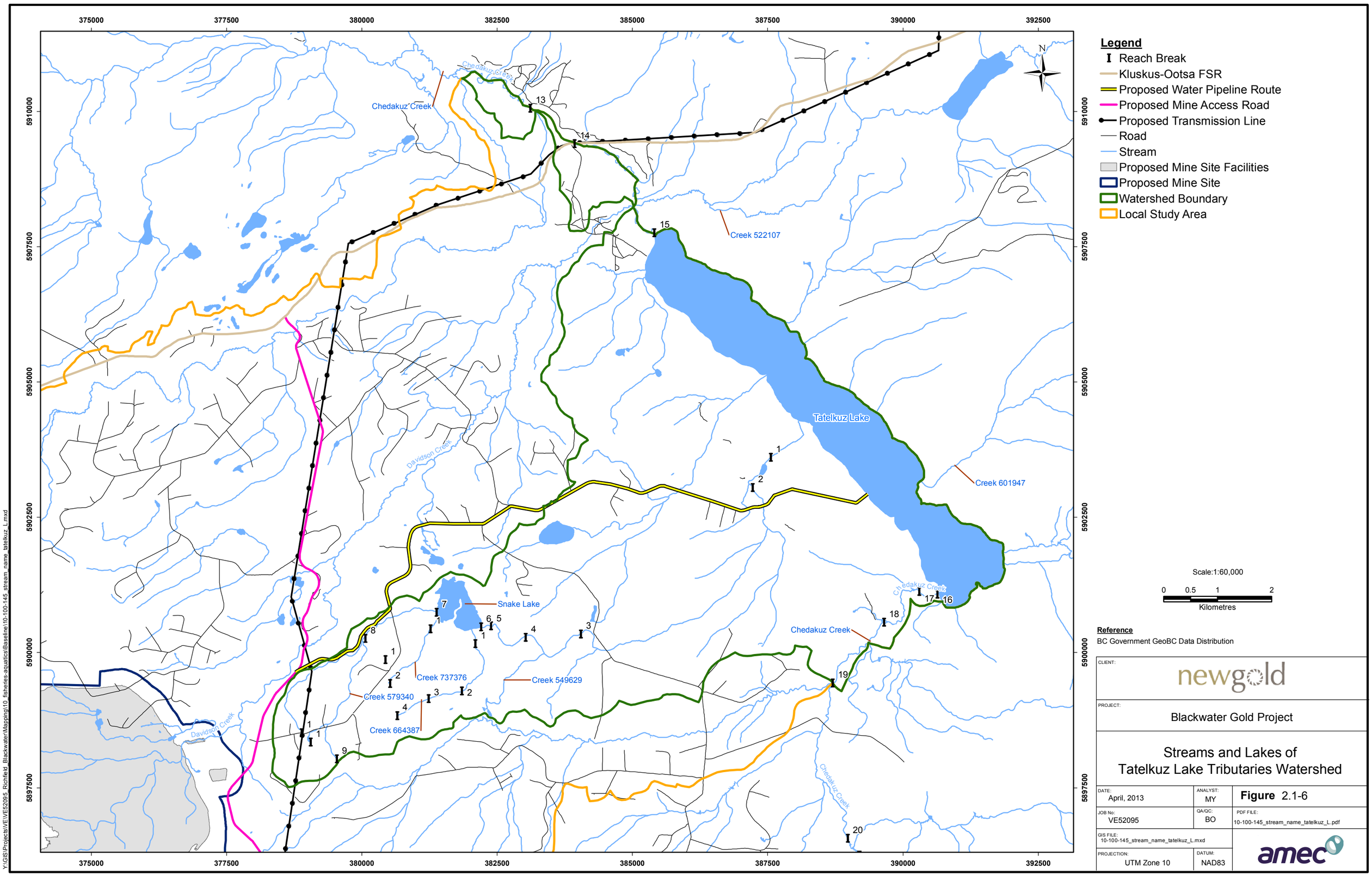
Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold		
PROJECT: Blackwater Gold Project		
Streams and Lakes of Creek 705 Watershed		
DATE: April, 2013	ANALYST: MY	**Figure** 2.1-5
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-144_stream_name_705.pdf
GIS FILE: 10-100-144_stream_name_705.mxd		amec
PROJECTION: UTM Zone 10	DATUM: NAD83	

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Legend

- Reach Break
- Kluskus-Ootsa FSR
- Proposed Water Pipeline Route
- Proposed Mine Access Road
- Proposed Transmission Line
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area

Scale:1:60,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

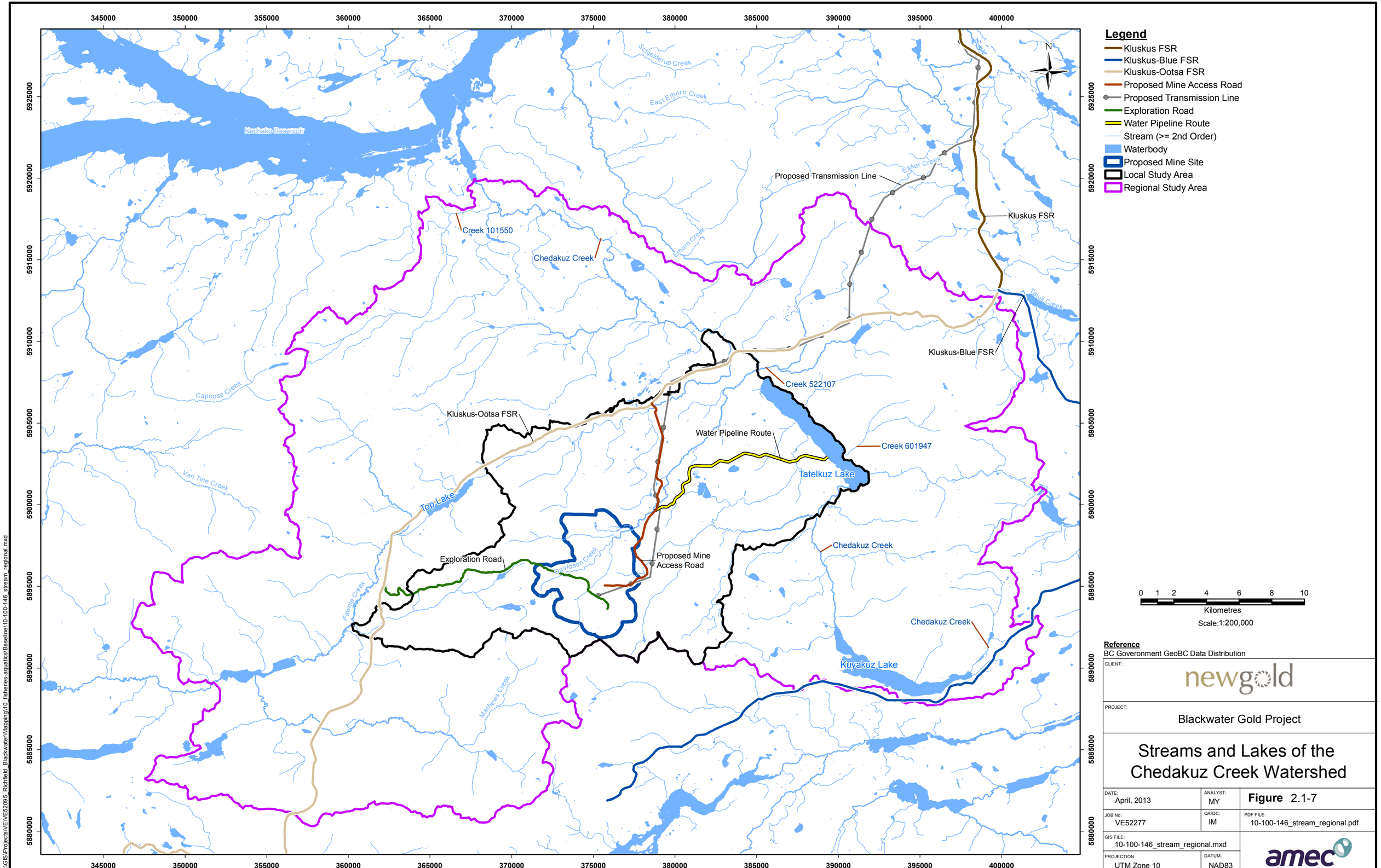
CLIENT: newgold

PROJECT: Blackwater Gold Project

Streams and Lakes of Tatelkuz Lake Tributaries Watershed

DATE:	ANALYST:	**Figure** 2.1-6
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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Reference
BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Streams and Lakes of the Chedakuz Creek Watershed

DATE: April, 2013	ANALYST: MY	**Figure** 2.1-7
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GIS FILE: 10-100-146_stream_regional.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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2.2 Regional Study Area

The Regional Study Area (RSA) is defined by CEAA as the area surrounding an LSA in which both direct and indirect effects may occur (CEAA 2013). The Aquatics RSA encompasses the whole of the Chedakuz Creek drainage and part of the Fawnie Creek drainage and includes the following streams and lakes (**Figure 2.1-1**):

- Kuyakuz Lake and all its tributaries;
- Middle Chedakuz Creek between Kuyakuz Lake and Tatelkuz Lake, and all its tributaries;
- Lower Chedakuz Creek between the confluence of Turtle Creek and the Nechako Reservoir, and all tributaries flowing into that stretch of the creek from the north-east and north-west;
- Tributaries to Chedakuz Creek between the outlet of Tatelkuz Lake and the confluence with Turtle Creek, including Davidson and Turtle creeks and those that drain Lake 113 and Mills Lake; and
- Upper Fawnie Creek Watershed from Laidman Lake upstream to Top Lake, and upstream of the headwaters of Creek 705 and Matthews Creek.

Section 3.1 provides a detailed summary of historical information on fish and fish habitat in lakes and streams of the RSA.

2.3 Transmission Line and Access Road Corridors

The Project will require connection to the BC Hydro electricity grid through construction of a 230 kV transmission line. The preferred route is a 133 km corridor that will connect with BC Hydro's 230 kV system at the Glenannon Substation near Fraser Lake (New Gold 2012). The route will run east from the substation for approximately 19 km and then south for another 114 km to the mine site (**Figure 1.2-2**).

Where possible, the route will follow existing logging roads and other disturbances (e.g., existing BC Hydro transmission line corridors) to avoid creating new disturbances. The corridor will be cleared to a width of 40 m, and will have 40 m-wide management zones on either side of the cleared strip to screen for danger trees that may fall on the line.

The proposed mine site is already accessed by vehicle from a network of forest service roads originating at the community of Engen, approximately 20 km west of Vanderhoof (**Figure 1.2-2**). Total distance from Engen to the mine site is approximately 194 km.

Both the transmission line and the access road will cross numerous streams. Culverts already exist at some crossings, and culverts will have to be installed at other crossings. Some culverts were installed incorrectly and may act as fish passage barriers during part or all of the year.

Section 3.1.3.3 and **Figure 3.2-1** provide more detail on the watersheds and streams that will be crossed by the transmission line and access road.

2.4 Waterbodies Not Affected by Project

The Project will not affect Fawnie Creek, Top Lake, tributaries of Mathews Creek, or the Blackwater River to the south of the RSA (**Table 2.4-1**). Therefore, baseline data collection was not necessary in those systems. The Blackwater River has been designated a "heritage river" by the BC MOE (BC MOE 2013a). It supports a diverse fish community, including chiselmouth (*Acrocheilus alutaceus*), a provincially blue-listed fish species (BC Conservation Data Centre (BC CDC) 2013). Because of this, the Blackwater Project has been specifically located and designed to avoid potential effects to the Blackwater River (New Gold 2011).

Table 2.4-1: Waterbodies Outside the Area of Potential Project Effects

Gazetted Name	BC Freshwater Atlas Code
Fawnie Creek	100-567134-641477-543682
Top Lake	01045UEUT
Mathews Creek	e.g., 100-567134-641477-543682-54870 and tributaries
Tributaries of the Blackwater River	e.g., 100-500560-668524 and tributaries

Notes: BC = British Columbia; ID = identifier

3.0 DATA GAP ANALYSIS AND STUDY DESIGN

Early in 2011, AMEC conducted a data gap analysis using historical information on fish, fish habitat, and aquatic resources collected in the LSA and RSA for forestry and mine exploration purposes. This analysis was then combined with an understanding of the potential linkages between the Project and the aquatic environment to develop baseline study tasks.

3.1 Review of Historical Data

Historical data on fish and aquatic resources in the LSA and RSA were available from studies conducted in the area since the late 1970s. These studies were locating using advice provided by BC MOE's *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012: Section 10.2).

3.1.1 Sources

The main sources of historical data were the following:

- Fish and fish habitat reconnaissance surveys completed by BC MOE on Tatelkuz Lake (Walsh and Hale 1977), Kuyakuz Lake (Burns 1977), Laidman Lake (Coombes 1985a), and Top Lake (Coombes 1985b);
- Fish distribution reports, and lake, stream, and stocking reports from the BC Fisheries Inventory Summary System (FISS) (BC FISS 2012), Fisheries Inventory Data Query (FIDQ), EcoCat, FishWizard, and HabitatWizard databases – all maintained by BC MOE (BC MOE 2013a, 2013b);
- Reconnaissance 1:20,000 fish and fish habitat inventory data provided by BC MOE for the Creek 705 Watershed (Golder Associates Ltd. (Golder) 1998);
- Fish and fish habitat inventory data obtained from CanFor Forest Products Ltd. for their Planning Areas 8, 14, 30, 72, 73 (DWB Forestry Services Ltd. (DWB) 2001, 2002, 2008; Ecofor Consultants Ltd. (Ecofor) 2004; Triton Environmental Consultants Ltd. (Triton) 2006);
- Stream and lake inventories of fish and fish habitat reported by contractors for the Chu Molybdenum Project in the drainage of Chedakuz Creek northeast of the Blackwater LSA (Avison 2010b, 2010c, 2010d); and
- BMI data from historical sampling sites within the study areas available on-line through the Canadian Aquatic Biomonitoring Network (CABIN) (CABIN 2011, 2012).

Secondary sources included the following:

- 1:20,000 stream network, Light Detection and Ranging (LiDAR) imagery, and ortho-photographs;

- Species summary and status reports from the BC Conservation Data Center (BC CDC);
- Vanderhoof Land and Resource Management Plan (British Columbia Integrated Land Management Bureau (BC ILMB) 1997);
- Vanderhoof Sustainable Forest Management Plan (BC ILMB 2010); and
- Reports on fish life history and habitat use cited by review papers such as Scott and Crossman (1973), Ford et al., 1995, and McPhail (2007).

Annex 3.1-1 shows historical fish habitat information, and **Annex 3.1-2** shows historical fish capture data. The following sections summarize those data.

3.1.2 Fish Habitat

3.1.2.1 Chedakuz Creek Watershed

Chedakuz Creek is situated along the northern flanks of the Fawnie Range within the greater Nechako Plateau, and drains into the Nechako Reservoir. The watershed is characterized by predominantly lodgepole pine (*Pinus contorta*) forests interspersed with natural meadows (BC MOF 1997). Upper Chedakuz Creek is the main tributary to Kuyakuz Lake. Middle Chedakuz Creek is approximately 12 km long and runs from the outlet of Kuyakuz Lake to the Inlet of Tatelkuz Lake. Below Tatelkuz Lake, the creek flows northwest through the Chedakuz Creek Valley for a distance of approximately 53 km into the Nechako Reservoir.

Timber harvest and road construction operations have occurred throughout the watershed for many decades. Ranches and hayfields are present in the lower valley downstream of Tatelkuz Lake (BC MOF 1997). On-going recreational activities in the watershed include hunting, fishing, hiking, and camping (Burns 1977; Walsh and Hale 1977; BC MOF 1997). The Tatelkuz Lake Ranch Resort is located on the northwest edge of Tatelkuz Lake and along the south side of Chedakuz Creek.

Kuyakuz Lake

A reconnaissance survey of Kuyakuz Lake was conducted in August 1977 by BC MOE (Burns 1977). It included bathymetry (**Table 3.1-1**), physical limnology, and surveys of fish and fish habitat.

Mountain alder (*Alnus tenuifolia*) is the dominant tree species around the lake perimeter. There is an open grass-dominated area on the north side of the lake. The surrounding terrain is mountainous with spruce (*Picea spp.*) and lodgepole pine forest.

Table 3.1-1: Bathymetry of Kuyakuz and Tatelkuz lakes, 1977

Lake	Unit	Kuyakuz Lake	Tatelkuz Lake
Elevation	masl	1,090	945
Surface Area	m^2	8,200,000	9,272,000
Volume	m^3	63,165,000	187,587,000
Mean Depth	m	7.7	20.2
Maximum Depth	m	14	29
Perimeter	m	16,940	21,300
Littoral Zone Area (<6 m depth contour)	m^2	5,284,000	8,006,000

Source: Burns (1977)
Notes: m = metre; m^2 = metres squared; m^3 = cubic metres

Vertical profiles of temperature and dissolved oxygen (DO) concentrations were recorded in the middle of the lake in August 1977. Temperature was 21.2°C at the surface and 13°C at a depth of 14 m with no obvious thermocline. DO was 9 mg/L at the lake surface and 0.6 mg/L at the lake bottom.

Potential spawning habitat for salmonid fish was reported in the mainstem of Chedakuz Creek downstream of the lake, as well as in one inlet stream located on the east side of the lake. The other inlets were unsuitable for spawning due to steep gradients or lack of gravel substrate.

A total of 353 fish were captured by a combination of beach seining, gill-netting and minnow trapping. A total of six species were identified, including 157 longnose sucker (*Catostomus catostomus*), 80 rainbow trout (*Oncorhynchus mykiss*), 66 lake chub (*Couesius plumbeus*), 19 kokanee (*Oncorhynchus nerka*), 15 mountain whitefish (*Prosopium williamsoni*), and 16 large-scale sucker (*Catostomus macrocheilus*).

Burns (1977) suggested that the lake water level was relatively high at the time of the survey because a beaver dam on the outlet was impeding downstream outflow. Despite the obstruction, Chedakuz Creek at the lake outlet was reported to contain mainly gravel substrates and was classified as potential spawning habitat. Juvenile mountain whitefish were the only fish species observed in the outlet during the survey.

Triton (2006) subsequently reported few spawning areas in Kuyakuz Lake, but noted that the lake provides good over-wintering habitat for fish.

Tatelkuz Lake

The BC MOE also completed a reconnaissance lake survey for Tatelkuz Lake in July 1977 (Walsh and Hale 1977) (**Table 3.1-1**). The shoreline of the lake is characterized by exposed cobble and sandy beaches. The surrounding forest is mixed lodgepole pine and spruce, with deciduous trees on the north side of the lake.

Tatelkuz Lake has six inlets, of which middle Chedakuz Creek is the major inlet, and one outlet (lower Chedakuz Creek). Based on the lake survey, two inlets and the outlet were reported to have spawning potential for salmonid fish. Numerous fish were observed, including rainbow trout fry and juveniles within the lake outlet. The Chedakuz Creek Inlet and Inlet Number 1 had gravel and cover, but no fish were observed there during the survey. The other four inlets have only marginal spawning and rearing capacity. In later surveys of the area, Triton (2006) also reported few spawning areas in Tatelkuz Lake, but suggested the lake provides good over-wintering habitat.

Two vertical profiles of temperature and DO were collected in July 1977. Temperatures were 14.6°C at the surface and decreased to 6.2°C at the lake bottom with a thermocline at about 9.0°C. DO concentrations were 9 and 10 mg/L at the surface, and 5 to 6 mg/L at the maximum depth of 29 m.

A total of 447 fish were captured in gill nets and minnow traps, including 195 mountain whitefish, 127 rainbow trout, 52 kokanee, 33 northern pikeminnow (*Ptychocheilus oregonensis*), 25 longnose sucker, 13 large-scale sucker, and 2 burbot (*Lota lota*).

Chedakuz Creek

Triton (2006) reported that lower Chedakuz Creek is a low gradient stream with extensive beaver activity. It provides good quality fish habitat with productive spawning, rearing, and over-wintering habitats. However, more barriers and obstructions to fish migration are present in the headwater tributaries of upper Chedakuz Creek upstream of Kuyakuz Lake. These include steep stream gradients, beaver dams, cascades, and one culvert obstruction. The mainstems of major tributaries within the upper watershed have the highest quality habitat.

Rainbow trout were the only fish species captured in the upper Chedakuz Creek Watershed during operational fish and fish habitat inventories completed in 2006 (Triton 2006). No historical information sources were identified that contained detailed fish and fish habitat data for middle Chedakuz Creek.

3.1.2.2 Fawnie Creek Watershed

Fawnie Creek Watershed drains the southern flanks of the Fawnie Range, to the southwest of Chedakuz Creek Watershed. Fawnie Creek is approximately 48 km in length, and flows a distance of 13 km from Top Lake to Laidman Lake. The surrounding topography is dominated by gently rolling hills in an area with deep deposits of glacial till (Coombes 1985a). Lodgepole pine forests dominate the lower elevations and frequent fires occur in the area (BC MOF 1997). Spruce and balsam are more common at higher elevations.

Timber harvesting began in the watershed in 1975 (Coombes 1985b; BC MOF 1997). Consequently, road construction has occurred throughout the watershed. Other activities include fishing and trapping (Coombes 1985a, 1985b).

Fawnie Creek

Upstream of Top Lake, the gradient of Fawnie Creek rises and the stream becomes too narrow and shallow to support valuable fish habitat (Coombes 1985a). Some obstacles to fish migration exist upstream of Top Lake, including beaver dams and cascades (FISS 2012). No fish were captured above the any of those obstructions (DWB 2001).

Downstream of Top Lake, Fawnie Creek flows through a swampy sedge meadow with a silt streambed. Although no potential spawning areas exist due to unsuitable substrates, this reach has good rearing potential (Coombes 1985a). The gradient is low to moderate and the few beaver dams along the mainstem are passable by fish (Coombes 1985b).

Stream gradient increases in Fawnie Creek further downstream and closer to Laidman Lake. The substrate changes to gravel and rock, and there is more spawning potential. Rainbow trout fry and longnose suckers are present in this section (Coombes 1985b). More beaver dams are downstream of Laidman Lake, but these are not major obstructions to fish passage (Coombes 1985b). The high presence of cover indicated good quality rearing habitat in this stream reach.

Operational fish and fish habitat inventories in upper Fawnie Creek Watershed captured one juvenile rainbow trout in Creek 705 (DWB 2001), and one lake chub in upper Matthews Creek (Ecofor 2004), a tributary to Laidman Lake.

One BC MOE biomonitoring site (VAN26) is located in an unnamed stream approximately 2 km downstream of Top Lake (**Appendices 3.1-1** and **3.1-2**). The site is located immediately upstream of the bridge on the Kluskus Forest Service Road (FSR) and the confluence to Fawnie Creek. Habitat data, water quality samples, and one BMI taxonomy sample was collected at this site in September 2006 using standard CABIN protocols (CABIN 2012). Of the 2,368 organisms counted in the sample, dipteran (midges, 29%), ephemeropteran (mayflies, 28%), tricopteran (caddisflies, 16%) and plecopteran (stoneflies, 16%) families composed the largest portion. Small counts of trombidiformes (water mites, 0.04%) were also observed.

In addition, during a lake survey conducted in 1985, many invertebrates were observed in this section of Fawnie Creek, including Coleoptera (beetles), Tricoptera (caddisflies), Plecoptera (stoneflies), Gerridae (true bugs), and small freshwater clams (Coombes 1985b).

Top Lake

Top Lake is situated in the headwaters of the Fawnie Creek Watershed. A survey of Top Lake was conducted in July 1985 for BC MOE (Coombes 1985a) (**Table 3.1-2**).

Table 3.1-2: Bathymetry of Top and Laidman Lakes, 1985

Lake	Unit	Top Lake	Laidman Lake
Elevation	masl	1,082	991
Surface Area	m^2	1,397,000	2,190,000
Littoral Area (<6 m deep)	m^2	316,000	1,680,000
Volume	m^3	14,500,000	9,730,000
Mean Depth	m	10	4.4
Maximum Depth	m	19	11
Perimeter	m	8,200	13,300

Source: Coombes (1985a, 1985b)

Notes: m = metre; m^2 = metres squared; m^3 = cubic metres

The shoreline of Top Lake is forested, and Engelmann spruce (*Picea engelmannii*), lodgepole pine, and amabilis fir (*Abies amabilis*) are the main tree species in the area. Lake substrate is derived from till, alluvial, and colluvial materials. Littoral substrates are mainly comprised of silts with a narrow gravel beach around the lake perimeter.

Temperature in July ranged from 18°C at the surface to 5.9°C at a depth of 10 m. DO concentrations ranged from 8.7 mg/L at the surface to 4.2 mg/L at the bottom (Coombes 1985a).

A total of 183 fish were captured using gillnets, including 118 longnose sucker, 33 mountain whitefish, and 32 rainbow trout (Coombes 1985a). Three minnow traps were set for a total of 54 trap-hours, but no fish were captured. At the time of the survey, there was a debris jam at the outlet of the lake. Small fish were observed upstream and downstream of the outlet, and it was determined that the obstruction was not a barrier to fish passage. Coombes (1985a) suggested that Top Lake offered good rearing habitat, but spawning habitat around the lake was poor due to the lack of suitable gravels.

Laidman Lake

Laidman Lake was surveyed in July 1985 for BC MOE (Coombes 1985b) (**Table 3.1-2**). The shoreline of Laidman Lake is mainly comprised of gravel substrates. The littoral zone is shallow and the lake bottom is flat with a clayey sand substrate (Agra Earth & Environmental (Agra) 2004). The surrounding vegetation is dominated by alder forest and some meadows (Coombes 1985b).

Temperature was 17.2°C at the surface of the lake and 15.1°C at the lake bottom, and DO concentrations ranged from 8.1 mg/L at the surface to 5.4 mg/L at a depth of 11 m (Coombes 1985b).

Gillnets captured a total of 167 fish, including 53 longnose sucker, 40 mountain whitefish, 29 rainbow trout, 23 large-scale suckers, and 22 northern pikeminnow (Coombes 1985b). Minnow traps captured two prickly sculpin (*Cottus asper*). At the time of the lake survey, there was a debris jam in the outlet created by beavers. However, numerous rainbow trout

were observed in the outlet ranging from 25 to 35 cm in length, indicating that the obstruction did not impede fish passage (Coombes 1985b).

Livestock grazing and recreation activities are widespread near the lake (Coombes 1985b). A camp with horses and cattle was situated near Matthew Creek on the south side of the lake, and some campsites were set at the main inlet (Coombes 1985b).

No kokanee were observed in the Fawnie Creek Watershed during the lake surveys and operational fish and fish habitat inventories (Coombes 1985a, 1985b; DWB 2001), but one kokanee was observed in Johnny Lake 10 km downstream of Laidman Lake (FISS 2012).

3.1.3 Historical Fish Inventories

3.1.3.1 Local Study Area

A total of 80 sites were sampled in the LSA during fish and fish habitat inventories conducted from 1997 to 2006 (Ecofor 2004; Triton 2006). Methods included backpack electrofishing, minnow trapping, and visual observations.

In the Davidson Creek Watershed, 28 individual fish sampling surveys were conducted at 26 sites. One rainbow trout was captured by electrofishing in Creek 226858 in May 2004. In July 2006, rainbow trout were observed in Creek 688328 and in another tributary named Creek 704454 in July 2006.

A total of 22 fish sampling surveys were conducted at 15 sites in the Turtle Creek Watershed in 2004 and 2006 (Ecofor 2004; Triton 2006). In May 2004, two rainbow trout were captured in Reach 3 of Turtle Creek in minnow traps. No fish were captured at any other sites in Turtle Creek, in Creek 700 (its main tributary), or in any other tributaries.

In 2006, sampling was conducted at 20 sites in Creek 661 (Triton 2006). One rainbow trout was captured in each of Reaches 1, 5 and 7 of the mainstem. Small numbers of rainbow trout were also captured in three tributaries to Creek 661 (Creeks 290525, 340300, and 505659).

A total of nine sites in the Creek 705 Watershed were sampled for fish from 1997 to 2004 (Golder 1998; DWB 2001; Ecofor 2004). In Creek 705, these included sampling sites in Reaches 2 and 3. Seven smaller tributaries to Creek 705 were sampled, inluding tributaries to Reach10 upstream of Lake 01538UEUT and Creek 606013 upstream of Lake 01428UEUT.

One rainbow trout fry was captured in Reach 2 of Creek 705, but no fish were captured in Reach 3. No fish were captured in any of the smaller tributaries to Creek 705 with the exception of the tributary to Creek 606013 upstream of Lake 01428UEUT. A total of 23

rainbow trout and one longnose sucker were captured at this location in July 1997 using backpack electrofishing and minnow trapping.

In 2006, ten fish sampling surveys were conducted in tributaries of Tatelkuz Lake (Triton 2006). No fish were captured at any sites. One rainbow trout was observed in a tributary to Creek 579340, which flows from Snake Lake into Tatelkuz Lake.

3.1.3.2 Regional Study Area

In 2008 and 2009, fish and fish habitat inventory surveys were carried out for the proposed Chu Molybdenum mining project in a watershed that drains via an unnamed creek into the eastern side of Chedakuz Creek downstream of Tatelkuz Lake (Avison 2010a, 2010b, 2010c, 2010d) (**Figure 2.1-1**). Part of that watershed falls within the northeast corner of the Blackwater Project RSA. The studies reported a fish community similar to that reported for the Blackwater LSA (i.e., rainbow trout, kokanee, longnose sucker, large-scale sucker, prickly sculpin, lake chub, mountain whitefish, and northern pikeminnow). Rainbow trout was the predominant species. Most streams in this unnamed watershed were classified as fish-bearing.

Mills Lake and Lake 113 were surveyed (**Figure 2.1-1**). Mills Lake is a small lake (60 ha) with a mean depth of 5.2 m, a maximum depth of 8.7 m, a perimeter of 3,956 m, and a volume of 3,101,484 m^3. Only 19.6% of its area (or 12 ha) is classified as littoral zone. A thermocline was recorded at a depth of 6 m, and anoxic conditions were measured below that depth. Six fish species were reported to be present: rainbow trout, mountain whitefish, northern pikeminnow, large-scale sucker, longnose sucker, and prickly sculpin. Lake chub were reported in the inlet, and kokanee were reported in the outlet.

Lake 113 is a small (32 ha), shallow lake. It has a mean depth of 1.5 m, a maximum depth of 2.9 m, a perimeter of 3,031 m, a volume of 463 683 m^3, and all of its area is classified as littoral zone. Rainbow trout were the only fish species captured in the lake.

A total of 65 whole-body samples of rainbow trout were collected from 11 stream sites and Mills Lake and Lake 113 in the Chu Molybdenum Project area and measured for tissue metal concentrations (Avison 2010a). In **Section 5.10.3.6** of this report that data is compared to metal concentrations measured from whole-body samples of rainbow trout collected from sites in the Blackwater Project LSA and RSA in 2011 and 2012.

3.1.3.3 Transmission Line Corridor and Access Road Corridor

Avison (2013) reviewed the historical data on fish and fish habitat in streams that may be crossed by the proposed transmission line corridor and access road corridor (**Annex 5.10-5**). Their sources were the habitat and fish inventory databases maintained by the BC MOE (BC MOE 2013b, 2013c).

Twenty of the proposed transmission line crossings are located in the Cheslatta River Watershed, with all of the associated drainages connected to the Swanson Creek system, a 28 km-long, fourth-order stream (**Figure 3.2-1**). Swanson Creek supports rainbow trout, mountain whitefish and numerous other non-game fish species. Chinook and sockeye salmon have been observed in the lower reaches of Swanson Creek.

Thirteen existing stream crossings by the access road are in the Chilako River Watershed, and all of the drainages are part of the Finger Creek system, a 17 km-long, fourth-order stream. Fish species in Finger Creek include rainbow trout, kokanee, prickly sculpin, and redside shiner (*Richardsonius balteatus*). There are documented obstacles upstream of Finger Lake including beaver dams and waterfalls that may limit fish passage.

There are 16 stream crossings associated with the transmission line and existing roads in the Euchinko River Watershed. All associated drainages flow into an unnamed system that eventually empties into Taiuk Creek. This fourth-order, unnamed stream is 17 km in length and contains rainbow trout, lake chub, and several unidentified species. There are no obstacles to passage identified on this stream or in upstream tributaries.

The Francois/Fraser Watershed includes 27 proposed transmission line stream crossings. The crossed drainages empty into the Robertson Creek and Stellako River systems. Both of these eventually empty into Fraser Lake. Robertson Creek is an 11 km-long, fourth-order drainage that supports lake chub, rainbow trout, longnose sucker, and redside shiner. There are no identified obstacles to fish passage along Robertson Creek or in its upper tributaries.

The Stellako River connects Francois Lake to Fraser Lake and supports Dolly Varden, kokanee, mountain whitefish, rainbow trout, and a variety of non-game fish species. The Stellako River contains important spawning areas for Chinook and sockeye salmon, and both species are observed throughout the river each year. Known obstacles to fish passage that may impede upstream migrations include a 1.5 m-high waterfall and numerous beaver dams.

A total of 90 potential stream crossings were identified in the Lower Nechako Reservoir Watershed (also known as the Knewstubb Lake basin). The crossings represent a mix of proposed and existing roads and proposed transmission line sites. The identified drainages are part of the Chedakuz Creek or Big Bend Creek systems. Big Bend Creek is a 37 km-long, fourth-order stream that flows from the Brewster lakes to the Nechako Reservoir. Documented species distributions are scarce for Big Bend Creek, but include rainbow trout and prickly sculpin. Several sucker species are also known to be present in the Brewster lakes.

The remaining 94 drainages are associated both with existing road or proposed transmission line crossings. The crossed drainages are part of the Stoney Creek, Engen Creek, Tahultzu Creek, Greer Creek, and three unnamed systems, which eventually empty into the Nechako River, or they represent smaller tributaries that empty directly into the Nechako River. The most common salmonid identified in these drainages is rainbow trout, especially in the upper reaches and tributaries. Except for the Nechako River, the only records of anadromous fish observations in any of the creeks potentially crossed by the

access road and transmission line include coho, Chinook, and sockeye salmon in the lower reaches of Greer Creek.

The nearest and only fish species at risk identified in all of the drainages above is the red-listed white sturgeon (*Acipenser transmontanus*), which is concentrated in the middle reaches of the Nechako River, about 4.5 km from the nearest proposed stream crossing.

3.1.4 Fisheries in the Study Areas

There are no commercial fisheries within the LSA, the RSA, or along the transmission line and road access corridors.

There are recreational fisheries for rainbow trout within the RSA, as evidenced by the resort at the northern end of Tatelkuz Lake. However, the magnitude and intensity of the recreational fisheries are not known because there have been no creel surveys in the area. All recreational fisheries in the RSA are expected to be lake-based because streams support only juvenile fish, mainly rainbow trout, except for brief periods of time when adult rainbow trout (in the spring) and kokanee (in the fall) migrate into streams to spawn.

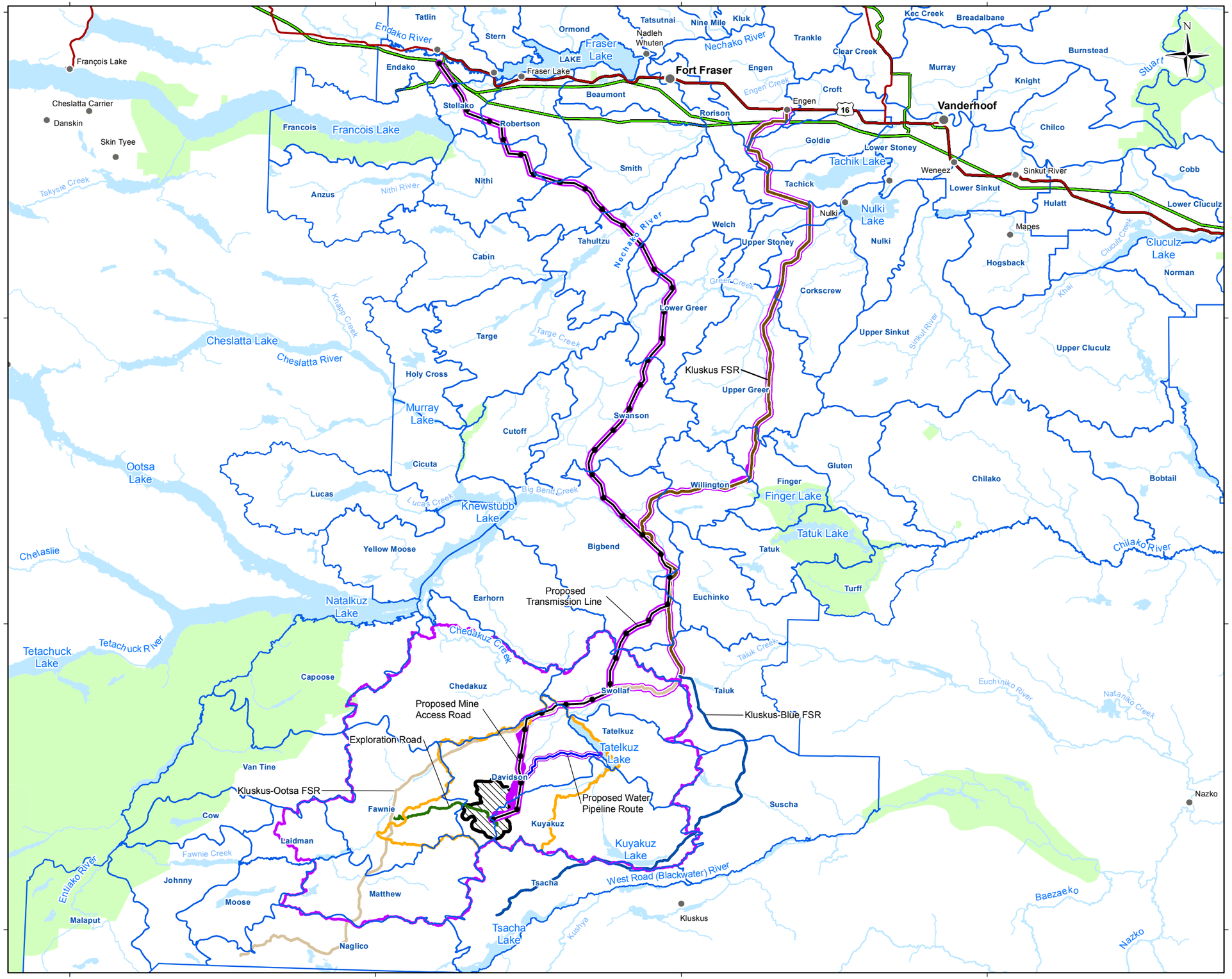
There are current Aboriginal fisheries in the RSA and along the corridors, as evidenced by the presence of an Aboriginal reserve at the northern end of Tatelkuz Lake. There have also been historical Aboriginal fisheries, as evidenced by the numerous archaeological sites distributed along the shorelines of Tatelkuz and Kuyakuz lakes (New Gold 2012). More detailed information on Aboriginal fisheries in the study area is currently being gathered as part of Traditional Knowledge (TK) and Traditional Use (TU) studies. Those TK/TU studies will eventually be used to support an application for an EA Certificate for the Project.

3.2 Data Gaps

The review of historical information showed there was a lack of basic information on fish and fish habitat in the LSA and along the transmission line and road access corridors.

There was some information on stream temperatures, but it was not sufficient in time or space to predict the impact of mine development, or the success of mitigation and compensation measures, on stream temperatures.

There was very little information on the biomass, density, and taxonomic composition of lower trophic levels of the aquatic food chain such as periphyton, BMI, phytoplankton, and zooplankton.



Legend

- Populated Place
- Highway
- Exploration Road
- Existing Transmission Line
- Stream
- Watershed
- Waterbody
- Parks & Protected Areas
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Water Pipeline Route
- Proposed Mine Site

Aquatic Environment & Wetland

- Regional Study Area
- Local Study Area

Scale: 1:500,000

0 5 10 20

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Map of the Transmission Line and Access Road Corridors Showing Major Watersheds

DATE:	ANALYST:	
April, 2013	WR	**Figure** 3.2-1
JOB No: VE52095	QA/QC: LR	PDF FILE: 10-100-136_overview_sub_basin.pdf
GIS FILE: 10-100-136_overview_sub_basin.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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There was also no information on concentrations of metals in tissues of fish. Metal concentrations in fish tissue is a basic information requirement for environmental effects monitoring of a proposed metal mine, as described by Environment Canada's (EC) *2010 Metal Mining EEM Technical Guidance Document* (EC 2011), and BC MOE's *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012).

Information on fish habitat was also sparse and much more needed to be collected to predict Project effects, to identify critical areas, and to quantify potential losses and gains.

Historical information showed that rainbow trout and kokanee are the dominant fish species in the area. However, there was no information on the number of populations of those two species, and little information on their absolute and relative numbers, spatial distribution, seasonal migrations, and key biological characteristics. Locations of spawning, rearing, and over-wintering habitat were not well documented.

Although recreational and Aboriginal fisheries exist in the study area, there is no information currently available on the locations, spatial extent, and intensity of those fisheries. Any fisheries that exist are assumed to be lake-based because rainbow trout fry and juveniles dominant the fish communities of streams in the study area.

3.3 Study Design

The study design was based on the data gap analysis described above, on the preliminary Project Description and footprint (New Gold 2012), on the typical data requirements for an environmental assessment of a metal mine in BC, and on the following guidelines:

- BC MOE's *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012);
- Environment Canada's (EC) *2010 Metal Mining EEM Technical Guidance Document* (EC 2011);
- Standards and procedures for fish and aquatic field inventories established by the BC Resources Information Standards Committee (RISC) (RISC 1997, 1999a, 1999b, 2000, 2001, 2008, 2009a, 2009b);
- Other standards and procedures for fish and aquatic field inventories developed by the BC government (Johnston and Slaney 1996; Clarke 2003; Beatty et al., 2006);
- Procedures for lake benthos sampling established by the Ontario Ministry of Environment (Jones et al., 2004);
- CABIN protocols for field surveys of streams (EC 2010), and for laboratory methods of processing BMI (McDermott et al., 2010); and
- Protocol for derivation of fish tissue residue guidelines for the protection of wildlife consumers of aquatic biota established by the Canadian Council of Ministers of the Environment (CCME) (CCME 1998).

Baseline studies in the LSA and RSA had to include the following components:

- Continuous stream temperature monitoring;
- Surveys of biomass, density, and taxonomic composition of lower trophic levels (i.e., periphyton and BMI in streams and phytoplankton, zooplankton, and BMI in lakes);
- Comprehensive surveys of fish habitat in streams and lakes;
- Surveys to determine the size, timing, and species composition of spring and fall spawning migrations in streams potentially affected by the Project;
- Surveys to determine locations of critical spawning, rearing, and overwintering habitat for rainbow trout and kokanee;
- Measurement of tissue metal concentrations in fish resident in streams and lakes potentially affected by the Project;
- Surveys of relative abundance and biological characteristics of rainbow trout and kokanee throughout their life cycle and over the areas covered by their seasonal migrations; and
- Surveys to determine the genetic relatedness of rainbow trout and kokanee populations of different lakes and streams in the study area to other population in BC.

A multi-year baseline program was required to collect these data. Because the Project was still under development in 2011, early emphasis was placed on characterizing the physical and biological attributes of the mainstem creek reaches closest to the proposed mine site, i.e., Davidson Creek, Turtle Creek, Creek 661, and Creek 705. Several study components were deferred to 2012 to allow further development of the Project design, as well as opportunities for consultation with provincial and federal regulatory agencies, local First Nations, and stakeholders.

Tasks completed in 2011 included the following:

- Reconnaissance surveys during spring to identify and validate reach and watershed boundaries;
- Installation of water temperature data loggers in streams during the spring;
- Sampling of periphyton and BMI for measurement of density and taxonomic composition at stream sites during late summer;
- Characterization of fish habitat at stream sites during the summer low flow period;
- Characterization of fish habitat in headwater lakes during the late summer period through bathymetric surveys, vertical profiles of temperature and DO, and habitat assessments of the littoral zone;
- Survey of abundance, timing and biological characteristics of rainbow trout during the spring spawning period within selected drainages using hoop nets;
- Survey of presence/absence, species diversity, relative abundance, and biological characteristics of fish communities during summer months at stream and lake sites;

- Survey of kokanee spawner distribution and number through streambank counts on two main drainages in late summer;
- Collection of samples of rainbow trout tissue (whole-body, muscle and liver) from stream and lake sites for measurement of tissue metal concentrations; and
- Collection of samples of rainbow trout tissue for analysis of microsatellite DNA so as to identify population structure.

The Project team prepared a baseline report of the 2011 field studies. That report was incorporated into the present report for 2011 and 2012.

In 2012, the LSA expanded to include Tatelkuz Lake and the Creek 705 Watershed, and the RSA expanded to include the entire Chedakuz Creek Watershed and the upper Fawnie Creek Watershed. Tatelkuz Lake was included in the LSA because New Gold concluded that it was the only feasible source of the large quantities of water that were needed for mine processing purposes and to maintain flows in Davidson Creek during construction, operation and post-closure phases on the Project. Creek 705 Watershed was included in the LSA because one of the major fish habitat compensation options included damming the outlet of Lake 01682LNRS, the headwater lake of Davidson Creek, and creating a new outlet that would send water through a short, natural channel into Lake 01538UEUT in upper Creek 705. Due to the expansion of the LSA, the RSA was also expanded.

The design of the 2012 program had three goals:

- Continuing programs from 2011 (such as stream temperature monitoring) so as to measure among-year variation in aquatic ecology;
- Completing surveys that had been initiated in 2011 (such as periphyton and BMI sampling, summer fish and fish inventories, kokanee spawner surveys, and sampling of rainbow trout tissue for metal concentrations); and
- Conducting surveys that had been deferred in 2011 such as sampling phytoplankton, zooplankton and BMI in the three headwater lakes, surveying kokanee spawner distribution and number in the RSA, and sampling kokanee for tissue samples for microsatellite DNA analysis.

The goals for 2011 and 2012 did not include estimating population numbers for rainbow trout and kokanee in the streams and lakes of the LSA. That goal would have to involve a hydroacoustic survey of the fish community of Tatelkuz Lake, the principal overwintering lake of the LSA. That work was set aside for a later date when the mine planning process had reached a point where the mine's water requirements were well understood.

Tasks for the 2012 baseline field programs included:

- Continuing stream temperature monitoring and installing new data loggers;

- Completing vertical profiles of temperature and DO in three headwater lakes during the late summer period;
- Sampling periphyton and BMIs during the late summer period at stream sites, including additional sites and reference streams, for taxonomic composition and tissue metals concentrations;
- Sampling phytoplankton, zooplankton, and BMIs during the late summer period at three headwater lakes for measurement of taxonomic composition, density, biomass, and tissue metals concentrations (BMI only);
- Characterization of available habitat for fish at stream sites by conducting fish habitat assessments during summer base flows;
- Survey of fish presence/absence, species diversity, relative abundance, and biological characteristics of fish communities during the summer months at stream and lake sites;
- Collection of samples of rainbow trout tissue (whole-body, muscle and liver) from stream and lake sites for measurement of metal concentrations;
- Survey of fish and fish habitat in streams that will be crossed by the proposed transmission line and access road corridors;
- Survey of kokanee spawning distribution and abundance through stream bank counts on two main drainages during late summer;
- Collection of samples of kokanee tissue for analysis of microsatellite DNA; and
- Survey of the mountain whitefish spawning migration in the late summer and autumn using hoop nets.

Table 3.1-1 and **Table 3.1-2** show the overall design of the baseline studies for the LSA and RSA, respectively. They show each component of the study and the number of sampling sites for each component, distributed across watersheds. The exception to that rule were fish tissue samples for metals analysis and microsatellite DNA analysis where the total number of fish sampled are shown rather than the number of sampling sites because fish tissue samples were taken from a large number of sites.

The study design for the surveys of stream crossings of the transmission line and access road corridors consisted of only one component – reconnaissance 1:20,000 fish and fish habitat inventories, as described by RISC (2001).

Table 3.3-1: Number of Sampling Sites, Fish and Aquatic Resources, Blackwater Project Local Study Area, 2011 and 2012

Field Component	Units	Watershed					Total
		Davidson Creek	Turtle Creek	Creek 661	Creek 705	Tatelkuz Lake Tributaries	
Reconnaissance overflights	n/a	yes	yes	yes	yes	yes	yes
Stream temperature monitoring	Dataloggers[1]	7	3	3	1	1	15
Stream periphyton	Sites	3	0	0	2	0	5
Stream benthic macroinvertebrates	Sites	5	2	2	2	1	12
Phytoplankton (lakes)	Sites	1	0	0	2	0	3
Zooplankton (lakes)	Sites	1	0	0	2	0	3
Lake benthic macroinvertebrates (littoral)	Sites	1	0	0	2	1	4
Lake benthic macroinvertebrates (profundal)	Sites	1	0	0	2	2	5
Fish habitat (streams)	FHAP sites	22	5	5	0	2	34
	Recon. 1:20,000K sites	64	10	21	5	13	113
Fish habitat (lakes)	Sites	1	0	0	2	0	3
Spring rainbow trout spawning survey	Hoop nets	2	3	2	1	0	8
Summer fish inventory (streams)	Sites	33	9	16	4	8	70
Summer fish inventory (lakes)	Sites	1	0	0	2	1	4
Summer-fall kokanee spawning survey	Sites	1	0	1	0	2	4
Fall mountain whitefish spawning survey	Sites	1	1	1	1	0	4
Fish tissue metals concentrations	Fish	17	16	15	39	0	87
Fish microsatellite DNA sampling	Tissue samples[2]	71	32	71	59	65	298

Notes: [1]includes Knight Piésold hydrometric stations
[2]includes both rainbow trout and kokanee
n/a = not applicable

Table 3.3-2: Number of Sampling Sites, Fish and Aquatic Resources, Blackwater Project Regional Study Area, 2011 and 2012

Field Component	Units	Watershed				Total
		Chedakuz Creek	Fawnie Creek	Blackwater River	Meadow Creek	
Reconnaissance overflights	n/a	yes	yes	yes	no	
Stream periphyton	Sites	0	1	1	0	2
Stream benthic macroinvertebrates	Sites	0	1	1	0	2
Fish habitat (streams)	Recon. 1:20,0000 sites	4	0	0	0	4
Summer/fall kokanee spawning survey	Sites	4	0	0	0	4
Fish microsatellite DNA sampling	Tissue samples[1]	68	33	0	30	131

Notes: [1]includes both rainbow trout and kokanee
n/a = not applicable

4.0 METHODS

This section describes the methods used in the baseline studies conducted in 2011 and 2012.

4.1 Mapping, Stream Names, and Reach Break Analysis

An office-based study of map resources was conducted in spring 2011 before field studies could begin. The drainage network of the LSA and RSA was defined using three sources:

- the provincial 1:20,000 Freshwater Atlas stream and waterbody data layer (BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO 2011);
- 1 m topographic contours from LiDAR imagery; and
- 5 m topographic contours from the provincial GeoBC Land and Resource Data Warehouse dataset in a Geographic Information System (GIS), specifically ArcGIS 10.0.

Stream and waterbody identifiers were derived using BC Freshwater Atlas codes, which were used for planning purposes and in the development of stream and lake naming conventions to support the baseline reporting. Local names for streams were derived using the last six digits of the Freshwater Atlas Code (e.g., Creek 704454) and waterbody identifiers for lakes (e.g., Lake 01538UEUT). The BC Freshwater Atlas was selected because it provides codes for all streams classified as permanent at 1:20,000 resolution. The older BC Watershed Atlas only provides codes for most streams mapped as permanent at 1:50,000 resolution. Several stream names (e.g., Creek 661) were established during the early planning stages using the first three digits of the last number string of the older BC Watershed Atlas Codes. These names were retained to maintain consistency within proposed Project documentation. Interim Location Points (ILPs) were assigned to streams mapped as intermittent at 1:20,000 resolution and therefore were not assigned a BC Freshwater Atlas Code.

Reach breaks were identified for watercourses in Davidson Creek, Turtle Creek, Creek 661, and Creek 705 watersheds based on *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Reach Information Guide* (RISC 2000) and *Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001). Reaches are relatively homogenous sections of streams having a sequence of repeating structural characteristics (i.e., channel pattern, confinement, morphology, streambed substrates, and bank materials), and similar gradient, processes (e.g., uniformity in discharge), and fish habitat types. Reaches were numbered sequentially for each stream, beginning with Reach 1 at the lowest elevation and increasing reach numbers with increasing upstream distance elevation.

Topographic maps and LiDAR data were used to make preliminary identifications of the locations of fish passage barriers, based on steepness of channel gradient or location of potential culvert barriers.

Finally, a reconnaissance trip and aerial survey was conducted early in 2011 to validate watershed boundaries and reach breaks within the LSA, and to identify potential barriers to fish passage. Those were further ground-truthed during the 2011 and 2012 field studies.

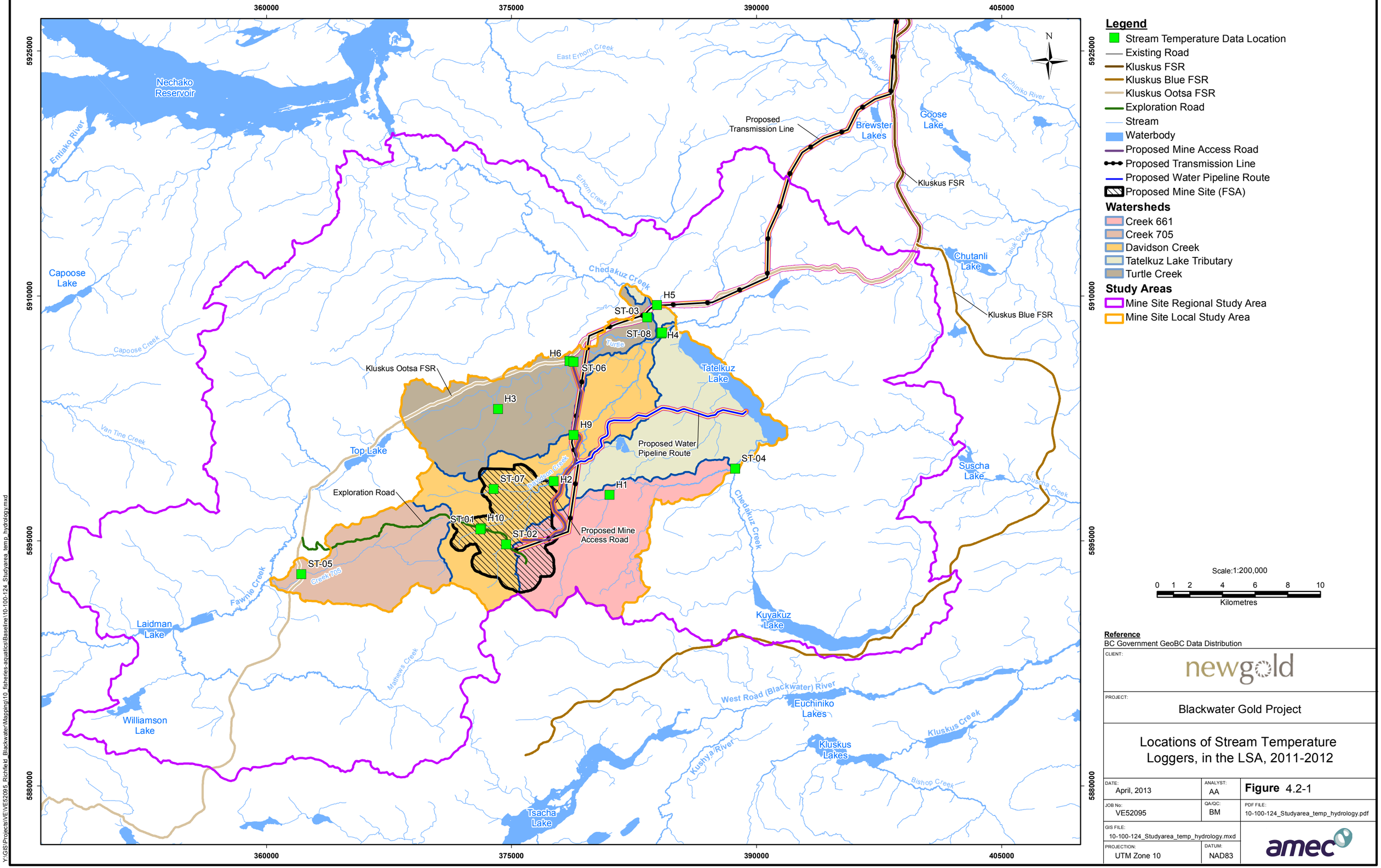
4.2 Stream Water Temperature

Temperature is a crucial determinant of biological processes in streams. It influences survival and growth of periphyton, benthic macroinvertebrates, and fish. Freezing of streams during the winter restricts available overwintering habitat and can have profound impacts on the distribution and abundance of fish populations. During the open water season, low water temperatures can impede growth and survival; high temperatures can similarly impede growth or, if too high, can be fatal.

Temperature data loggers (HOBO Tidbit, Onset Computer Corp.) were installed at five stream sites in the LSA in spring 2011 and were downloaded in the fall (**Figure 4.2-1**, **Plate 4.2-1** and **Table 4.2-1**). They were left in each stream over the winter of 2011-2012, and were downloaded again in the spring and fall of 2012. In spring of 2012, additional data loggers were installed at three new stream sites in the LSA. All data loggers were set to measure and record stream water temperatures continuously at 30 min intervals.

Stream temperatures were also obtained from data loggers attached to five hydrometric sites installed and maintained by Knight Piésold within the LSA (**Figure 4.2-1**, **Plate 4.2-2**, and **Table 4.2-1**). (Note that **Figure 4.2-1** shows only those five hydrometric sites to which temperature data loggers were attached. Knight Piésold (2013) shows the full list of hydrometric sites). Stream temperatures at the hydrometric sites were recorded at 15 min intervals from late May to early November 2011 and 2012. These hydrometric stations are removed each fall before they can be damaged by ice, and are re-installed each spring.

To date, the only interruption to continuous stream temperature measurement occurred at site ST-05 in Creek 705 from 11 August to 9 September 2011, when the data logger was exposed to the air due to low stream flows. Data were downloaded from that logger on September 9, 2011, and the logger was moved to a more suitable location several hundred meters downstream to ensure it remained submerged during low flow conditions.



Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Locations of Stream Temperature Loggers, in the LSA, 2011-2012

DATE:	ANALYST:	
April, 2013	AA	**Figure** 4.2-1
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-124_Studyarea_temp_hydrology.pdf
GIS FILE: 10-100-124_Studyarea_temp_hydrology.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Plate 4.2-1: Temperature data logger installed in Davidson Creek, 17 June 2011



Plate 4.2-2: Hydrometric data logger installed in Turtle Creek, 17 June 2011

Table 4.2-1: Stream Temperature Data Logger Locations, and Dates of Installation and Data Retrieval

Stream	Baseline Map Site ID	Location (UTM[1])		Deployment Dates	Data Retrieval Dates	Comments
		Easting	Northing			
Lower Davidson Creek[2]	H4	384162	5907699	20-May-11 18-Jun-12	08-Nov-11 16-Sep-12	At ranch road
Middle Davidson Creek	H2	377586	5898645	19-May-11 10-May-12	08-Nov-11 07-Nov-12	Reach Break 7.1
Upper Davidson Creek[3]	H10	373139	5895780	10-Jun-11 continuous	09-Sep-11 8-Nov-12	At Blackwater Camp Road
Creek 428073	H9	378806	5901498	n/a 10-May-12	n/a 17-Oct-12	Outlet flow from Three Ponds area
Creek 688328	ST-07	373909	5898184	n/a 19-Jun-12	n/a 16-Sep-12	At Priority Road C;, tributary to Davidson Creek
Creek 704454	ST-02	374670	5894770	10-Jun-11 continuous	09-Sep-11 16-Sep-12	At Blackwater Camp Road; tributary to Davidson Creek
Lower Creek 661	ST-04	388684	5899435	9-Jun-11 continuous	09-Sep-11 14-Sep-12	Upstream of Chedakuz Creek confluence
Upper Creek 661	H1	381002	5897828	19-May-11 15-May-12	n/a 07-Nov-12	Downstream of Creek 505659 confluence
Lower Turtle Creek	ST-03	383309	5908697	10-Jun-11 continuous	09-Sep-11 16-Sep-12	At Oostsa FSR
Middle Turtle Creek[4]	H6	378554	5906018	n/a 17-Jun-12	n/a 16-Sep-12	At Davidson Main Road
Creek 700	H3	374174	5903066	19-May-11 11-May-12	n/a 08-Nov-12	Upstream of Turtle Creek confluence
Creek 705[5]	ST-05	362121	5892938	10-Jun-11 continuous	09-Sep-11 16-Sep-12	At Ootsa FSR
Lower Chedakuz Creek	H5	383902	5909444	19-Apr-11 11-Apr-12	08-Nov-11 08-Nov-12	At Ootsa FSR

Notes: [1] NAD 83, Zone 10
[2] 2011 data from hydrometric station; 2012 data from TIDBIT
[3] 2011 data from TIDBIT, 2012 data from TIDBIT and hydrometric station
[4] Temperature data from TIDBIT at this location
[5] No data available from 11 August to 9 September 2011

Hx = hydrology station with attached temperature data logger, ST-x = temperature data logger only, FSR = Forest Service Road; ID = identification; km = kilometre; UTM = Universal Transverse Mercator; continuous = logger left in place over winter.

4.3 Periphyton

Periphyton is a complex mix of algae, bacteria and protozoans attached as a biofilm to submerged surfaces in streams and lakes. It is the primary photosynthetic community in streams. Periphyton is an important food source for BMI in streams (RISC 2009b). Because it is fixed to the substrate during spring and summer, periphyton is sensitive to changes in flows, water temperature, and water quality. Hence, it is an early indicator of stress in EEM programs, although its high spatial and temporal variability means that BMI are usually preferred to periphyton as bio-monitors.

The objective of sampling periphyton was to measure density (cells/cm^2), biomass (the concentration of chlorophyll *a*, the dominant photosynthetic pigment, expressed as µg/cm^2),

and taxonomic composition during mid-summer (August to early September) when the periphyton community is at its peak of biomass and species diversity.

4.3.1 Field Sampling

Nine stream sites were sampled for periphyton in 2011, and seven sites were sampled in 2012 (**Figure 4.3-1** and **Table 4.3-1**). These included five new sites established in 2012, of which two (BI-13 and BI-14) are potential reference sites (i.e., an undisturbed site that may be used for comparison with sites potentially affected by Project activities). Only two sites were sampled for periphyton in both 2011 and 2012 to measure inter-annual variability: Lower Davidson Creek (BI-01) and Creek 705 (BI-09). The other 14 sites were sampled only once in either 2011 or 2012.

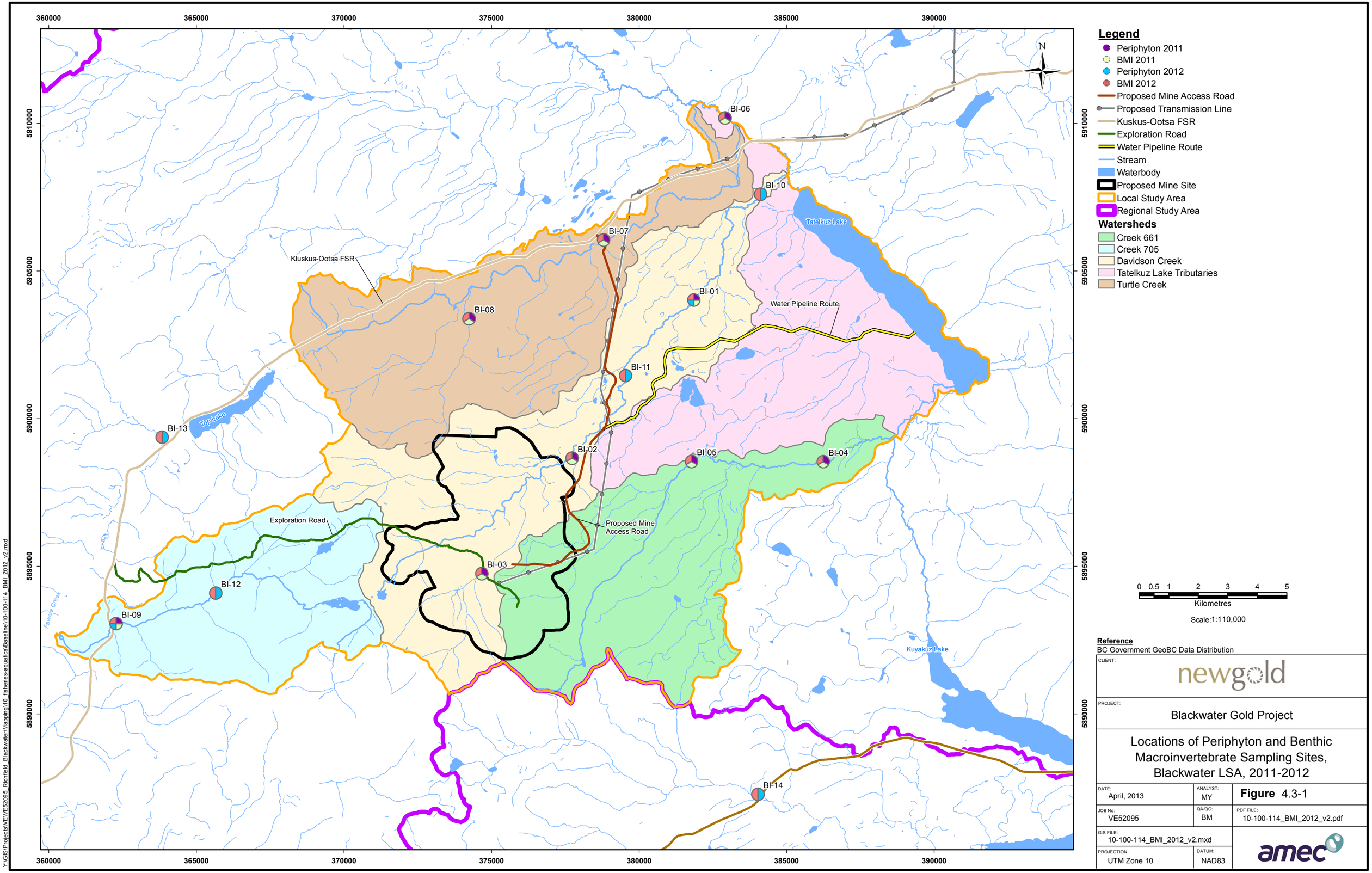
Methods for collecting periphyton samples followed the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012), and the *British Columbia Field Sampling Manual* (Clark 2003). Sampling sites were located in cobble substrates in riffles. At each sampling site, habitat data were collected following the CABIN protocol for wadeable streams (EC 2010). It included supporting explanatory variables required for metal mining EEM (EC 2011). Collected data included the following:

- Site elevation and location measured with a handheld GPS;
- Air temperature measured with an alcohol thermometer;
- pH, water temperature, conductivity, and DO concentration (upstream of the sample site and prior to sampling) measured with a YSI 665 multimeter;
- Macro-habitat type, percent canopy cover, percent macrophyte and periphyton cover, and riparian vegetation type estimated by visual observation;
- Stream channel width and wetted width measured with a tape measure;
- Stream gradient measured with a survey rod and level;
- Water depth and mean water column velocity at stream bottom measured with a Swoffer Current Meter 2100 and a graduated wading rod; and
- Substrate pebble count (including an estimate of embeddedness) estimated by visual observation.

Table 4.3-1: Stream Periphyton and Benthic Macroinvertebrate Sampling Sites in 2011 and 2012

Stream	Baseline Map Site ID	2011 Sampling Date	2012 Sampling Date	Location (UTM[1])		Site Rationale
				Easting	Northing	
Davidson Creek near the mouth	BI-10	n/a	10-Sep	384114	5907603	Gradient design location paired with BI-01
Lower Davidson Creek	BI-01	31-Aug	5-Sep	381854	5904018	Potential water quality and flow changes; resampled to capture inter-annual variation
Mid Davidson Creek	BI-11	n/a	14-Sep	379544	5901458	Gradient design location paired with BI-01
Upper Davidson Creek	BI-02	31-Aug	n/a (P); 13-Sep (BMI)	377728	5898659	Potential water quality and flow changes
Creek 704454	BI-03	4-Sep	n/a (P); 7-Sep (BMI)	374668	5894747	Proposed Project mine site, potential food/nutrient supply
Lower Creek 661	BI-04	2-Sept	n/a (P); 9-Sep (BMI)	386237	5898542	Potential water quality and flow changes;
Upper Creek 661	BI-05	3-Sept	n/a (P); 11-Sep (BMI)	381775	5898547	Potential water quality and flow changes
Turtle Creek	BI-07	1-Sept	n/a (P); 6-Sep (BMI)	378796	5906055	Potential water quality and flow changes;
Creek 700	BI-08	30-Aug	n/a (P); 8-Sep (BMI)	374238	5903388	Potential water quality and flow changes
Chedakuz Creek	BI-06	21-Sep	n/a (P); 10-Sep (BMI)	382910	5910188	Potential water quality and flow changes, integrates potential upstream effects
Lower Creek 705	BI-09	29-Aug	7-Sep	362275	5893055	Potential water quality and flow changes; resampled to capture inter-annual variation
Upper Creek 705	BI-12	n/a	12-Sep	365653	5894088	Gradient design location paired with BI-09
Tributary to Fawnie Creek	BI-13	n/a	21-Sep	363839	5899370	Potential reference site
Tributary to the Blackwater River	BI-14	n/a	15-Sep	384027	5887271	Potential reference site

Notes: [1] NAD 83, Zone 10
P = periphyton; BMI = benthic macro-invertebrate; n/a = not applicable


360000
365000
370000
375000
380000
385000
390000
5910000
5905000
5900000
5895000
5890000
N
BI-06
BI-10
BI-07
BI-01
BI-08
BI-11
BI-13
BI-02
BI-05
BI-04
BI-03
BI-12
BI-09
BI-14
Kluskus-Ootsa FSR
Water Pipeline Route
Tatelkuz Lake
Top Lake
Exploration Road
Proposed Mine Access Road
Fawnie Creek
Kuyakuz Lake
Legend
Periphyton 2011
BMI 2011
Periphyton 2012
BMI 2012
Proposed Mine Access Road
Proposed Transmission Line
Kuskus-Ootsa FSR
Exploration Road
Water Pipeline Route
Stream
Waterbody
Proposed Mine Site
Local Study Area
Regional Study Area
Watersheds
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
0 0.5 1 2 3 4 5
Kilometres
Scale:1:110,000
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Locations of Periphyton and Benthic Macroinvertebrate Sampling Sites, Blackwater LSA, 2011-2012
DATE: April, 2013
ANALYST: MY
Figure 4.3-1
JOB No: VE52095
QA/QC: BM
PDF FILE: 10-100-114_BMI_2012_v2.pdf
GIS FILE: 10-100-114_BMI_2012_v2.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
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Cobbles were selected randomly from a water depth ranging between 0.2 and 0.4 m and mean stream velocity ranging between 0.3 and 0.5 m/s. Periphyton was collected from the surface of cobbles by gently scraping a known surface area using a toothbrush and washing the fragments into a rinse bottle. Two circular samples were collected from each cobble, each 5 centimetres (cm) in diameter, one for taxonomy and one for biomass.

Taxonomy samples were preserved with 5% Lugol's iodine solution in 125 mL plastic bottles. Samples for chlorophyll *a* analysis were stored in 125 mL plastic bottles wrapped in foil (to reduce photosynthesis after collection), and stored in a cooler on ice until they could be processed in camp. In the evening, those samples were filtered, under low light conditions, through a 0.45 micrometre (µm) membrane filter paper using a hand vacuum pump and filter apparatus. Magnesium carbonate ($MgCO_3$) solution was added to each sample as a buffer to prevent any potential acidic degradation of the chlorophyll. The filter and filtrate were carefully placed in a larger Whatman filter, folded with the residue to the inside, labelled, and sealed in amber glass bottles containing a desiccant. The bottles were then wrapped in foil, and frozen for later transport to the analytical laboratory.

A total of 80 periphyton samples were collected for taxonomic analysis. In 2011, five replicate samples were collected at each of nine sites for a total of 45 samples. In 2012, five replicate samples were collected at seven sites for a total of 35 samples.

4.3.2 Laboratory Analysis

In 2011 and 2012, periphyton samples were analysed for chlorophyll *a* concentration at ALS Environmental Services (ALS) in Burnaby, BC. Fluorometric analysis was carried out using procedures adapted from United States Environmental Protection Agency (US EPA) Method 445.0 (Arar and Collins 1997). Pigments were extracted from the filter with 90% aqueous acetone and the concentration of the extract was read with a fluorometer.

In both 2011 and 2012, ALS used method blanks as part of the measurement of chlorophyll *a* concentrations in periphyton, and the results of method blank analysis were considered by ALS to be within acceptable limits. Detection limits for sample analysis ranged from 0.01 to 1.00 µg.

In 2011, periphyton samples were analysed for taxonomy at EcoAnalysts Inc. (EcoAnalysts) in Moscow, Idaho. At their laboratory, a 10 millilitre (mL) sub-sample was removed from the original periphyton sample container and placed into a known aliquot and dispensed into the counting chamber. Periphyton were classified using a light microscope at 400X magnification via a transect method until at least 300 algal units had been identified to lowest practical taxon and enumerated. Filaments were counted as one unit per ten micro-filament length. Colonies were counted as one unit. Live versus dead diatoms were not distinguished. Results were expressed on a unit volume basis.

EcoAnalysts maintain an extensive library of taxonomic references, which were consulted as needed to identify the genus in samples. Upon receipt of the results, species were assigned to phyla based upon the classification system by Systema Naturae 2000 (Brands 2012).

EcoAnalysts re-classified and recounted 5 of the 45 samples as part of their QA/QC procedures. The Bray-Curtis similarity index (B-C) was calculated for each re-counted sample to determine the similarity of the two counts (Bray and Curtis 1957). The index was calculated as:

$$B - C = \frac{\sum_{i=1}^{n} |y_{i1} - y_{i2}|}{\sum_{i=1}^{n} (y_{i1} - y_{i2})} - 1$$

where y_{i1} = number of individuals of the *ith* species i at site 1, y_{i2} = number of individuals of the *ith* species i in the replicate sample, and n = total number of species present between the two samples. D_{BC} ranges from 0 (no similarity) to 1 (identical). Agreement between the original counts and re-counts is typically considered adequate when the index is greater than 0.60 (Kelly 2001). The mean similarity for 2011 periphyton samples was 0.74, which satisfied the QA/QC threshold (**Table 4.3-2**).

Table 4.3-2: QA/QC Indices for Periphyton, 2011 and 2012

Index	Year	n	Mean	SE	Min	Max
Bray-Curtis	2011	5	0.74	0.06	0.53	0.85
	2012	4	0.73	0.03	0.66	0.83
Dominance	2011	5	75	6	53	85
	2012	4	78	4	70	88

Notes: n = number of samples; SE = standard error; Min = minimum; Max = maximum

A Dominance Identity index ($D_{1,2}$) was also used to determine how similar the periphyton communities were between counts and re-counts (Kelly 2001). That index was calculated as:

$$D_{1,2} = \sum q_i$$

where $D_{1,2}$ = similarity between samples 1 and 2, and q_i = the smaller relative abundance of the *ith* species between the two samples. $D_{1,2}$ ranges from 0% (no similarity) to 100% (identical). Similarity between the two samples is typically considered adequate when $D_{1,2}$ is greater than 60% (Kelly 2001). The mean $D_{1,2}$ for 2011 periphyton samples was 75%, which satisfied the QA/QC threshold (**Table 4.3-2**).

In 2012, periphyton samples were analysed for taxonomy at Bio-Limno Laboratories (Bio-Limno) in Halifax, NS. The analysis was performed in two stages: for non-diatoms (soft algae) and diatoms. For non-diatoms, the samples were first appropriately diluted depending on the concentration of the samples. To determine the appropriate dilution, the original samples were first screened to assess the densities of algae and non-algal matter (debris

and particulate matter). Aliquots of the appropriately diluted samples were allowed to settle overnight in sedimentation chambers following Utermöhl's procedure described in Lund et al., 1958. Algal units were counted from a minimum of four transects on a Zeiss Axiovert 40 CFL inverted microscope. Counting units were individual cells, filaments, or colonies depending on the organization of the algae. Both diatoms and non-diatoms were counted. A minimum of 250 diatoms was set as the target.

For soft algae, between 250 and 300 units were counted at 500X magnification; a number of transects were scanned at 250X magnification for larger algae. At this stage, diatoms were not identified to species or genus, but were recorded as "diatoms." Diatoms were later identified to species from prepared slides (see below). Biomass was calculated from recorded abundance and specific biovolume estimates, based on geometric solids (Rott 1981) and assuming unit specific gravity. The biovolume (mm^3 m^{-3} fresh weight) of each species was estimated from the average dimensions of 10 to 15 individuals. The biovolumes of colonial taxa were based on the number of individuals in a colony. All calculations for cell concentration and biomass were performed with Hamilton's (1990) computer program.

Preparation of diatom slides consisted of digesting sub-samples using concentrated nitric acid and hydrogen peroxide, and washing several times (by centrifuging) with distilled water. A few drops of the diatom slurry were placed on a cover slip and allowed to evaporate overnight. Once dry, it was mounted in Naphrax and the diatoms were identified at between 1,000 and 1,500X magnification (under oil immersion) on a Zeiss Axioskop 40 compound microscope. A minimum of 500 diatom frustules were counted on each slide. Measurements were taken at this stage for biovolume calculations. The diatom counts on the slides were converted to density based on the number of transects covered during the fresh (Utermöhl) counts.

Taxonomic identifications of soft algae were based on the following key documents: Findlay and Kling (1976), Anton and Duthie (1981), Prescott (1982), Huber-Pestalozzi (1961, 1972, 1982, 1983), Whitford and Schumacher (1984), Starmach (1985), Tikkanen (1986), Wehr and Sheath (2003), Komarek and Anagnostidis (1998, 2005), and Cronberg and Annadottir (2006).

Diatom identifications were based primarily on the following texts and supplemented with other publications: Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Cumming et al., 1995, Siver and Kling (1997), Reavie and Smol (1998), Bahls (2004), and Siver et al., 2005.

In 2012, Bio-Limno re-counted 4 of the 35 periphyton taxonomy samples (**Table 4.3-2**). The mean B-C was 0.73, and the mean $D_{1,2}$ was 78, hence the QA thresholds were satisfied.

4.3.3 Data Analysis

Periphyton density (cells/cm^2) and biomass (µg chl *a*/cm^2)) were calculated for each sample. Densities of major diatom groups such as Cyanobacteria (blue-green algae), Chlorophyta (green algae), and "Other" (which included the infrequent chrysophytes, euglenoids, and red algae), were compared to infer environmental conditions. High cyanobacterial density is considered to indicate nutrient enrichment (Stevenson 1998). The relative densities of motile diatoms, of which common genera include *Navicula*, *Nitzschia*, *Surirella*, *Gyrosigma*, and *Cylindrotheca*, are an index of siltation. Increased percentages of these genera indicate the presence of soil erosion and siltation, perhaps from past logging activities.

Richness, diversity, and evenness were calculated for each site by pooling data from replicates within a sampling site. Taxon richness (*S*) is the number of taxa observed in a community and is generally positively correlated with environmental quality. "Quality" is this regard means how different a sample is from pristine, undisturbed conditions. Genus richness may be a more robust indicator of biological integrity. Therefore, in this study genus richness and phylum richness were used for analysis.

Shannon's Diversity Index (*H*') was calculated because it provides a single representation of species richness and evenness at a site (Krebs 1989; Wetzel 2001). It does so by measuring the average degree of uncertainty in predicting to what taxon an individual, chosen at random from a community, described by its species diversity (*S*) and species abundance (*N*) will belong. This uncertainty increases as the number of taxa increases and as the distribution of individuals among the taxa becomes more even. If *H*' = 0 there is only one taxon in the sample whereas *H*' is maximized when each taxon in the sample is represented by the same number of individuals (i.e., individuals are distributed evenly among sampled taxa). *H'* was calculated as:

$$H' = \sum \frac{n_i}{n} \ln\left(\frac{n_i}{n}\right)$$

where n_i = number of individuals for species i, and n = total number of individuals in all species.

Equitability was evaluated by Pielou's Evenness Index (*J*). *J* was calculated because, unlike *H'*, it accounts for the number of each taxon observed as a fraction of the community to determine evenness. *J* was calculated as:

$$J = \frac{H'}{ln(S)}$$

where *S* = the total number of taxa. *J* can fall between 0 and 1, where *J* = 1 represents equal distribution of individuals between all taxa present (i.e., a stable community). *J* tends to decrease with increasing environmental perturbation.

4.4 Benthic Macroinvertebrates

BMI are a diverse group of animals living on or in the substrates of streams, wetlands and lakes. They include protozoans, flatworms, nematodes, aquatic worms, crustaceans (i.e., ostracods, isopods, and amphipods), molluscs (i.e., snails and clams), and larvae of aquatic insects (i.e., mayflies, dragonflies, and blackflies). Many BMI feed on periphyton and so provide a link between primary production and fish. Fish species in the LSA and RSA do not feed directly on algae but instead feed on the larger, more energy-rich BMIs (and other fish).

BMIs are not only prey for fish, but also serve as indicators of changes in water quality because of their sessile nature, high taxonomic diversity, and relatively long lifespan (1 to 3 years) (Resh and Rosenberg 1984; Metcalfe 1989; Barbour et al., 1999).

The main objectives of sampling BMI in streams were to characterize BMI communities in the LSA and RSA and to collect the baseline information necessary to apply the Reference Condition Approach. That is, to compare the Blackwater BMI community to an appropriate undisturbed, reference condition – either the Fraser Georgia Basin Model 2005 or the Skeena Model 2010.

The main objective of sampling BMI in lakes was to characterize lake BMI communities in the LSA and RSA. There are no reference BMI communities for lakes as there are for streams.

4.4.1 Stream BMI Communities

4.4.1.1 Field Sampling

Stream BMI sampling methods were based on standard procedures as described in BC MOE's *Guidelines for Sampling Benthic Invertebrates in British Columbia Streams* (Beatty et al., 2006), the *CABIN Field Manual Wadeable Streams* (EC 2010), the metal mining EEM guidance documents (EC 2011), and the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE 2012).

BMI samples were collected from late August to early September in 2011 and 2012 at the same stream sites and dates as were periphyton (**Table 4.3-1**, **Figure 4.3-1**, and **Plate 4.4-1** and **Plate 4.4-2**). Samples were collected during low flows and the timing was consistent with that required under the CABIN protocol. Five replicates were collected at each of 9 sites in 2011, for a total of 45 samples, and five replicates were collected at each of 14 sites in 2012, for a total of 70 samples. Sampling was conducted in 2012 at all sites sampled in 2011 plus five additional sites – three within the preliminary LSA and two potential reference sites. One of those sites was within the RSA (BI-13) and one was outside (BI-14).



Plate 4.4-1: Benthic macroinvertebrate sampling with a kick net, Lake 01682LNRS, 20 September 2012



Plate 4.4-2: Benthic macroinvertebrate sampling, Lake 01538UEUT, 11 September 2012

BMIs were sampled from riffles using a pole-mounted kick-net, which is triangular in shape with a 400-µm mesh and a plastic detachable cod end for sample concentration and removal (**Plate 4.4-1** and **Plate 4.4-2**). Each kick was conducted by the same crew member working in a zig-zag pattern across the stream in an upstream direction for 3 min. Substrate was disturbed to a depth between 5 and 10 cm. Larger substrates encountered during the sampling were cleaned by hand immediately upstream of the kick-net.

Samples were washed from the cod end of the net into 500 mL wide-mouth jars. Care was taken to avoid loss of organisms by working over a clean tray and pouring water generated during kick-netting through a 250 µm sieve. Each jar was labelled externally and internally before fixing the sample with 37% phosphate-buffered formalin at a ratio of 3:1 to 10:1, depending on the organic content of the sample. More formalin was added to samples with higher organic content. Samples were transferred to 70% ethanol after approximately 72 hours of preservation. Samples were drained of formalin through a 250-µm sieve prior to the addition of the ethanol.

Habitat data for each site was collected following the CABIN protocol for wadeable streams (EC 2010), and included supporting explanatory variables required for metal mining EEM (EC 2011). Methods for habitat data collection were the same as for periphyton. All habitat variables were measured within the kick-net sampling area and data were recorded in the field on standard BC MOE CABIN field data sheets (CABIN 2011). Photographs were taken at each site looking upstream, downstream, across the channel, at the riparian area, and stream areas with representative substrate composition.

Field QA/QC procedures in both 2011 and 2012 were based on standardized protocols (Clark 2003; McDermott et al., 2010; EC 2011) and included the following:

- field crew lead and sampler for all stream BMIs was trained and certified by EC in CABIN protocols;
- equipment was maintained, calibrated and operated consistent with applicable standards and manufacturers' guidelines;
- standardized field forms were used to collect habitat data which were reviewed for completeness at the conclusion of sampling before leaving the site;
- samples were stored securely and shipped with a chain of custody from the field to the lab;
- sites, data, samples, and physical habitat features were documented photographically;
- data and photographs were stored in a pre-determined file structure in triplicate (hard copy, lap-top, and external memory); and
- samples were labelled on the outside of the jars with a permanent marker and inside of jars using "Rite-in-the-Rain" paper with pencil.

4.4.1.2 Laboratory Analysis

Cordillera Consulting (Cordillera) of Summerland, BC, processed, identified and enumerated all BMI samples collected in 2011 and 2012 (Cordillera 2013). The first step was to drain formalin from each sample and replace it with 80% ethanol. Inorganic material was then removed from the sample by elutriation. This involved swirling the sample in a circular manner to separate light from heavy objects and then filtering the top layer through a fine-mesh filter. Elutriate (i.e., the filtrate) was examined under low-power magnification to ensure the removal of molluscs and trichopteran cases.

Each sample was examined to estimate total invertebrate numbers. If total number was greater than 600, then it was sub-sampled. Following the Canadian Aquatic Biomonitoring Network (CABIN) laboratory manual (EC 2012), a Marchant box was used for sub-sampling. A minimum number of invertebrates for sub-sampling was set at 300 individuals. When more than 50% of the sample had to be used to obtain 300 individuals, the entire sample was identified and enumerated. Any cladocera, copepod, porifera, or taxa other than insects were excluded from these counts because they are either non-benthic or they are colonial and cannot be identified as individuals (McDermott et al., 2010).

Individual BMI were identified with a dissecting microscope with at least 10 to 80X magnification or a compound microscope with 60X to 1,500X magnification for slide-mounted organisms. Taxonomic identification was conducted to at least family level following current published taxonomic references (Brook and Kelton 1967; Brown and White 1978; Morihara and McCafferty 1979; Oliver and Roussel 1983; Weiderholm 1983; Stonedahl and Lattin 1986; Clifford 1991; Thorpe and Covich 1991; Needham 1996; Westfall and May 1996; Wiggins 1998; Kathman and Brinkhurst 1999; Needham et al., 2000; Epler 2001, no date; Stewart and Stark 2002; Jacobus and McCafferty 2003, 2004; Prescott et al., 2004; Jacobus and Randolph 2005; Larson et al., 2005; Tinerella and Gunderson 2005; Stewart and Oswood 2006; Merritt et al., 2007; Rogers and Hill 2008; Proctor no date). Organisms were identified to genus or species for specimens that were undamaged and in later stages of maturation. Nomenclature followed the Integrated Taxonomic Information System (ITIS) (ITIS 2013).

Laboratory QA/QC procedures focused on the two areas for potential error: sorting and sub-sampling; and error in taxonomic classification. These two types of errors were minimized by:

- Use of certified taxonomists (Sue Salter and Nicole Hunziker-Basler) who have achieved Groups 1, 2 and 3 (West) certification by the North American Benthological Society's Taxonomic Certification Program;
- Use of the ITIS to ensure valid classifications and meet revisions and additions to species lists;

- Estimating sorting efficiency (S_{Eff}) by having an independent certified taxonomist re-sort at least 10% of samples. The criterion for an acceptable sort was that a mean S_{Eff} ≥95%; and
- Estimating percent error in taxonomic classification by having an independent certified taxonomist re-classifiy at least 10% of samples. The criterion for an acceptable re-classification is an identification error of less than 5%.

S_{Eff} was calculated for each re-sorted sample as follows (McDermott et al., 2010):

$$S_{Eff} = 1 - \frac{\text{Number of Organisms Missed}}{\text{Total Organisms Found in Audit}} \times 100$$

Percent identification error was calculated for each re-classified sample as follows:

Percent error = 100 x (Number of incorrect organisms/total number of organisms)

Ten samples were randomly selected and sent to Rhithron and Associates in Missoula, Montana. The taxonomists in that laboratory are also certified by the Society of Freshwater Science Taxonomic Certification Program. Sorting efficiency ranged from 96% to 100% with a mean of 99%, meeting the QC criteria. Percent identification error ranged from 2.9% to 5.2% with a mean of 3.7%, also meeting the QC criteria.

4.4.1.3 Data Analysis

Analysis of stream BMI taxonomic data was rigorous and sophisticated because of the use of the CABIN Reference Condition Approach, which is heavily dependent on multivariate statistical modelling.

Comparisons among Sampling Sites

BMI communities in each sample were compared using the Bray-Curtis similarity index (or B-C) (Bray and Curtis 1957), a statistic which ranges from 0 to 1, where scores of zero represent communities with no species in common and scores of 1 represent communities with all taxa occurring in both samples at the same abundance. This statistic was calculated for every combination of samples.

The B-C index was calculated by dividing the number of families unique to each site by the total number of families at each site. The resultant ratio was then presented as percent similar. The index was calculated in the CABIN database using the formula (Belbin 1993).

$$\text{B-C} = 1 - \frac{\sum_{i=1}^{n} |y_{i1} + y_{i2}|}{\sum_{i=1}^{n} (y_{i1} + y_{i2})}$$

where y_{i1} = count for species i at site 1, y_{i2} = count for species i at site 2, and n = total number of species present at the two sites.

Using these similarity scores, BMI communities were assessed for differences associated with site and year of sampling using a permutation-based multivariate analog of analysis of Variance (ANOVA) (Anderson 2001). Site and year were included as fixed effects, while replicate was incorporated as a nested variable within a site to overcome issues of pseudoreplication. In addition to examining the significance of fixed effects, the components of variation associated with this analysis were examined to determine the relative importance of each year, as well as among-site and within-site variability.

Project BMI communities were characterized and grouped to understand important habitat drivers and community characteristics as well as to inform future monitoring program design.

For these purposes, BMI data were averaged across all replicates and years for each site to determine an average community composition. Bray-Curtis index scores were calculated and carried through PRIMER cluster analysis (Clarke and Warwick 2001), which allowed sites to be aggregated into groups that were statistically differentiated according to their BMI community. Taxa and habitat that most characterized the differences among these groups were identified using a SIMPER algorithm (Clarke and Warwick 2001) – a method that evaluates the contribution of each taxa/habitat attribute to Bray-Curtis dissimilarity values (equivalent to one minus the Bray Curtis similarity) for pairs of sites within and among groups.

Environmental variables (**Table 4.4-1**) were examined for subsets that best reflected the community structure observed in the Project BMI data using the BEST algorithm (PRIMER 6; Clarke and Warwick 2001). Specifically, the ranked relationships among pairs of sites were compared for each possible subset of environmental variables in terms of their relationship (measured with Spearman rank correlation coefficients) with the BMI data (i.e., pattern matching). Unlike the BMI data, which used Bray-Curtis similarities, environmental patterns among sites were assessed using normalized Euclidean distances (Clark and Warwick 2001). When environmental variables were heavily correlated ($r>0.90$), one was removed from the analysis. For example, median substrate size was highly correlated with mean substrate size. Therefore, only mean substrate size was retained.

Table 4.4-1: Environmental Variables Included in the BEST Analysis, to Identify Potential Drivers of the Blackwater BMI Community

Landscape	Substrate		Water Chemistry	Physical Environment	Biota
Latitude	% Boulder	Substrate matrix size	Dissolved Oxygen	Channel depth	Dominant streamside vegetation
Longitude	% Gravel	Substrate embeddedness	pH	Water velocity	Macrophyte coverage
Altitude	% Pebble	Mean substrate size	Conductivity	Stream slope	% Canopy
Stream order	% Sand			Stream temperature	Periphyton
% Bedrock geology	% Silt			Wetted width	

Comparisons with CABIN Reference Models

Field collections were conducted in a way that enabled the use of the Reference Condition Approach (RCA) using reference models developed for the Canadian Aquatic Biomonitoring Network (CABIN). Sample information including habitat, water quality, and taxonomy were entered into the CABIN database maintained by Environment Canada's National Water Research Institute.

Two reference condition models developed by Environment Canada for CABIN RCA data, the Skeena 2010 model and the Fraser 2005 model, were evaluated based on their spatial and temporal consistency with Project sites, the comparability of habitat attributes and the consistency of laboratory methods. Neither model was ideal. The Skeena 2010 model was based on collections that used slightly different laboratory methods from CABIN protocols (Bennett 2010). However, the habitat comparability was superior to the Fraser 2005 model because the Skeena model was based on more recent data collections. The latter is important because climate-related changes in habitat may have resulted in changes to reference communities, therefore increasing the risk of Type I errors (i.e., identifying a site as impacted when it is not) (S. Strachan, Environment Canada, pers. comm., 2013). Both Fraser and Skeena models are being updated and should be considered in future assessments of the LSA and RSA, however neither was ready at the time of this study. In the interim, the decision was made to use the Skeena 2010 model.

Reference condition assessments of Project samples were conducted using the Benthic Assessment of Sediment (BEAST) analysis (Reynoldson et al., 1997). The model is available as part of CABIN's on-line analytical tools. The approach classifies each sample to a reference condition group based on habitat. The Skeena 2010 model consists of four reference groups: Groups 1 to 4 (**Table 4.4-2**). The analytical tools in the BEAST database assign test sites to one the Skeena reference groups. Habitat variables for the Skeena model are total January precipitation, January snowfall, and percentages of intrusive bedrock geology, ice cover, lakes, and wetlands on a watershed scale.

Table 4.4-2: 2010 Skeena Model Reference Groups

Reference Group	Description
Group 1	Very low productivity watersheds with considerable ice cover and precipitation
Group 2	Moderate productivity streams with low bedrock and low precipitation
Group 3	Low productivity coastal sites with high levels of precipitation
Group 4	Highest productivity streams with highest levels of lakes and wetlands

Source: Adapted from Bennett (2010)

Once assigned to an appropriate reference group, each sampled BMI community was evaluated relative to the natural range of variation observed in these reference sites. This exercise resulted in a probability that the test site was of the same population of unimpacted reference sites, which in turn was used to categorize the degree of BMI community stress (**Table 4.4-3**).

Table 4.4-3: Description of Probability Ellipses Used in CABIN Assessments

CABIN Assessment	Probability (%)	Description
Similar to Reference	<90%	The benthic community is assumed to be unstressed by the environment because it is similar to the reference communities
Mildly Divergent	90-99%	The benthic community is assumed to be only possibly stressed by the environment as some reference sites are also found in this band
Divergent	99-99.9%	The benthic community is assumed to be stressed by the environment as it is different from the reference communities
Highly Divergent	>99.9%	The benthic macroinvertebrate community is assumed to be severely stressed by the environment as it is very different from the reference communities

Notes: CABIN = Canadian Aquatic Biomonitoring Network; % = percent
Source: Adapted from Yeow et al. (2011).

The BEAST analysis can incorrectly assign a test site. The error rate is specific to each reference group and does not change unless the reference model is updated (**Table 4.4-4**).

Table 4.4-4: Error Rates Associated with CABIN Skeena 2010 Model

Reference Group	Group 1	Group 2	Group 3	Group 4	Average
Error Rate (%)	40.0%	22.9%	5.9%	33.3%	23.4%

Notes: % = percent
Source: CABIN (2012)

The BEAST analysis is also affected by errors in assigning probabilities (i.e., degree of impact) to test sites. Stress values on the ordination plot indicate how well the ordination plot represents the actual relationship between sample and reference sites in “multivariate space.” Stress values should be less than 0.2 (Reynoldson et al., 2001). Low stress values suggest close agreement between the ordination and the ordinal data (Hammer and Harper

2006), and as a result, more confidence in the assessment when using the multivariate approach.

Comparisons using RIVPACS

The River Invertebrate Prediction and Classification System (RIVPACS) was used to support the BEAST analysis. RIVPACS uses presence and absence of observed and expected taxa to indicate environment quality. The observed taxa are those occurring in the samples collected and the expected taxa are based on the reference condition. The method predicts the probability of a taxon occurring at a site using the probability of each sample site belonging to a reference group determined by the BEAST analysis (Reynoldson et al., 2001).

The CABIN database calculates the ratios of observed and expected taxa based on all reference sites in the reference model. (Reference groups are weighted according to the test sites probability of group membership, and not just the relevant habitat-defined model group as in BEAST analysis). Deviation of the ratio of observed to expected is a measure of taxonomic completeness, where results near 1.0 indicate the taxa observed are close to the reference groups. Generally, a ratio less than 0.75 indicates a site in poor condition (also called “impaired”), a ratio between 0.75 and 1.25 indicates good condition, and a ratio greater than 1.25 indicates enrichment (also known as a “biodiversity hotspot”) (Hargett et al., 2005; Feldman 2006; de Zwart et al., 2006; Hubler 2008).

Community Metrics

Community metrics were used to add context to the ordination analyses described above. Several metrics were acquired from the CABIN database for each sample replicate including total abundance, taxa richness (S, defined in **Section 4.3.3**), percent EPT (defined below), EPT richness, percent Chironomidae, and H’ (defined in **Section 4.3.3**). Each index has an expected response to various anthropogenic impacts (Barbour et al., 1999). For example, heavily enriched streams would be expected to have high total abundance and low scores of the remaining metrics because nutrients eliminate pollution sensitive species and enhance abundance of tolerant species.

Percent EPT is the percentage of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in each sample. These taxa are typically most sensitive to habitat disturbance and changes in water quality. An even distribution and high numbers of EPTs are indicative of good water quality. Special attention should be paid to the absence of any one of the three EPT groups at a site. As with taxonomic richness, moderate organic enrichment may result in an increase in the number of EPTs present in samples.

Percent Chironomidae refers to the occurrence of chironomidae (i.e., midge) taxa that tends to increase when disturbance increases as many genera are highly tolerant of and opportunistic relative to EPT taxa or insects. A sample containing high numbers of

Chironomidae may suggest eutrophic conditions (Armitage et al., 1995) or presence of heavy metals (Hayford and Ferrington 2005).

4.4.2 Lake BMI Communities

4.4.2.1 Field Sampling

BMI were collected with a kick net from the littoral zones of the three headwater lakes between 13 and 20 September 2012 (**Table 4.4-5** and **Figure 4.4-1**). Sample timing was consistent with the protocol of the Ontario Benthos Biomonitoring Network (OBBN) (Jones et al., 2004). OBBN was picked as best available protocol, in the absence of an approved protocol from Environment Canada, based on discussions with three BC MOE biologists (John Love of Smithers; James Jacklin of Prince George; and Leon Gaber of Victoria), and with two regional leads for the CABIN program at Environment Canada.

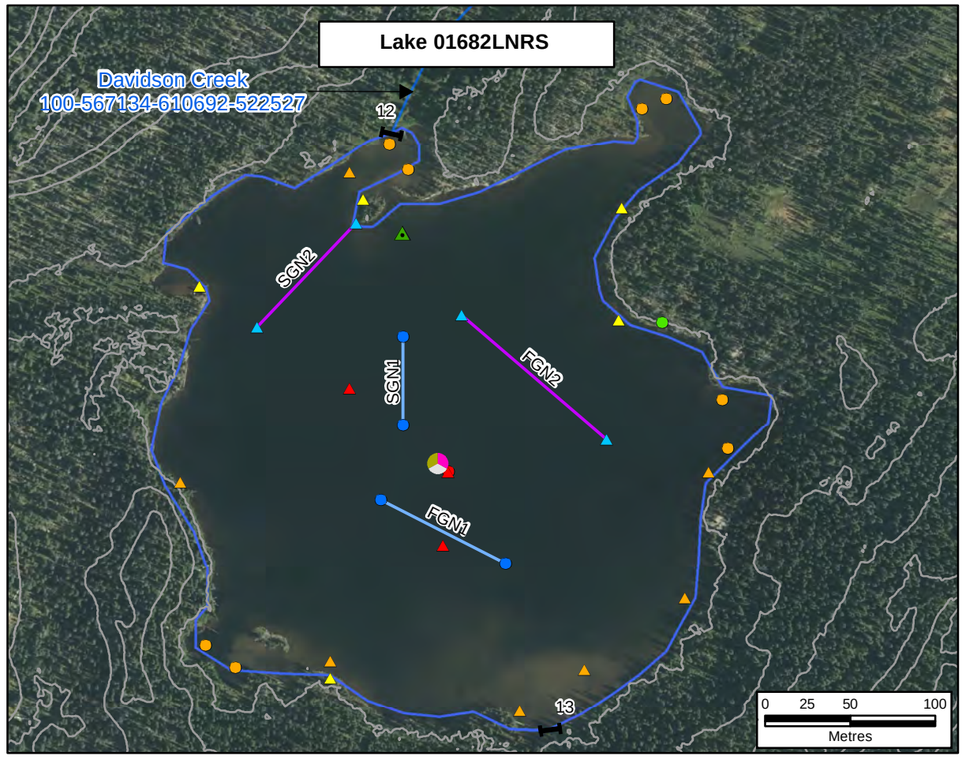
Table 4.4-5: Littoral BMI Sampling Sites in 2012

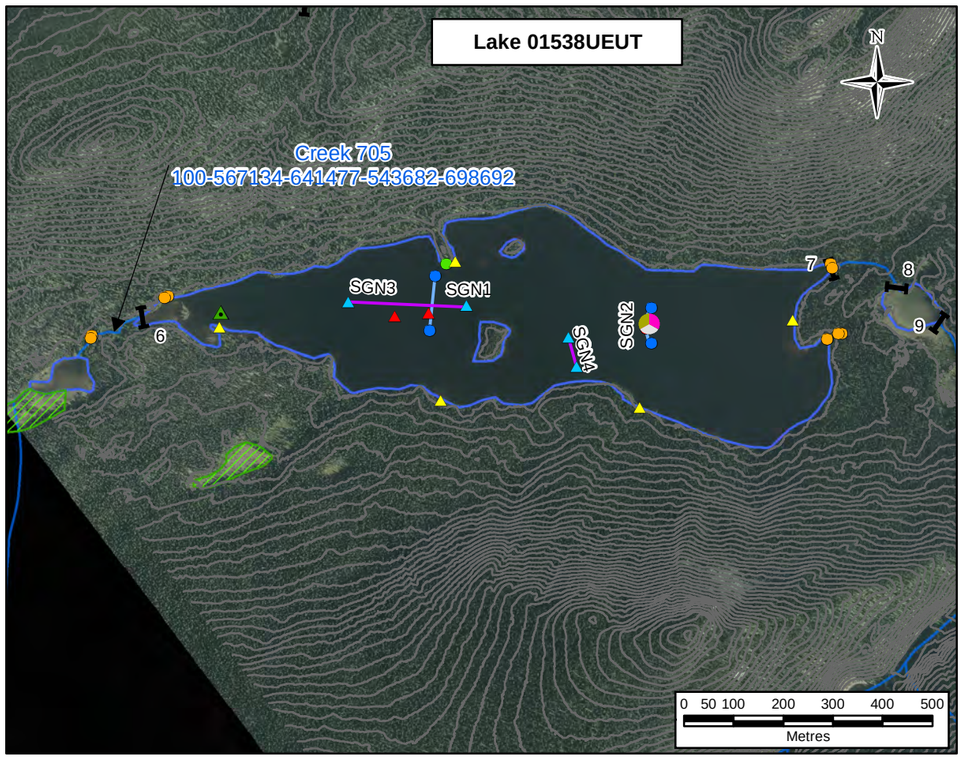
Lake	Baseline Site Map ID	Date	Location (UTM)[a]	
			Easting	Northing
Lake 01682LNRS	16-01	20-Sep	371239	5894170
	16-02		371391	5894165
	16-03		371389	5894099
	16-04[b]		371220	5893889
	16-05		371143	5894119
Lake 01538UEUT	15-01[b]	18-Sep	369321	5893723
	15-02		369766	5893575
	15-03		370167	5893561
	15-04		370475	5893737
	15-05		369796	5893855
Lake 01428UEUT	14-01	13-Sep	369660	5895791
	14-02		369610	5895702
	14-03		369559	5895614
	14-04		369590	5895835
	14-05[b]		369558	5895845

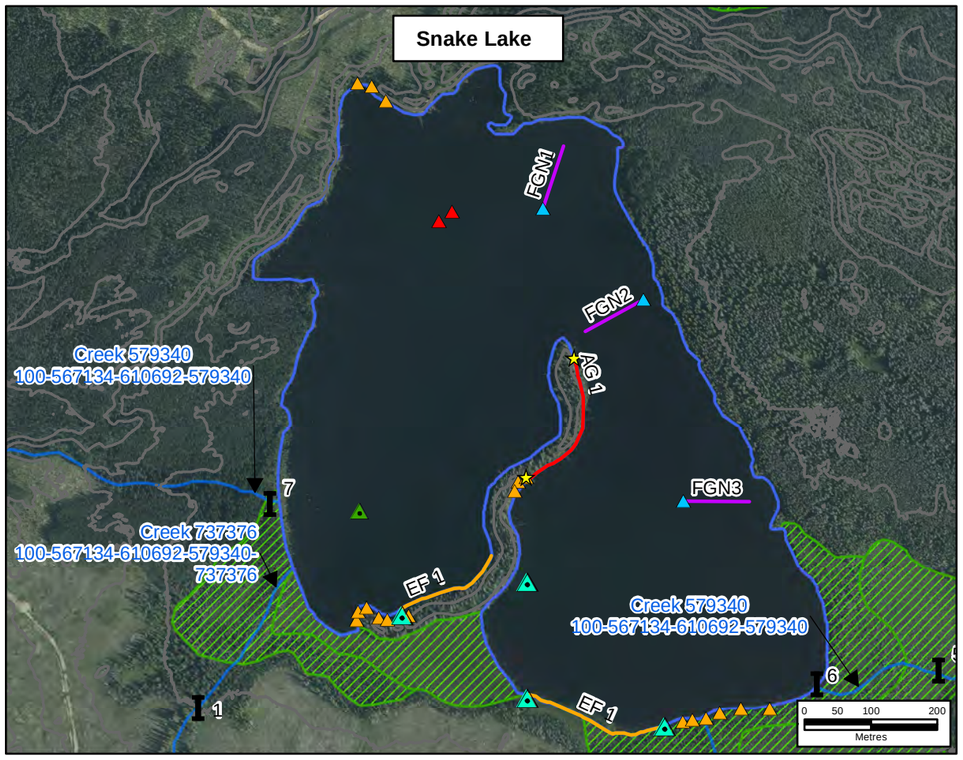
Notes: UTM = Universal Transverse Mercator; m = metre
[a] North American Datum 83, Zone 10; b Tissue metal sampling location

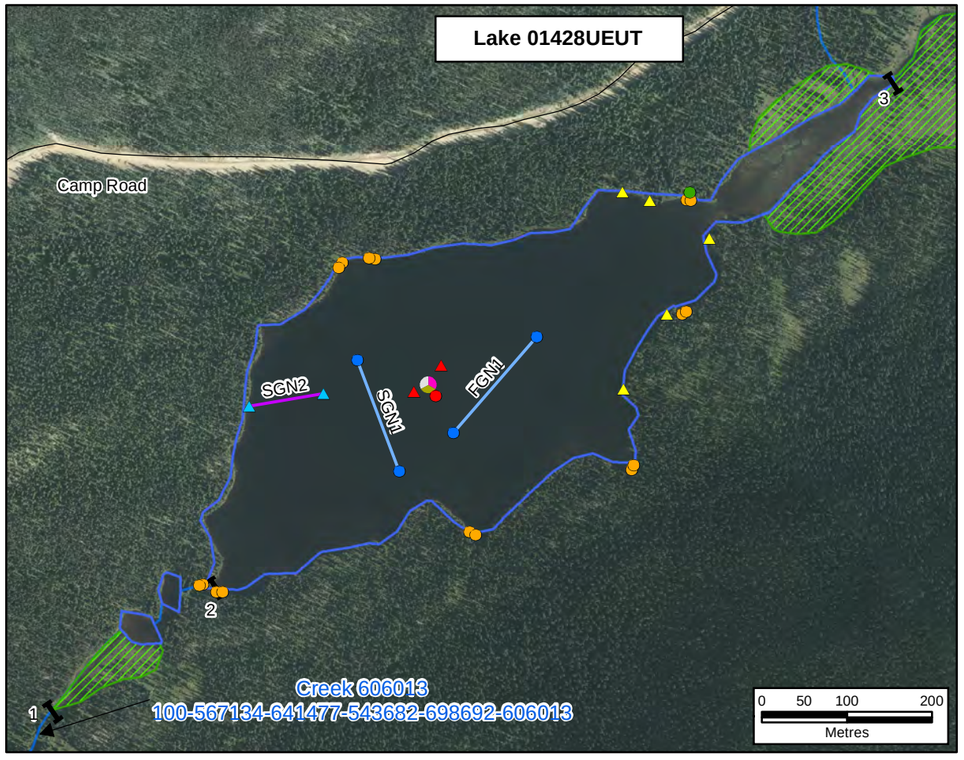
Samples were collected for taxonomic identification and for tissue metals analysis within the representative (most common) lake littoral habitat, defined by substrate type.

Five replicate samples for were collected from each lake. Each sample was collected with a 400 µm mesh kick-net by two crew members working along multiple transects for 10 minutes (5 minutes each). Transects were established perpendicular from the lake shore towards the middle of the lake to a maximum of 0.75 m depth. Substrates were disturbed by vigorously kicking the net to a depth of 5 cm.





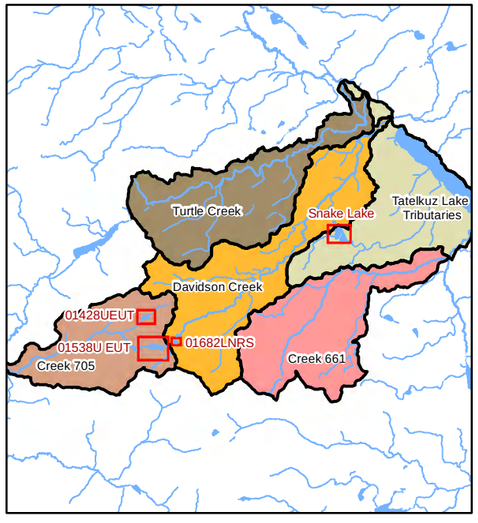




Legend

- Benchmark 2011
- Zooplankton 2012
- Phytoplankton 2012
- Profundal BMI 2012
- Limnology Station 2011
- Limnology Station 2012
- Minnow Trapping 2011
- Minnow Trapping 2012
- Littoral BMI 2012
- Overwinter (DO) Survey 2012
- Reach Break
- Gill Netting 2011 (SGNX - sinking, FGNX-floating)
- Gill Netting 2012 (SGNX - sinking, FGNX-floating)
- Angling 2012
- Electrofishing 2012
- Existing Road
- Contour (5m)
- Stream
- Lake
- Wetland

KEY MAP



Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Lake Sampling Overview Map 2011-2012

DATE: April, 2013	ANALYST: MY	**Figure** 4.4-1
JOB No: VE52277	QA/QC: IM	PDF FILE: 10-100-033_Lake_sampling_2012_v2.pdf
GIS FILE: 10-100-033_Lake_sampling_2012_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-033_Lake_sampling_2012_v2.mxd

Each replicate was transferred to 500 mL labelled plastic jars and preserved with 10% buffered formalin. To protect the integrity of the organisms, large non-organic debris were removed from the sample, cleaned and the rinsate returned to the sample jar. Samples were transferred to 70% ethanol after approximately 72 hours by draining off the formalin through a 250 µm sieve. All samples collected for taxonomic identification and enumeration were sent to Cordillera Consulting.

Habitat data for each erosional habitat in the littoral zone were collected following the OBBN protocol for lakes (Jones et al., 2004), and included supporting explanatory variables for metal mining environmental effects monitoring (EC 2011). These data included:

- Site elevation and location measured with a handheld GPS;
- pH, water temperature, conductivity, and DO concentration measured with a YSI 665 multimeter (prior to BMI sampling);
- Dominant substrate class estimated by visual means;
- Organic matter (%), and areal coverage (%) estimated by visual means; and
- Dominant canopy type estimated by visual means.

BMIs in the profundal zones of the three lakes were collected at the same locations as the phytoplankton and zooplankton samples (**Table 4.5-1** and **Plate 4.4-3**). BMI samples were collected using an Ekman dredge with dimensions of 15 x 15 x 15 cm. Five replicate samples were collected at each lake from five different points of the boat. For each grab sample, the sample volume was approximately 3,000 cm^3 of sediment taken from an area of 225 cm^2 of lake bed to a depth of 9 to 14 cm. Samples were sieved through a 500 µm mesh net prior to preservation in 10% buffered formalin. Each sample location was measured with a handheld GPS and depth was measured with a weighted rope.



Plate 4.4-3: Benthic macroinvertebrate sampling using an Ekman dredge, Lake 01538UEUT, 11 September 2012

4.4.2.2 Laboratory Analysis

Cordillera Consulting processed, identified, and enumerated all BMI samples from headwater lakes in 2012. The same QA/QC tools were applied as were used for stream BMI samples (**Section 4.4.1.2**).

4.4.2.3 Data Analysis

The use of differing sampling methods in littoral and profundal habitats precluded quantitative and statistical comparisons among zones. Therefore, comparisons were restricted to similar habitats among lakes.

As with stream BMI communities, samples were compared using the Bray-Curtis Index. This statistic was calculated for every combination of samples on data that were square-root transformed. (The square-root transformation is used to normalize count data or count-like data.) Unlike the stream BMI communities, which were analysed without transformation to be consistent with CABIN protocols, lake communities were transformed to add weight to less dominant elements of the BMI community and to improve potential future detection of biological effects (Clarke and Green 1988).

Bray-Curtis scores were used as inputs for three analytical approaches. First, they were the basis for assessing differences across lakes using PERMANOVA, a permutation-based multivariate analog of ANOVA. PERMANOVA was applied using the ANOSIM algorithm of PRIMER 6 (Clarke and Warwick 2001). Second, Bray-Curtis scores were used to aggregate BMI samples into statistically defined groups using the CLUSTER algorithm of PRIMER 6 (Clarke and Warwick 2001), and, finally, they were used in ordinations to visually represent the relationships of BMI communities across samples and across lakes.

Taxa and habitat that most characterized the differences among lakes were identified using a SIMPER algorithm of PRIMER 6 (Clarke and Warwick 2001), a method that evaluates the contribution of each taxa/habitat attribute to Bray-Curtis dissimilarity values (equivalent to one minus the Bray Curtis similarity) for pairs of sites within and among groups.

Environmental variables were examined for subsets that best reflected the community structure observed in lake BMI data using the BEST algorithm of PRIMER 6 (Clarke and Warwick 2001). Specifically, the ranked relationships among pairs of sites were compared for each possible subset of environmental variables in terms of their relationship (measured with Spearman rank correlation coefficients) with the BMI data (i.e., pattern matching). Unlike the BMI data, which used Bray-Curtis similarities, environmental patterns among sites were assessed using normalized Euclidean distances (Clark and Warwick 2001). Environmental variables included in the analysis included Secchi depth, DO, conductivity and depth. Environmental variables were screened to ensure variables were not highly correlated ($r>0.90$).

Community metrics were used to add context to the ordination analyses described above. Several metrics were calculated for each sample replicate, including total abundance, taxa richness (S), H', the Hilsenhoff Biotic Index (HBI), the proportion of EPT taxa (for littoral zones only) and the proportion of chironomids. HBI was calculated as

$$HBI = \Sigma(n_i * a_i)/N$$

where n_i = the number of organisms of the *ith* tolerance class, a_i = the tolerance value (ranging from 0 to 1) for the *ith* tolerance class, and N = the sum of all organisms in a sample.

Each index has an expected response to various anthropogenic impacts (Barbour et al., 1999). For example, heavily enriched lakes would be expected to have high total abundance and HBI scores and low EPT proportions and Shannon-Weiner Diversity scores as nutrients would eliminate pollution sensitive EPT species and enhance the abundance and/or dominance of tolerant species such as chironomids.

4.4.3 BMI Tissue Metals Concentrations

4.4.3.1 Field Sampling

One additional CABIN kick-net sample was collected at each of the 14 stream sampling sites for measurement of BMI tissue metals concentrations (**Figure 4.3-1** and **Table 4.3-1**). A single composite sample was collected at each site with the exception of one site where five replicate samples were collected to estimate within-site variability in tissue metals (BC MOE 2012).

These samples were collected because the 2011 surveys had shown that the fish community in streams and lakes of the LSA was dominated by one species – rainbow trout. There were no other small, resident fish species such as sculpins that could be sampled for tissue metals concentrations. Therefore, it was decided to sample BMI tissues in 2012 in order to have a second indicator of baseline metal concentrations.

Samples of stream BMI for tissue metals analysis were collected using a 400 µm mesh kick net. Sampling effort for each sample was allowed to vary from 1 to 20 min in order to collect a minimum of 4 wet grams (g) for each sample. Each composite sample was stored in a plastic container with volumes of 500 or 1,000 mL. The container was filled with sufficient stream water to keep the benthos alive.

Samples were processed in the field laboratory on the day of sampling. Plastic tweezers were used to remove all woody debris and algae from samples. All laboratory equipment was acid-washed to avoid cross-contamination among sampling sites. Sorted samples were placed in a 500 mL plastic jar of deionised water overnight so that they could purge their gut contents. In the morning, each sample was rinsed with deionised water using a 250 µm

sieve, and was then placed in a labelled Ziploc bags and frozen to -20°C. Frozen samples were shipped to ALS on a bed of ice in an insulated cooler. They were stored frozen until analysis. All samples were analyzed within ALS recommended hold times.

For measurement of BMI tissue metal concentrations in lakes, shrimp-like benthic crustaceans (commonly known as "scuds") of the genus Gammarus and Hyalella were targeted in the littoral zone because of their large body size and high abundance, and as agreed with BC MOE (James Jacklin, BC MOE, Prince George, 2012, personal communication). One composite sample was collected at each of two lakes (Lake 01682LNRS and Lake 01428UEUT) and five replicate samples were collected at one site in Lake 01538UEUT to estimate within-site variability (BC MOE 2012) (**Table 4.4-5** and **Figure 4.4-1**).

Lake samples were processed the same way as stream samples, except that scuds were allowed to purge gut contents longer than stream BMIs because scuds feed primarily on organic debris in lake sediments rather than on periphyton.

4.4.3.2 Laboratory Analysis

At ALS, samples were analyzed for percent moisture, concentrations of 41 total metals, and lipid content (**Table 4.4-6**). All tests were conducted within ALS recommended hold times. The parameters that were analyzed and their detection limits were consistent with BC MOE requirements. Moisture content was determined gravimetrically by drying the sample at 105°C for a minimum of 6 hours.

Table 4.4-6: Variables, Laboratory Methods, and Detection Limits Used in Analysis of Tissue Metals Concentrations

Variables	Method	Detection Limit (mg/kg wwt)
% moisture	Gravimetric	0.10%
Lipids[1]	Gravimetric	
Total Aluminum	HR-ICP-MS	0.4
Total Antimony	HR-ICP-MS	0.002
Total Arsenic	HR-ICP-MS	0.004
Total Barium	HR-ICP-MS	0.01
Total Beryllium	HR-ICP-MS	0.002
Total Bismuth	HR-ICP-MS	0.002
Total Boron	HR-ICP-MS	0.2
Total Cadmium	HR-ICP-MS	0.002
Total Calcium	ICP-OES	0.5
Total Cesium	HR-ICP-MS	0.001
Total Chromium	HR-ICP-MS	0.01
Total Cobalt	HR-ICP-MS	0.004
Total Copper	HR-ICP-MS	0.01
Total Gallium	HR-ICP-MS	0.004

Table continues…

Table 4.4-6 (cont'd)

Variables	Method	Detection Limit (mg/kg wwt)
Total Iron	HR-ICP-MS	0.2
Total Lead	HR-ICP-MS	0.004
Total Lithium	HR-ICP-MS	0.02
Total Magnesium	ICP-OES	1
Total Manganese	HR-ICP-MS	0.004
Total Mercury	CVAFS	0.001
Methyl-mercury[1]	GCAFS	0.001
Total Molybdenum	HR-ICP-MS	0.004
Total Nickel	HR-ICP-MS	0.01
Total Phosphorus	HR-ICP-MS	5
Total Potassium	ICP-OES	20
Total Rhenium	HR-ICP-MS	0.002
Total Rubidium	HR-ICP-MS	0.01
Total Selenium	HR-ICP-MS	0.02
Total Silver	HR-ICP-MS	0.001
Total Sodium	ICP-OES	20
Total Strontium	HR-ICP-MS	0.01
Total Tellurium	HR-ICP-MS	0.004
Total Thallium	HR-ICP-MS	0.0004
Total Thorium	HR-ICP-MS	0.002
Total Tin	HR-ICP-MS	0.004
Total Titanium	HR-ICP-MS	0.01
Total Uranium	HR-ICP-MS	0.0004
Total Vanadium	HR-ICP-MS	0.004
Total Yttrium	HR-ICP-MS	0.002
Total Zinc	HR-ICP-MS	0.1
Total Zirconium	HR-ICP-MS	0.04

Notes: CVAFS = Cold Vapour Atomic Fluorescence Spectrometry; HR-ICP-MS = High Resolution-Inductively Coupled Plasma-Mass Spectrometry; ICP-OES = Inductively Coupled Plasma-Optical Emission Spectrophotometry; mg/kg wwt = milligrams per kilogram wet weight; % = percent
[1] 2012 only

Samples were prepared for total metal analysis by homogenization followed by acid digestion. Most metal concentrations were measured by High Resolution-Inductively Coupled Plasma-Mass Spectroscopy (HR-ICP-MS). Cold Vapour Atomic Fluorescence Spectrometry (CVAFS) was used for mercury and Inductively Coupled Plasma-Optical Emission Spectrophotometry (ICP-OES) was used to measure calcium, magnesium, potassium, and sodium concentrations. Results were reported as total metal concentrations per wet weight (milligrams per kilogram wet weight (mg/kg wwt).

Concentrations of methyl-mercury were measured in 2012 at only one site in each drainage. Methyl-mercury concentrations were measured by digesting tissue samples with methanol and potassium hydroxide. A portion of the digestate was analyzed by aqueous phase ethylation and purge and trap, followed by capillary gas chromatography. Highly selective and sensitive detection was achieved by Atomic Fluorescence Spectrometry (AFS) after pyrolytic decomposition of the GC eluent (GCAFS). Results were reported as HgMe concentrations per wet weight (milligrams per kilogram wet weight (mg/kg wwt).

Lipid content was measured by extracting a portion of the homogenized sample with dichloromethane. The extract was evaporated to dryness and the lipid content determined gravimetrically. Results were reported as percent wet weight (% wwt).

ALS followed standard QA/QC procedures required by the Canadian Association for Laboratory Accreditation (CALA) during analysis of all BMI tissue samples. These procedures included:

Analysis of method blanks (digested blank in de-ionized water). A total of 241 metal concentrations were produced from method blank testing while the stream BMI samples were analyzed, of which 2 concentrations exceeded ALS's Data Quality Objectives (DQO). This was an exceedance frequency of 0.8%, which was considered acceptable by ALS. A total of 447 metal concentrations were produced from method blank testing while the lake BMI samples were analyzed, of which 26 exceeded DQO. This was an exceedance frequency of 5.8%, which was considered acceptable by ALS.

Analysis of certified reference material ("TORT 2" and "DOLT 4"). A total of 74 metal concentrations were produced from tests of reference material done while the stream BMI samples were analysed and 129 metal concentrations were produced from tests of reference material done while the lake BMI samples were analyzed. All test results fell within acceptable measurement ranges.

Comparison of replicates

A total of 164 Relative Percent Differences (RPD) were calculated between metal concentrations in two replicate stream BMI samples, of which 14 or 8.5% could not be calculated because one or both values were below the MDL, and 37 or 22.6% fell outside ALS' DQO of 30% due to sample heterogeneity. The average RPD of those that exceeded the DQO was 49% (range: 30 to 97%). Eighty RPD were calculated between two replicate lake BMI samples, of which 15 or 19% could not be calculated because one or both values were below the MDL, and 38 or 47% fell outside ALS' DQO of 30% due to sample heterogeneity. The average RPD of those that exceeded the DQO was 76% (range: 32 to 159%). These results were considered acceptable by ALS, considering the heterogenous nature of the stream BMI tissue.

4.4.3.3 Data Analysis

To conduct statistical analyses of BMI tissue metal concentrations, all concentrations below the method detection limit (MDL) were replaced with one-half the MDL. This allowed means and standard errors (SE) of metal concentrations to be calculated.

The coefficient of variation (CV) of mean metal concentration was used to assess the amount of among-replicate variability in metal concentrations.

Principle Component Analysis (PCA) was used to identify major trends in the BMI tissue metals data set by reducing the 41 variables to three uncorrelated variables called principle components (PC1, PC2 and PC3). The first step in PCA was to combine all records of BMI tissue metal concentrations from all sites in both streams and lakes into a single data matrix. The columns of the matrix were metals and the rows were site records, including replicates taken at each site. Then, all metals for which more than 90% of the values were below the MDL were removed because they contained too little information to be worthwhile. For the remaining metals, all concentrations below the MDL were replaced by one-half the MDL. Metal concentrations were then ln-transformed to normalize their frequency distributions – a pre-requisite of parametric statistics. This matrix was entered into the PCA module of JMP10 software, and the first three principle components were extracted. (The other 37 components that were extracted – one for each variable – explained insignificant amounts of variance). In doing so, the size of the data set was reduced from 41 to 3 variables – a factor of ten – thereby improving comprehension.

Each component was assigned a name and meaning by examining a loading table – the correlation coefficients between each component and the original 41 variables. Each component was highly correlated (i.e., heavily "loaded") with a different subset of metals, and so was labelled accordingly.

Factor scores for each component for each sampling site were then plotted on sampling sites aggregated into watersheds, and on sampling sites aggregated into groups based on cluster analysis of BMI taxonomic composition (see **Section 4.4.1.3**). These plots were reviewed to determine if BMI metal concentrations were driven by factors related to location (i.e., watershed) or taxonomic composition (which in turn was driven by physical habitat). Factor scores were also plotted against each other (i.e., PC2 on PC1) to search for provide insight into differences in metal concentrations between lake and stream BMI and among watersheds and taxonomic groups.

4.5 Phytoplankton

Phytoplankton are a group of single-celled plants that live suspended in the water column of lakes. They are the dominant photosynthesizing organisms in lakes, and so form the base of the food chain. For that reason, their density (cells/m^3), biomass (µg/ m^3 chlorophyll *a*), and taxonomic composition are used as measures of lake productivity.

4.5.1 Field Sampling

Phytoplankton was sampled in three headwater lakes (01682LNRS, 01538UEUT, and 01428UEUT) in September 2012 (**Figure 4.4-1**, **Table 4.5-1**, and **Plate 4.5-1**).

Table 4.5-1: Phytoplankton, Zooplankton, and Profundal Benthic Macroinvertebrate Sampling Sites in Lakes in 2012

Lake	Field Site ID	Sampling Date	Shallow Sample Depth (m)	Deep Sample Depth (m)	Thermocline Sample Depth (m)	Location (UTM1)	
						Easting	Northing
01682LNRS	**Lake 16**	**19-Sept-2012**	**1.0**	**13.0**	**10.5**	**369313**	**5895612**
01538UEUT	Lake 15	11-Sept-2012	1.0	8.5	n/a	370186	5893729
01428UEUT	Lake 14	9-Sept-2012	1.0	4.5	n/a	369330	5895619

Notes: UTM = Universal Transverse Mercator; m = metre
1 North American Datum 83, Zone 10



Plate 4.5-1: Phytoplankton sampling with a Van Dorn bottle in Lake 01538UEUT, 11 September 2012

Phytoplankton samples were collected at the surface and bottom of all three lakes. An additional sample was collected just below the thermocline in Lake 01682LNRS to determine if lake stratification had an effect on phytoplankton abundance by either limiting or concentrating nutrients in the water below the thermocline. A thermocline was measured for Lake 01682LNRS at time of sampling using vertical profiles of temperature and DO.

Phytoplankton was sampled following standard methods (Clark 2003; RISC 2008). Water samples were collected using a Van Dorn water sampler lowered to the selected depth and then opened and closed by a messenger. Upon retrieval, the contents were transferred into 1 L plastic bottles. At each sampling depth, five replicate samples were collected for taxonomy analysis and another five replicates were collected for chlorophyll *a* measurement. A total of 10 taxonomy samples were collected from each of Lakes

01538UEUT and 01428UEUT, and 15 taxonomy samples were collected from Lake 01682LNRS. For biomass, a total of 10 water samples were collected at Lakes 01538UEUT and 01428UEUT, and 15 samples at Lake 01682LNRS.

Phytoplankton samples were preserved following the same procedures outlined for periphyton samples. Taxonomic samples were preserved in 5% Lugol's iodine solution and were sent to Bio-Limno Laboratories Inc. (Bio-Limno) for analysis. Chlorophyll *a* samples were kept cool (in a cooler) until they could be processed at camp. There, they were filtered and the filters were frozen until they could be sent to ALS. Laboratory methods for measurement of chlorophyll *a* concentration were the same as those described for periphyton.

4.5.2 Laboratory Analysis

Phytoplankton samples for biomass estimation were analyzed at ALS using the same techniques used for periphyton (**Section 4.3.2**). ALS used method blanks as part of their QA/QC procedures, and the results were considered to be within acceptable limits.

At Bio-Limno, aliquots of the preserved samples were allowed to settle overnight in sedimentation chambers following the procedure of Lund et al., 1958. Algal units were counted from randomly selected transects on a Zeiss Axiovert 40 CFL (inverted) microscope. Counting units were individual cells, filaments, or colonies depending on the organization of the algae. A minimum of 400 units were counted for each sample. The bulk of the counts was made at 500X magnification. The large and rare organisms (such as *Ceratium*) were scanned for at 250X magnification. Fresh weight biomass was calculated from recorded abundance and specific biovolume estimates, based on geometric solids (Rott 1981), assuming unit specific gravity. The biovolume (mm^3 m^{-3} fresh weight) of each species was estimated from the average dimensions of 10 to 15 individuals. The biovolumes of colonial taxa were based on the number of individuals in a colony. All calculations for cell concentration and biomass were performed with Hamilton's (1990) computer program.

Taxonomic identifications were based primarily on Geitler (1932, 1949), Findlay and Kling (1976), Ettl (1978), Rieth (1980), Anton and Duthie (1981), Prescott (1982), Huber-Pestalozzi (1961, 1972, 1982, 1983), Whitford and Schumacher (1984), Starmach (1985), Tikkanen (1986), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Wehr and Sheath (2003), Komarek and Anagnostidis (1998, 2005), Kristiansen and Preisig (2007), and Popovský and Pfiester (2008)

In 2012, Bio-Limno recounted 4 of the 35 phytoplankton samples for QA purposes (**Table 4.5-2**). Both the mean Bray-Curtis index and the mean Dominance Identity index were below the threshold values of 0.6 and 60%, respectively.

Table 4.5-2: QA/QC Indices for Phytoplankton, 2012

Index	n	Mean	SE	Min.	Max.
Bray-Curtis Similarity (D_{BC})	4	0.46	0.11	0.17	0.72
Dominance Identity ($D_{1,2}$)	4	59	8	37	73

Notes: n = number of samples; SE = standard error; Min. = minimum; Max. = maximum

4.5.3 Data Analysis

Mean phytoplankton density (cells/L) and biomass (µg/L) were calculated for each sampling depth and lake and compared graphically. Mean density of major taxa and indices of diversity (S and H') and evenness (J) were calculated for each sampling depth of each lake and compared using tables.

4.6 Zooplankton

Zooplankton are a group of invertebrates that live suspended in the water column of lakes. They feed on phytoplankton and each other and, in turn, are prey for many fish species, including rainbow trout and kokanee. Their density (organisms/m^3), biomass (i.e., mg/m^3), and taxonomic composition are used as measures of lake productivity and ecosystem health.

4.6.1 Field Sampling

Zooplankton communities in the three headwater lakes were sampled at the same locations as phytoplankton communities (**Figure 4.4-1**, **Table 4.5-1**, and **Plate 4.6-1**). Samples of zooplankton were collected using the protocols described in the *British Columbia Freshwater Biological Sampling Manual* (Clark 2003). Five replicate samples were collected at each site using 0.5 m-diameter plankton net with an 80 µm mesh size. Zooplankton samples were collected by lowering the net to 1 m above the lake bottom and then raising the net to the surface at a constant speed of approximately 0.5 m/s. The contents of the cod end were transferred to clean, pre-labelled 250 mL plastic jars and preserved with 70% ethanol. Preserved samples were sent to Bio-Limno for taxonomic analysis.

Depth was recorded for each tow and the volume of water filtered (m^3) calculated by multiplying the area of the net opening by the total depth of the haul.



Plate 4.6-1: Zooplankton sampling net

4.6.2 Laboratory Analysis

At Bio-Limno, each sample was rinsed through a 64 µm Nitex sieve to remove preservative. Samples were enumerated from three 1 to 5 mL sub-samples using a dissecting microscope at magnifications of 12 to 50X for macro-zooplankton, and using an inverted microscope at magnifications of 200 to 400X for rotifers and copepod nauplii. Sub-samples for rotifers and nauplii were allowed to settle for 24 h prior to counting. The sub-sample volumes used was dependent primarily on the amount of particulate materials in the sample.

Identification used keys including Brooks (1957), Edmondson (1966), Chengalath (1971), Grothe and Grothe (1977), Pennak (1978), Stemberger (1979), Clifford (1991), Thorp and Covich (1991), and Green (2012).

Lengths were determined directly on a microscope fitted with a micrometer in the ocular. Generally, lengths were measured for a minimum of 40 to 50 individuals of each species or genus encountered from representative samples (where several samples from the lake are involved). For rare taxa or those that occurred in low numbers, measurements were taken as they were encountered.

Zooplankton biomass was calculated for each sample by summing biomass of each taxon (i.e., species or developmental stage) in each sample. Total biomass for each group was calculated as the product of its density and estimated mean individual weight. Weights were calculated from published length-weight regressions cited in Bottrell et al., 1976, Downing and Rigler (1984) and Stemberger and Gilbert (1987).

In 2012, Bio-Limno re-counted 3 of the 15 zooplankton taxonomy samples for QA/QC purposes (**Table 4.6-1**). Both the mean Bray-Curtis similarity and mean Dominance Identity indices were above the QA thresholds of 0.6 and 60%, respectively.

Table 4.6-1: QA/QC Indices for Zooplankton, 2012

Index	n	Mean	SE	Min	Max
Bray-Curtis (D_{BC})	3	0.72	0.04	0.64	0.77
Dominance Identity ($D_{1,2}$)	4	78	4	70	88

Notes: n = number of samples; SE = standard error; Min = minimum; Max = maximum

4.6.3 Data Analysis

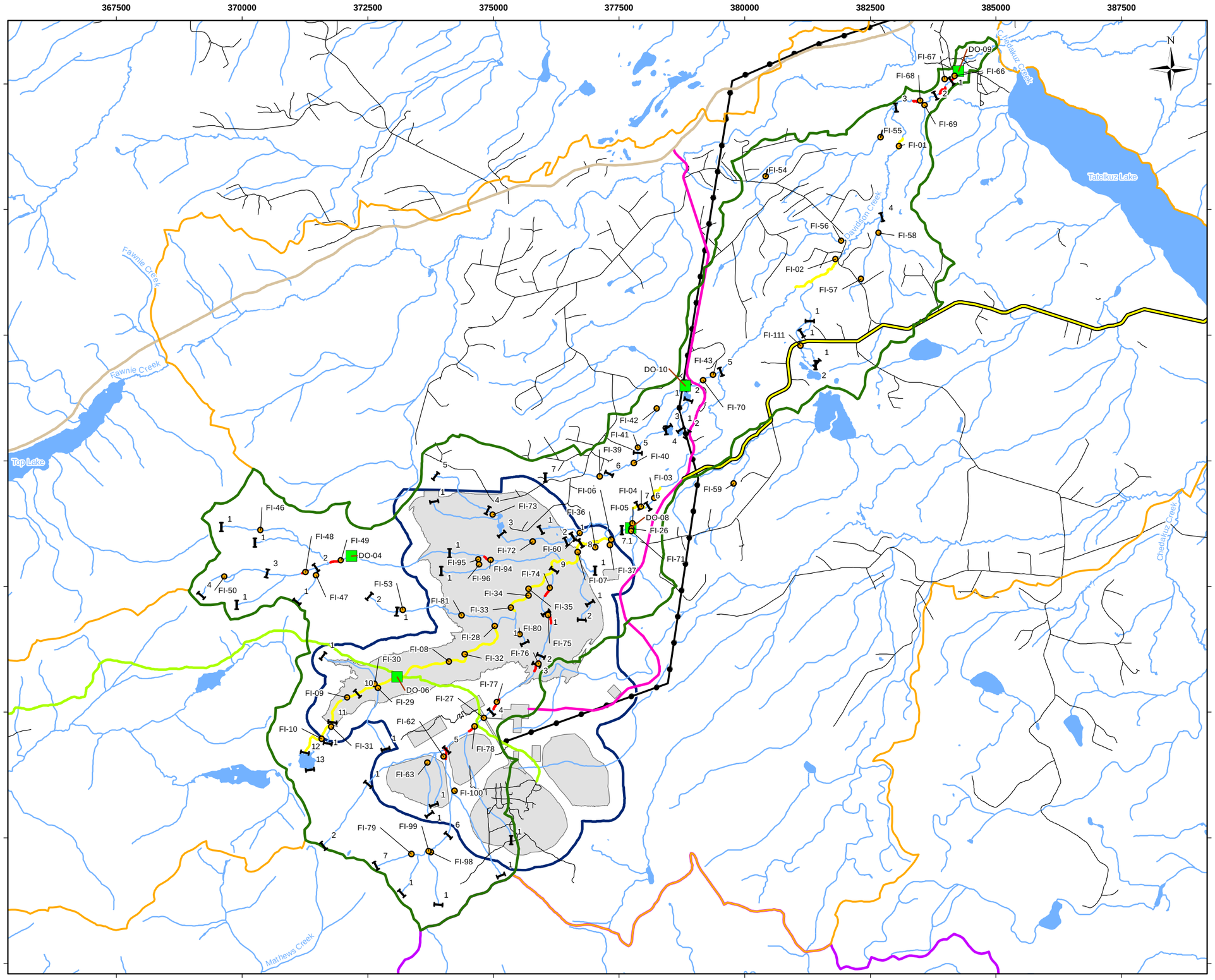
Mean zooplankton density (organisms/m^3) and biomass (mg/m^3) were calculated for each lake and compared graphically. Mean density of major taxa and indices of diversity (S and H') and evenness (J) were calculated for each lake and compared using tables.

4.7 Stream Fish Habitat

Stream habitat surveys were conducted in 2011 and 2012 to identify, characterize, and quantify the available habitat for fish within the LSA, and at stream crossings along the transmission line corridor and the road access corridor.

4.7.1 Surveys in the LSA

Two survey methods were used in the LSA: Level 1 *Fish Habitat Assessment Procedures* (FHAP) (Johnston and Slaney 1996) and *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001). They were used at different sites, depending on the size of the stream, the presence of fish, and the location of the stream in relation to proposed Project infrastructure and activities (**Figure 4.7-1** to **Figure 4.7-5**). The intensity of habitat surveying was highest in the mine footprint and lower outside the footprint.



Legend

- 1:20,000 Fish and Fish Habitat Inventory (AMEC 2011 & 2012)
- Winter Water Quality and Dissolved Oxygen Sampling Locations
- Reach Break
- FHAP Study Segment 2011
- FHAP Study Segment 2012
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

N

Scale:1:75,000

1 0.5 0 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

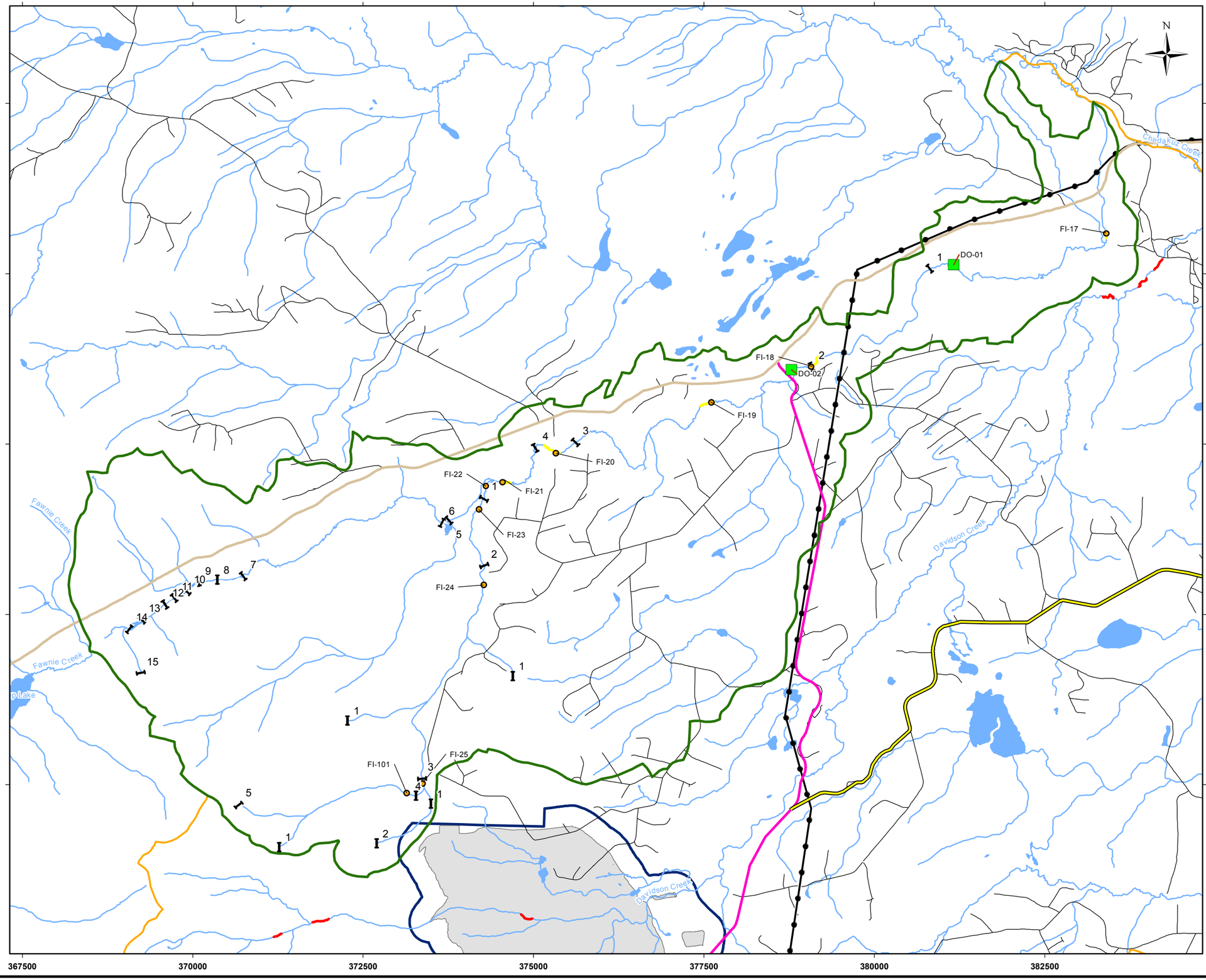
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PROJECT: Blackwater Gold Project

Stream Habitat Sites, Davidson Creek Watershed, 2011-2012

DATE:	ANALYST:	**Figure** 4.7-1
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Legend

- 1:20,000 Fish and Fish Habitat Inventory (AMEC 2011 & 2012)
- Winter Water Quality and Dissolved Oxygen Sampling Locations
- Reach Break
- FHAP Study Segment 2011
- FHAP Study Segment 2012
- Local Study Area
- Klusks-Ootsa FSR
- Road
- Stream
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Water Pipeline Route
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

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Kilometres

Reference

BC Government GeoBC Data Distribution

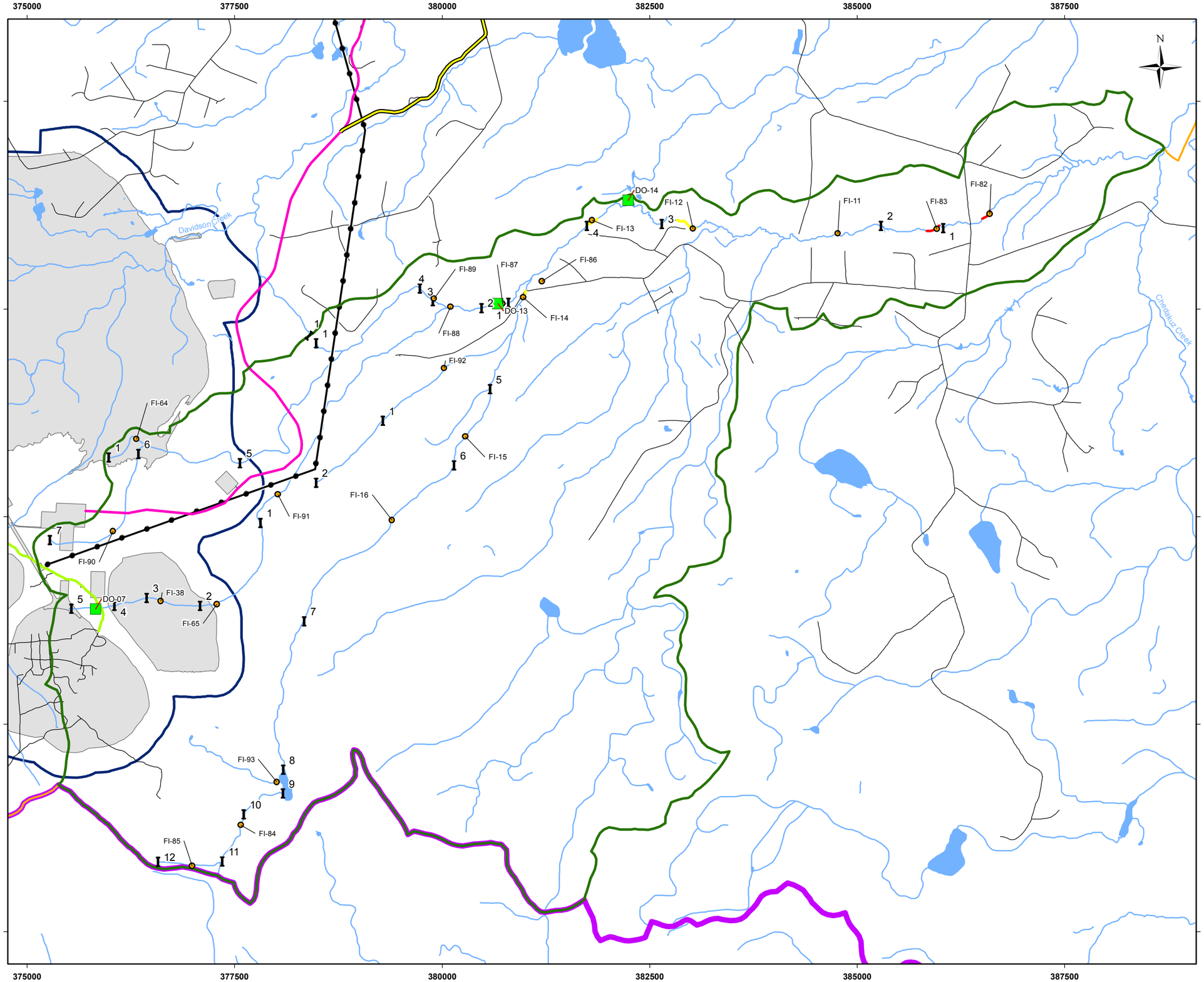
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PROJECT: Blackwater Gold Project

Stream Habitat Sites, Turtle Creek Watershed, 2011-2012

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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-035_v3_stream_habitat_TC_current.mxd



Legend

- 1:20,000 Fish and Fish Habitat Inventory (AMEC 2011 & 2012)
- Winter Water Quality and Dissolved Oxygen Sampling Locations
- Reach Break
- FHAP Study Segment 2011
- FHAP Study Segment 2012
- Local Study Area
- Regional Study Area
- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

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Kilometres

Reference

BC Government GeoBC Data Distribution

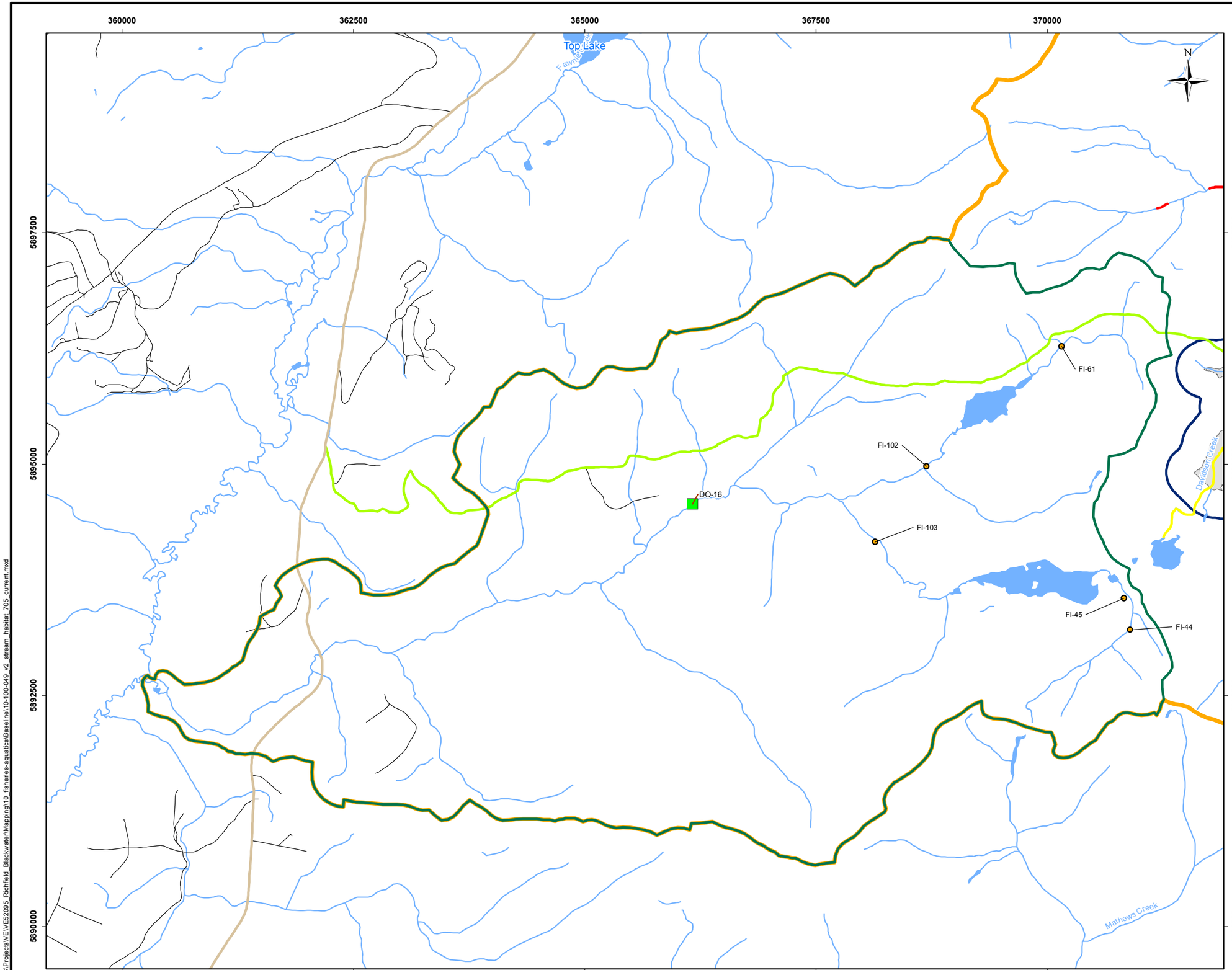
CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Habitat Sites, Creek 661 Watershed, 2011-2012

DATE: March, 2013	ANALYST: AA	**Figure** 4.7-3
JOB No: VE52095	QA/QC: MY	PDF FILE: 10-100-036_v3_stream_habitat_661_current.pdf
GIS FILE: 10-100-036_v3_stream_habitat_661_current.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-036_v3_stream_habitat_661_current.mxd



Legend

- 1:20,000 Fish and Fish Habitat Inventory (AMEC 2011 & 2012)
- Winter Water Quality and Dissolved Oxygen Sampling Locations
- Reach Break
- FHAP Study Segment 2011
- FHAP Study Segment 2012
- Local Study Area
- Exploration Road
- Kluskus-Ootsa FSR
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Scale:1:40,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Habitat Sites, Creek 705 Watershed, 2011-2012

DATE: March, 2013	ANALYST: AA	**Figure** 4.7-4
JOB No: VE52095	QA/QC: MY	PDF FILE: 10-100-049_v2_stream_habitat_705_current.pdf
GIS FILE: 10-100-049_v2_stream_habitat_705_current.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-049_v2_stream_habitat_705_current.mxd

375000 377500 380000 382500 385000 387500 390000 392500

5910000 5907500 5905000 5902500 5900000 5897500

N

13 FI-113 14 FI-112 FI-97 15

Tatelkuz Lake

Chelaslaz Creek

1 2

DO-12

FI-107 FI-108 7 1 FI-109 8 1 2 3 4 FI-110 6 1 5 FI-52 4 FI-105 FI-106 3 FI-104 FI-51 2

1 1 9

Davidson Creek

17 16 18 19 20

Legend

- 1:20,000 Fish and Fish Habitat Inventory (AMEC 2012)
- Winter Water Quality and Dissolved Oxygen Sampling Locations
- Reach Break
- FHAP Study Segment 2012
- Local Study Area
- Kluskus-Ootsa FSR
- Proposed Water Pipeline Route
- Proposed Mine Access Road
- Proposed Transmission Line
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Scale:1:60,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Habitat Sites, Tatelkuz Lake Tributaries Watershed 2012

DATE:	ANALYST:	**Figure** 4.7-5
April, 2013	MY	
JOB No: VE52095	QA/QC: BO	PDF FILE: 10-100-108_Tatelkuz_L_Trib_habitat_current.pdf
GIS FILE: 10-100-108_Tatelkuz_L_Trib_habitat_current.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095 Richfield Blackwater\Mapping\10 fisheries-aquatics\Baseline\10-100-108_Tatelkuz_L_Trib_habitat_current.mxd

The FHAP method collects continuous data, generally over longer stretches of habitat than the reconnaissance 1:20,000 method. It provides information on the distribution, frequency and surface area of various meso-habitat units (i.e., glides, riffles, and pools), and describes their unique hydraulic parameters. While similar to the reconnaissance 1:20,000 fish habitat inventory methods in the type of data collected, the FHAP method typically requires entire stream segments to be assessed. FHAP data can also be collected at randomly selected intervals, which permits extrapolation to the remaining stream segment. Data are collected on several stream features to characterize habitat conditions, including adult holding pools, spawning gravel quantity and quality, pool area and frequency, cover in pools and riffles, large woody debris (LWD) frequency and distribution, substrate characteristics, and off-channel habitat.

FHAP does not provide explicit evaluations of quantity and quality of fish habitat. That will be done during the development of a Fish Habitat Compensation Plan by multiplying meso-habitat units by Habitat Suitability Indices with values between 0 and 1 to produce Habitat Units. Habitat Units are quantitative measures of habitat quality and quantity.

The reconnaissance 1:20,000 method collects habitat information from discrete stream segments by measuring a suite of data over sites 100 m long. It is a particularly useful for describing how the stream interacts with its upslope valley, describing the stream's morphology, flow pattern, stream bed and bank characteristics, instream and overhead cover, habitat availability and quality, and documenting any past disturbances. This method was used in all smaller tributary streams and all reaches of main drainages that were sampled using the FHAP methods. Historical data collected by CanFor was completed using 1:20,000 habitat inventory standards. Unlike FHAP, the reconnaissance 1:20,000 method produces overall ratings of none, poor, fair, and good for fish habitat quality and habitat suitability for each life history (i.e., spawning, rearing, over-wintering, and migration) of salmonid fish species.

4.7.1.1 FHAP Surveys in the LSA

Stream habitat surveys using Level 1 FHAP methods were completed in August 2011 and 2012, focusing on the mainstems of the streams that are located within or downstream of the Project mine site. These included reaches of Davidson Creek within the proposed mine site, as well as two major tributaries to Davidson Creek within the proposed mine site (creeks 688328 and 704454), Turtle Creek, Creek 661 and Chedakuz Creek (**Table 4.7-1**).

A modified FHAP approach was used. It involved systematic sampling of each reach using a randomized starting point. This was done because the total length of streams in the LSA that had to be surveyed was too great to survey the entire length – sub-sampllng was required. At a minimum, the modified FHAP method was completed for 250 m-long stream segments within reaches downstream of the proposed mine site. The percent of reach length that was sub-sampled ranged from 5% to over 100% (**Table 4.7-1**). The overages

were due to errors in estimation of reach lengths using GIS techniques. Survey lengths were measured more accurately than reach lengths.

The surveys were completed by walking up each stream and recording the habitat variables listed in **Table 4.7-2** within each meso-habitat unit. Habitat unit types and categories were based on definitions used for FHAP surveys (Johnston and Slaney 1996). Start and end points for each sampling area were recorded with a handheld GPS unit. Length of each habitat unit was measured with a hip chain and handheld GPS unit. A 30 m-long fibreglass measuring tape, a clinometer, and a metre stick were used to measure widths, gradients, and depths, respectively. Photographs of significant features such as LWD, extensive riffles, and disturbance features were taken within each study section.

QA/QC procedures for FHAP surveys included the review of field data by team leaders every evening during the survey period. After the end of the survey, data were sent to a senior AMEC biologist who was not involved in the Project. He reviewed the data for completion and consistency.

All fish habitat data collected in 2011 and 2012 was entered into the provincial Field Data Information System (FDIS) database. This database was then used to create individual site habitat data summaries. Individual site habitat data were also summarized for the historical data (**Annex 3.1-1**) in the same format to facilitate analysis using all available habitat data.

Table 4.7-1: FHAP Locations for Stream Reaches Sampled in 2011 and 2012

Stream	BC Freshwater Atlas Code	Reach No.	Reach Length (m)	Start Location (UTM[1])		End Location (UTM)		Survey Length (m)	Survey Date
				Easting	Northing	Easting	Northing		
Davidson Creek	100-567134-610692-522527	1	1,375	384224	5907707	384113	5907551	265	04-Aug-12
		2	499	383988	5907428	383881	5907303	272	04-Aug-12
		3	1,182	383498	5907141	383351	5907131	271	06-Aug-12
		4	2,929	383045	5906220	383148	5906415	251	08-Aug-11
		5	5,310	381843	5904042	381016	5903445	1,270	07-Aug-11
		6	4,146	378203	5899307	378318	5899465	264	17-Aug-11
		7	232	377998	5899063	377780	5899056	253	17-Aug-11
		7.1	789	377728	5898790	377673	5898656	250	19-Aug-11
		8	953	377382	5898435	377245	5898455	836	07-Aug-11
		9	1,120	377245	5898455	376197	5897821	1,174	07-Aug-11
		10	5,599	376197	5897821	372282	5895367	2,374	09-Aug-11
		11	851	372282	5895367	371792	5894792	709	10-Aug-11
		12	975	371792	5894792	371267	5894213	1,113	10-Aug-11
Creek 688328	100-567134-610692-522527-688328	1	2,436	374979	5898040	374812	5898091	265	07-Aug-12
		2	2,869	371993	5898035	371755	5897980	253	08-Aug-12
		3	1,026	371301	5897821	371183	5897801	255	08-Aug-12
Creek 704454	100-567134-610692-522527-704454	1	892	376145	5897513	376028	5897311	253	09-Aug-12
		2	960	376056	5896961	376145	5896766	256	07-Aug-12
		3	195	375912	5896011	375816	5895816	257	09-Aug-12
		4	1,348	375119	5895243	374995	5895061	257	05-Aug-12
		5	1,195	374667	5894740	374533	5894588	250	05-Aug-12
		6	1,749	374015	5894069	374027	5894266	248	06-Aug-12
Turtle Creek	100-567134-610692-480511	1	3,373	383417	5908122	383367	5908093	105	16-Aug-11
		2	2,885	379212	5906281	379075	5906132	255	09-Aug-11
		3	5,509	377651	5905605	377454	5905547	279	16-Aug-11
		4	735	375384	5904859	375156	5904968	275	15-Aug-11
		5	2,256	374653	5904428	374505	5904448	192	09-Aug-11
Creek 661	100-567134-610692-671007	1	-	386585	5898688	386508	5898596	251	03-Aug-12
		2	-	385986	5898505	385836	5898403	252	02-Aug-12
		3	3,217	383063	5898469	382831	5898582	265	11-Aug-12
		4	1,368	381872	5898574	381763	5898544	108	12-Aug-12
		5	2,459	381011	5897712	380973	5897626	101	12-Aug-12
Chedakuz Creek	100-567134-610692	14	-	383935	5909409	383927	5909408	307	18-Sep-12
		15	-	383927	5909408	384502	5909238	350	18-Sep-12

Notes: [1] NAD 83, Zone 10
BC = British Columbia; m = metre, UTM = Universal Transverse Mercator

Table 4.7-2: Habitat Variables Measured During FHAP Surveys Conducted in 2011 and 2012

Physical Measurements	Channel Observations	Cover/Habitat
Length (m)	Habitat unit type and category	Dominant substrate type
Bankfull width (m)	Pool type	Sub-dominant substrate type
Wetted width (m)	Presence of barriers	Total cover (%)
Wetted depth (m)		Cover composition (%)
Gradient (%)		Off-channel habitats present
Pool depth (m)		Riparian vegetation type
Residual pool depth (m)		Riparian vegetation structure
		Disturbance indicators
		Functional LWD tally
		Canopy closure (%)

Source: Johnston and Slaney (1996)
Notes: LWD = large woody debris; m = metre; % = percent

Total survey length, mean bankfull width and mean wetted width were calculated for each habitat unit in all stream reaches where a FHAP survey was conducted. The total area of each habitat unit, by reach, was derived using the total surveyed length and mean bankfull width. Percent composition of different habitat unit types surveyed was calculated using the habitat unit type and total habitat areas surveyed for each reach. Other habitat variables that were calculated or summarized for each habitat unit type by reach from the FHAP dataset included:

- Mean water depth and residual pool depth;
- Dominant and sub-dominant substrate types and general distribution of spawning gravels;
- Mean total of functioning and non-functioning LWD;
- Dominant and sub-dominant fish cover types;
- Presence and type of off-channel habitat; and
- Type and structure of riparian vegetation.

Gradients in each stream reach were determined from 1-m contour LiDAR imagery.

4.7.1.2 Reconnaissance 1:20,000 Surveys in the LSA

In 2011 and 2012, reconnaissance 1:20,000 fish habitat inventories were completed at a total of 113 stream sites (**Figure 4.7-1** to **Figure 4.7-5** and **Table 4.7-3**). This included 43 sites in all mainstem reaches of Davidson Creek, Turtle Creek, Creek 661, Creek 688328, Creek 704454, and Chedakuz Creek where FHAP surveys were conducted, plus an additional 42 sites in tributaries to Davidson Creek, 5 sites in the Creek 700 drainage (of the Turtle Creek Watershed), 14 sites in the Creek 661 Watershed, 7 sites in the Creek 705 Watershed, and 13 sites in the Tatelkuz Lake Tributaries Watershed.

Reconnaissance 1:20,000 protocols were also used to assess additional sites surveyed during kokanee surveys in August and September of 2012. Four of five sites fell outside of the five main watersheds, but within the Chedakuz Creek drainage. One site was part of the Tatelkuz Lake Tributaries Watershed.

Between 1997 and 2006, reconnaissance 1:20,000 fish and fish habitat inventories were completed for all the main drainages within the preliminary LSA (Golder 1998; DWB 2001, 2002; Ecofor 2004; Triton 2006). A total of 107 sampling sites from this dataset were relevant to the main drainages studies as part of this baseline report. Therefore, information was extracted from this dataset and incorporated into this report to support descriptions of fish habitat conditions within the preliminary LSA. **Annex 3.1-1** summarizes the location and timing of data collection for the historical 1:20,000 fish habitat inventories completed in the four main drainages.

Habitat variables listed in **Table 4.7-4** were collected at discrete 100 m-long sampling sites for the 1:20,000 fish habitat inventory. Site cards were filled out as per the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Site Card Field Guide* (RISC 1999b). Sampling equipment included a 30 m-long fibreglass tape measure, clinometer, hip chain, and 2 m-long measuring stick.

At each sampling site, overall fish habitat quality and habitat suitability for each life history (i.e., spawning, rearing, over-wintering, and migration) of salmonid fish species was rated according to professional judgment and known salmonid life history requirements (e.g., presence of spawning gravel, presence of deep-pools, presence of abundant cover) (**Table 4.7-5**). Salmonid criteria were used because rainbow trout was the predominant fish species that used stream habitat in the LSA. The second most common fish species was kokanee, also a salmonid fish.

As with FHAP surveys, QA/QC procedures for reconnaissance surveys included the review of stream cards by team leaders every evening during the survey period. After the end of the survey, stream cards were sent to a senior AMEC biologist who was not involved in the Blackwater Project. He reviewed the cards for completion and consistency.

All fish habitat data collected in 2011 and 2012 was entered into a database using the provincial Field Data Information System (FDIS). This database was then used to create individual site habitat data summaries. Individual site habitat data were also summarized for the historical data (**Annex 3.1-1**) in the same format to facilitate analysis using all available habitat data.

Table 4.7-3: Reconnaissance (1:20,000) Stream Habitat Sampling Sites in 2011 and 2012

Watershed	Stream	BC Freshwater Atlas Code	ILP	Reach No.	Baseline Map Site ID	Location (UTM[1])		Month/Year Sampled
						Easting	Northing	
Davidson Creek	Davidson Creek	100-567134-610692-522527	n/a	1	FI-66	384175	5907661	Aug-12
	Davidson Creek	100-567134-610692-522527	n/a	2	FI-67	383983	5907396	Aug-12
	Davidson Creek	100-567134-610692-522527	n/a	3	FI-68	383491	5907167	Aug-12
	Davidson Creek	100-567134-610692-522527	n/a	4	FI-01	383074	5906262	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	5	FI-02	381812	5904012	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	6	FI-03	378202	5899256	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	7	FI-04	377944	5899087	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	7.1	FI-05	377773	5898757	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	8	FI-06	376675	5893011	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	9	FI-07	376677	5898181	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	10	FI-08	374116	5896003	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	11	FI-09	372092	5895287	Aug-11
	Davidson Creek	100-567134-610692-522527	n/a	12	FI-10	371587	5894469	Aug-11
	Creek 083617	100-567134-610692-522527-083617	n/a	1	FI-69	383582	5907072	Aug-12
	Creek 114028	100-567134-610692-522527-114028	n/a	1	FI-55	382703	5906441	Jun-12
	Creek 114028	100-567134-610692-522527-114028	n/a	2	FI-54	380417	5905658	Jun-12
	Creek 226858	100-567134-610692-522527-226858	n/a	1	FI-58	382665	5904532	Jun-12
	Creek 262989	100-567134-610692-522527-262989	n/a	1	FI-56	381923	5904375	Jun-12
	Creek 062193	100-567134-610692-522527-226858-062193	n/a	1	FI-57	382318	5903620	Jun-12
	Creek 314089	100-567134-610692-522527-314089	n/a	1	FI-111	381101	5902303	Sep-12
	Creek 428073	100-567134-610692-522527-428073	n/a	1	FI-43	377880	5900258	Jun-12
	Creek 428073	100-567134-610692-522527-428073	n/a	1	FI-70	379171	5901598	Aug-12
	Creek 184112	100-567134-610692-522527-428073-184112	n/a	1	FI-42	378253	5901041	Jun-12
	Creek 428073	100-567134-610692-522527-428073	n/a	5	FI-41	377880	5900258	Jun-12
	Creek 428073	100-567134-610692-522527-428073	n/a	6	FI-40	377798	5899955	Jun-12

Table continues…

Table 4.7-3 (cont'd)

Watershed	Stream	BC Freshwater Atlas Code	ILP	Reach No.	Baseline Map Site ID	Location (UTM[1])		Month/Year Sampled
	Creek 428073	100-567134-610692-522527-428073	n/a	7	FI-39	377117	5899691	Jun-12
	Creek 616152	100-567134-610692-522527-616152	n/a	1	FI-26	377752	5898652	Aug-11
	Creek 616713	100-567134-610692-522527-636713	n/a	1	FI-26	377752	5898652	Aug-11
	Creek 636713	100-567134-610692-522527-636713	n/a	1	FI-60	376723	5898562	Jun-12
	Creek 636713	100-567134-610692-522527-636713	n/a	3	FI-72	375780	5898392	Aug-12
	Creek 636713	100-567134-610692-522527-636713	n/a	4	FI-73	374985	5898930	Aug-12
	Creek 688328	100-567134-610692-522527-688328	n/a	1	FI-94	374945	5898027	Aug-12
	Creek 688328	100-567134-610692-522527-688328	n/a	2	FI-49	371962	5898019	Jun-12, Aug-12
	Creek 688328	100-567134-610692-522527-688328	n/a	3	FI-48	371263	5897784	Jun-12, Aug-12
	Creek 688328	100-567134-610692-522527-688328	n/a	4	FI-50	369644	5897698	Jun-12, Aug-12
	Creek 667871	100-567134-610692-522527-688328-667871	n/a	1	FI-47	371471	5897718	Jun-12, Aug-12
	Creek 634527	100-567134-610692-522527-688328-634527	n/a	1	FI-46	370367	5898621	Jun-12, Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	1	FI-74	376125	5897471	Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	2	FI-75	376086	5896933	Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	3	FI-76	375893	5895964	Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	4	FI-77	375072	5895202	Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	5	FI-78	374624	5894718	Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	5	FI-27	374808	5894882	Aug-11
	Creek 704454	100-567134-610692-522527-704454	n/a	6	FI-62	374009	5894113	Jun-12, Aug-12
	Creek 704454	100-567134-610692-522527-704454	n/a	7	FI-79	373370	5892175	Aug-12
	Creek 686326	100-567134-610692-522527-704454-686326	n/a	1	FI-100	374223	5893433	Aug-12
	Creek 853864	100-567134-610692-522527-704454-853864	n/a	1	FI-99	373709	3892235	Aug-12
	Creek 076095	100-567134-610692-522527-704454-569241-076095	n/a	1	FI-63	373689	5893994	Jun-12, Aug-12
	Creek 758727	100-567134-610692-522527-758727	n/a	1	FI-80	375529	5896543	Aug-12
	Creek 776798	100-567134-610692-522527-776798	n/a	1	FI-28	375028	5896712	Aug-11
	Creek 776798	100-567134-610692-522527-776798	n/a	1	FI-81	374364	5896926	Aug-12

Table 4.7-3 (cont'd)

Table continues…

Watershed	Stream	BC Freshwater Atlas Code	ILP	Reach No.	Baseline Map Site ID	Location (UTM[1])		Month/Year Sampled
	Creek 776798	100-567134-610692-522527-776798	n/a	1	FI-53	373199	5897035	Jun-12
	Creek 896157	100-567134-610692-522527-896157	n/a	1	FI-29	372705	5895478	Aug-11
	Creek 899664	100-567134-610692-522527-899664	n/a	1	FI-30	372641	5895562	Aug-11
	Creek 948457	100-567134-610692-522527-948457	n/a	1	FI-31	371778	5894709	Aug-11
	x	-	145	1	FI-37	377319	5898321	Aug-11
	x	-	144	1	FI-36	377025	5898277	Aug-11
	x	-	95A	1	FI-95	374705	5898037	Aug-12
	x	-	96A	1	FI-96	374715	5897936	Aug-12
	x	-	98A	1	FI-98	373757	5892214	Aug-12
	x	-	137	1	FI-35	375698	5897455	Aug-11
	x	-	136	1	FI-34	375699	5897317	Aug-11
	x	-	134	1	FI-33	375351	5897080	Aug-11
	x	-	127	1	FI-32	374433	5896152	Aug-11
Turtle Creek	Turtle Creek	100-567134-610692-480511	n/a	1	FI-17	383404	5908086	Aug-11
	Turtle Creek	100-567134-610692-480511	n/a	2	FI-18	379075	5906132	Aug-11
	Turtle Creek	100-567134-610692-480511	n/a	3	FI-19	377609	5905611	Aug-11
	Turtle Creek	100-567134-610692-480511	n/a	4	FI-20	375328	5904866	Aug-11
	Turtle Creek	100-567134-610692-480511	n/a	5	FI-21	374548	5904434	Aug-11
	Creek 700	100-567134-610692-480511-645840	n/a	1	FI-22	374306	5904380	Aug-11
	Creek 700	100-567134-610692-480511-645840	n/a	2	FI-23	374201	5904040	Aug-11
	Creek 700	100-567134-610692-480511-645840	n/a	3	FI-24	374273	5902933	Sep-11
	Creek 700	100-567134-610692-480511-645840	n/a	4	FI-25	373378	5900015	Sep-11
	Creek 700	100-567134-610692-480511-645840	n/a	5	FI-101	373138	5899878	Sep-12
Creek 661	Creek 661	100-567134-610692-671007	n/a	1	FI-82	386594	5898646	Aug-12
	Creek 661	100-567134-610692-671007	n/a	2	FI-83	385959	5898462	Aug-12
	Creek 661	100-567134-610692-671007	n/a	3	FI-11	384769	5898411	Aug-11
	Creek 661	100-567134-610692-671007	n/a	3	FI-12	383023	5898466	Aug-11
	Creek 661	100-567134-610692-671007	n/a	4	FI-13	381805	5898570	Aug-11

Table 4.7-3 (cont'd)

Table continues…

Watershed	Stream	BC Freshwater Atlas Code	ILP	Reach No.	Baseline Map Site ID	Location (UTM[1])		Month/Year Sampled
	Creek 661	100-567134-610692-671007	n/a	5	FI-14	380977	5897639	Aug-11
	Creek 661	100-567134-610692-671007	n/a	6	FI-15	380277	5895964	Aug-11
	Creek 661	100-567134-610692-671007	n/a	7	FI-16	379394	5894956	Aug-11
	Creek 661	100-567134-610692-671007	n/a	11	FI-84	377573	5891285	Aug-12
	Creek 661	100-567134-610692-671007	n/a	12	FI-85	376987	5890794	Aug-12
	Creek 505659	100-567134-610692-671007-505659	n/a	1	FI-86	381021	5897835	Aug-12
	Creek 505659	100-567134-610692-671007-505659	n/a	2	FI-87	380726	5897563	Aug-12
	Creek 505659	100-567134-610692-671007-505659	n/a	3	FI-88	380100	5897525	Aug-12
	Creek 505659	100-567134-610692-671007-505659	n/a	4	FI-89	379902	5897626	Aug-12
	Creek 505659	100-567134-610692-671007-505659	n/a	6	FI-64	376313	5895933	Jun-12
	Creek 505659	100-567134-610692-671007-505659	n/a	7	FI-90	376031	5894825	Aug-12
	Creek 146920	100-567134-610692-671007-505659-146920	n/a	1	FI-91	378017	5895265	Aug-12
	Creek 146920	100-567134-610692-671007-505659-146920	n/a	2	FI-65	377281	5893946	Jun-12
	Creek 146920	100-567134-610692-671007-505659-146920	n/a	3	FI-38	376609	5893983	Aug-11
	Creek 543585	100-567134-610692-671007-543585	n/a	1	FI-92	380021	5896786	Aug-12
	Creek 885275	100-567134-610692-671007-885275	n/a	1	FI-93	378008	5891802	Aug-12
Creek 705	Creek 705	100-567134-641477-543682-698692	n/a	4	FI-103	368140	5894161	Sep-12
	Creek 705	100-567134-641477-543682-698692	n/a	10	FI-45	370827	5893554	Jun-12, Sep-12
	Creek 705	100-567134-641477-543682-698692	n/a	11	FI-44	370895	5893207	Jun-12
	Creek 606013	100-567134-641477-543682-698692-606013	n/a	1	FI-102	368695	5894975	Sep-12
	Creek 606013	100-567134-641477-543682-698692-606013	n/a	4	FI-61	370155	5896294	Jun-12, Sep-12
Tatelkuz Lake Tributaries	Chedakuz Creek	100-567134-610692	n/a	-	FI-113	383804	5909445	Sep-12
	Chedakuz Creek	100-567134-610692	n/a	-	FI-112	384502	5909238	Sep-12
	Chedakuz Creek	100-567134-610692		-	KO-23	390308	5901131	Sep-12
	Creek 579340	100-567134-610692-579340	n/a	3	FI-104	384330	5900374	Sep-12

Table 4.7-3 (cont'd)

Table continues…

	Creek 579340	100-567134-610692-579340	n/a	4	FI-105	383127	5900311	Sep-12
	Creek 579340	100-567134-610692-579340	n/a	5	FI-52	382894	5900236	Jun-12, Sep-12
	Creek 579340	100-567134-610692-579340	n/a	6	FI-106	382254	5900472	Sep-12

Watershed	Stream	BC Freshwater Atlas Code	ILP	Reach No.	Baseline Map Site ID	Location (UTM[1])		Month/Year Sampled
	Creek 579340	100-567134-610692-579340	n/a	8	FI-107	380610	5900678	Sep-12
	Creek 579340	100-567134-610692-579340	n/a	9	FI-59	379780	5899548	Jun-12
	Creek 579340	100-567134-610692-579340	n/a	9	FI-59	379780	5899548	Sep-12
	Creek 549629	100-567134-610692-579340-549629	n/a	1	FI-51	383242	5899880	Jun-12
	Creek 549629	100-567134-610692-579340-549629	n/a	1	FI-51	383243	5899880	Sep-12
	Creek 664387	100-567134-610692-579340-664387	n/a	1	FI-110	382071	5900312	Sep-12
	Creek 737376	100-567134-610692-579340-737376	n/a	1	FI-108	381329	5900573	Sep-12
	Creek 737376	100-567134-610692-579340-737376	n/a	2	FI-109	381155	5900289	Sep-12
Chedakuz Creek	Chedakuz Creek	100-567134-610692	n/a	-	KO-30	398132	5889857	Sep-12
	Creek 101550	100-567134-610692-101550	n/a	-	KO-02	368657	5918211	Sep-12
	Creek 522107	100-567134-610692-522107	n/a	-	KO-12	385095	5908260	Sep-12
	Creek 601947	100-567134-610692-601947	n/a	-	KO-19	390540	5903032	Sep-12

Notes: [1] NAD 83, Zone 10
"-" = no BC Freshwater Atlas Code; BC = British Columbia; ID = identification; ILP = Interim Location Point; n/a = not applicable; UTM = Universal Transverse Mercator; x = no assigned name

Table 4.7-4: Habitat Variables Measured During Reconnaissance (1:20,000) Fish Habitat Inventories Conducted in 2011 and 2012

Physical Measurements	Channel Observations	Cover/Habitat
Channel width (m)	Morphology type	Dominant bed material
Wetted width (m)	Presence of disturbance indicators	Sub-dominant bed material
Residual pool depth (m)	Wildlife observations	Cover type
Gradient (%)	Bank shape and texture	Crown closure (%)
Temperature (°C)	Riparian vegetation type and stage	LWD functionality and distribution
pH	Presence of island/bars and type	Instream vegetation type
Conductivity (µS/cm)	Description of stream coupling and confinement	Habitat quality ratings for spawning, rearing, and over-wintering habitat for resident and migratory salmonids

Source: RISC (1999c, 2001)

Notes: °C = degrees Celsius; LWD = large woody debris; µS/cm = microSiemens per centimetre; m = metre; % = percent

Table 4.7-5: Criteria for Rating Habitat Quality for Salmonids in Streams

Habitat Quality Ranking	Criteria
None	No habitat present for any life history stage
Poor	Most of the necessary physical/biological components of the habitat are missing or severely deficient (e.g., no pools, little stream cover, fast flow, little spawning gravel)
Fair	Some of the necessary physical/biological components of the habitat are present, but a key component is missing
Good	All of the necessary physical/biological components of the habitat are present

Fish habitat data from all 1:20,000 fish habitat inventories was summarized by the five main drainages (i.e., Davidson Creek, Turtle Creek, Creek 661, Creek 705, and Tatelkuz Lake Tributaries) in tabular form and included:

- BC Freshwater Atlas Code or ILP;
- Reach number;
- Stream order (based on the 1:20,000 Freshwater Atlas data layer);
- Forest Practice Code stream classification (BC MOF 1995);
- Stream morphology/habitat;
- Mean site gradient;
- Mean bankfull and wetted width;
- Mean residual pool depth;
- Mean bankfull depth;
- Stream bed substrate composition;
- Cover composition; and
- Habitat quality ratings for over-wintering, rearing, spawning, and migration habitat for salmonids.

Stream classification mapping was completed using data from CanFor and fish habitat inventories conducted in 2011 and 2012 to provide an overview of fish habitat distribution within each of the five main drainages. The stream classification system follows the provincial S1 to S6 scheme that classifies a stream based on fish presence/absence and mean channel width (BC MOF 1995) (**Table 4.7-6**).

Table 4.7-6: Stream Classification Criteria and Definitions

Stream Class	Fish-Bearing Status	Stream Width (m)
S1	Yes	>20
S2	Yes	>5 – 20
S3	Yes	1.5 – 5
S4	Yes	<1.5
S5	No	>3
S6[1]	No	≤3

Source: Adapted from BC MOF (1995)

Notes: [1] S6 designation includes non-continuous drainages (NCDs) and no visible channel (NVC);
m = metre

For stream classification purposes, the most current data were used to determine the appropriate stream class. In the absence of data collected in 2011 or 2012, stream classifications were determined using historical data. In reaches where more than one survey took place, the stream class was determined using data from the furthest downstream station visited.

4.7.1.3 Over-Wintering Surveys in the LSA

In March 2012, 13 stream sites were visited by helicopter or by truck in order to assess their over-wintering habitat potential. Sites were chosen based on the presence of pools and beaver ponds. Sites were located in Davidson Creek, Turtle Creek, Creek 661, Creek 705, and the Tatelkuz Lake Tributaries Watershed (**Figure 4.7-1** to **Figure 4.7-5**, and **Table 4.7-7**).

Table 4.7-7: Winter Water Quality and Dissolved Oxygen Sampling Locations in Streams, March 2012

Watershed	Stream	Reach	FWA Code	Site Number	Date Sampled	Number of Samples	Habitat Type	UTM Coordinates	
								Easting	Northing
Davidson Creek	Davidson Creek	1	100-567134-610692-522527	DO-09	05-Mar-12	3	Pool/Glide	384257	5907757
Davidson Creek	Davidson Creek	8	100-567134-610692-522527	DO-08	08-Mar-12	2	Pool	377735	5898669
Davidson Creek	Davidson Creek	10	100-567134-610692-522527	DO-06	09-Mar-12	5	Pool	373085	5895698
Davidson Creek	Creek 428073	2	100-567134-610692-522527-428073	DO-10	08-Mar-12	5	Other	378819	5901492
Davidson Creek	Creek 688328	2	100-567134-610692-522527-688328	DO-04	08-Mar-12	3	Pool	372176	5898107
Turtle Creek	Turtle Creek	1	100-567134-610692-480511	DO-01	08-Mar-12	5	Other	381163	5907631
Turtle Creek	Turtle Creek	3	100-567134-610692-480511	DO-02	07-Mar-12	3	Pool/Glide	378784	5906089
Creek 661	Creek 661	4	100-567134-610692-671007	DO-14	07-Mar-12	7	Other	382243	5898809
Creek 661	Creek 505659	2	100-567134-610692-671007-505659	DO-13	06-Mar-12	4	Pool	380670	5897562
Creek 661	Creek 146920	5	100-567134-610692-671007-505659-146920	DO-07	07-Mar-12	1	Glide	375825	5893885
Creek 705	Creek 705	2	100-567134-641477-543682-698692	DO-16	08-Mar-12	2	Pool	366165	5894568
Tatelkuz Lake Tributaries	Lake 01526LNRS	1	100-567134-610692-571602	DO-12	07-Mar-12	5	Other	383822	5902232

Notes: UTM = Universal Transverse Mercator, NAD83 Datum, Zone 10U

Visual observations and photo documentation were carried out during the helicopter overflight. Quantitative physical measurements were completed at several individual sample sites for each site that was accessible by foot (**Table 4.7-7** and **Table 4.7-8**). Sites were rated for over-wintering habitat quality based on the mean concentration of dissolved oxygen and below-ice water depth (**Table 4.7-9)**. The lower of the two ratings were used. Ratings were based on the optimal and lethal dissolved oxygen concentrations for rainbow trout reported by Raleigh et al., 1984 and Ford et al., 1995.

Table 4.7-8: Habitat Variables Measured During Over-wintering Habitat Surveys Conducted in 2012

Physical Measurements	Visual Observations
Snowpack depth (m)	Under ice flow
Ice depth (m)	Hydraulic connection to habitat types
Water depth (m)	Presence of groundwater seeps
Dissolved oxygen (mg/l)	Open water
Temperature (°C)	Thin ice
pH	
Conductivity (µS/cm)	
Turbidity (NTU)	
Secchi depth (m)*	

Notes: °C = degrees Celsius; LWD = large woody debris; µS/cm = microSiemens per centimetre; m = metre; mg/L = milligrams per litre; NTU = nephelometric turbidity units

Table 4.7-9: Criteria for Rating Over-wintering Habitat Quality for Salmonids

Habitat Quality Rating	Dissolved Oxygen Concentration (mg/L)	Water Depth (cm)
None	<3	< 10
Poor	3 to 6	10 to 20
Fair	6 to 7	20 to 50
Good	> 7	> 50

Notes: mg/L = milligrams per litre
Ratings adapted from Raleigh et al. (1984); and Ford et al. (1995).

4.7.2 Surveys in the Transmission Line and Road Access Corridors

Early in 2012, AMEC provided Avison with a geo-referenced list of stream crossing sites along the transmission line corridor and the road access corridor that were to be characterized by a combination of field survey and desk-top survey (Avison 2013). These sites were provided with associated 1:20 000 and 1:50 000 watershed codes and gazetted names where this information existed. **Figure 3.2-1** shows the routes of the transmission line and access road in relation to major watersheds. Appendix A of Avison (2013), shown in this report as **Annex 5.10-5,** includes a series of maps detailing the site information for the crossing locations. Appendix B of Avison (2013) shows a table with coordinates and watershed codes for each site.

Stream crossings were cross-referenced with historical data collected from 2002 to 2006 and located in the provincial databases. First-order streams with a short reach upstream of the crossing that had been previously classified as “no visible channel” (NVC) or “no defined channel (NDC), and which had no obvious lentic point of origin such as a lake or wetland, were not included in the list of sites to be surveyed, and the last known assessment recorded in the provincial databases was deemed acceptable for reporting.

Field sample design included 137 sites associated with the proposed transmission line, 98 sites associated with existing roads, and 10 sites associated with proposed roads. There was often more than one site located within the same reach (i.e., one road and one transmission line site), and in those cases, just one field survey was planned, but both crossings were reported for ease of reference.

Stream crossings are located in the Cheslatta, Chilako, Euchinko, Francois/Fraser, Knewstubb (Nechako Reservoir), and Nechako (middle and upper) watersheds (**Figure 3.2-1**). Access to most sites was by the Kluskus FSR from Vanderhoof, then by secondary roads, including the Kluskus-500 and Davidson-1000 FSR. The northernmost transmission line sites were reached via Highway 16 west from Vanderhoof to the community of Fraser Lake, then south on Francois Lake Road and various secondary roads. Access to a number of the transmission line sites involved hiking several kilometers from the nearest road.

At each site, stream habitat surveys were conducted using *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001). A reach description was completed in accordance with the provincial site card requirements with the exception of survey length at sites that were also planned for navigable waters data collection. At those selected sites, the survey length was 200 m rather than 100 m to facilitate additional data collection requirements. Information on the FAFHI field cards included the following:

- Stream name;
- Reach number;
- Site number, UTM and length;
- Access;
- Date, time, agency and crew;
- Channel measurements (i.e., width and wetted width);
- Gradient;
- Bankfull width and stage;
- Stream cover (overhanging vegetation, LWD, SWD, boulders, undercut banks, and instream vegetation);
- Crown closure;
- Bank characteristics (left bank and right bank shape, texture, riparian vegetation stage);

- Flood signs;
- Channel morphology;
- Bed material;
- Disturbance indicators;
- Channel pattern;
- Islands and bars;
- Coupling and confinement; and
- Site features.

The comment section included the following information where applicable:

- Type and condition of existing crossing structure;
- Fish observations;
- Obvious evidence of habitation by fish (e.g., redds);
- All major features (i.e., fish passage barriers, beaver dams, clay slides, and any other features affecting fish values);
- Any obvious fish habitat limitations;
- Preliminary identification of obvious Fisheries Sensitive Zones as per the procedures outlined in the *Forest Practices Code of British Columbia Fish-Stream Identification Guidebook*; and
- The assessed stream classification at the time of the field survey.

Fish habitat was assessed for spawning (salmonid), rearing, overwintering, and migration potential at all streams that were known or assumed to be fish-bearing. Attributes that were considered during the assessment included:

- Water flow and depth;
- The presence of deep pools and proximity to lentic overwintering areas;
- Connectivity to other fish bearing waters;
- Substrate size, composition and embeddedness; and
- The diversity and abundance of cover types.

All field data were recorded on the applicable field forms, and each site was then marked with a ribbon labelled “Blackwater FAFHI-[site number]2012” tied to a stake embedded in the adjacent riparian zone.

All results from the field sampling phase, as well as stream classifications reported in the FISS from inventories carried out from 2002 to 2006, were entered into a MS Access database that includes several component-specific information tables (i.e., stream classification, fish sampling, riparian vegetation, culvert assessment, navigable waters data) that can be linked and queried by site ID.

4.8 Lake Fish Habitat

4.8.1 Field Sampling

In 2011, bathymetric surveys were conducted for three headwater lakes (Lake 01682LNRS, Lake 01538UEUT, and Lake 01428UEUT) following methods presented in *Bathymetric Standards for Lake Inventories* (RISC 2009a). This included conducting a shoreline cruise to determine the lake perimeter, establishing benchmarks at each lake, recording high water marks, surveying the shorelines, and spacing transects close enough to ensure spatial accuracy of the final bathymetry map. A Garmin GPSMAP 421s with an internal GPS receiver was used to collect depth and location data.

Lakes were divided into two major habitat zones: littoral (i.e., all areas less than 6 m deep) and profundal (i.e., all areas greater than 6 m deep). The areas of each zone were calculated from bathymetric maps.

Physical limnology data were collected from all three headwater lakes in August 2011 and September 2012 and from Tatelkuz Lake, Kuyakuz Lake, and Snake Lake in 2012. Data were measured at sites located at the maximum depth of each lake, as determined by a hand-held depth sounder (**Table 4.8-1** and **Figure 4.8-1**). In all six lakes, one or more vertical profiles of water temperature and DO concentration were measured with a YSI Model 85 multimeter. Temperatures and DO concentrations were taken at intervals of 0.5 m or 1.0 m during the descent and ascent of the probe through the water column.

Table 4.8-1: Dates and Locations of Vertical Profiles of Temperature and Dissolved Oxygen, Lakes in Blackwater RSA, 2011 and 2012

Lake	Date	Location (UTM)[1]	
		Easting	Northing
Lake 01682LNRS	14-Aug-11	371289	5894010
	26-Jun-12	371286	5893967
	11-Sep-12	371286	5893967
	19-Sep-12	371283	5894015
Lake 01538UEUT	12-Aug-11	369339	5895606
	26-Jun-12	369674	5893745
	10-Sep-12	370186	5893729
	11-Sep-12	369674	5893745
Lake 01428UEUT	16-Aug-11	370180	5893720
	08-Sep-12	369313	5895611
	11-Sep-12	369313	5895611
Tatelkuz Lake	25-Jun-12	385469	5907206
	10-Sep-12	385619	5907537
Kuyakuz Lake	25-Jun-12	394273	5888905
	10-Sep-12	394736	5888694
Snake Lake	26-Jun-12	381630	5901172
	11-Sep-12	381630	5901172

Notes: UTM – Universal Transverse Mercator
[1] North American Datum 83, Zone 10.

Secchi depth (D_s) was measured in the three headwater lakes by lowering a Secchi disc over the side of a boat with a cable marked in meters and recording the depth at which the disc disappeared from sight.

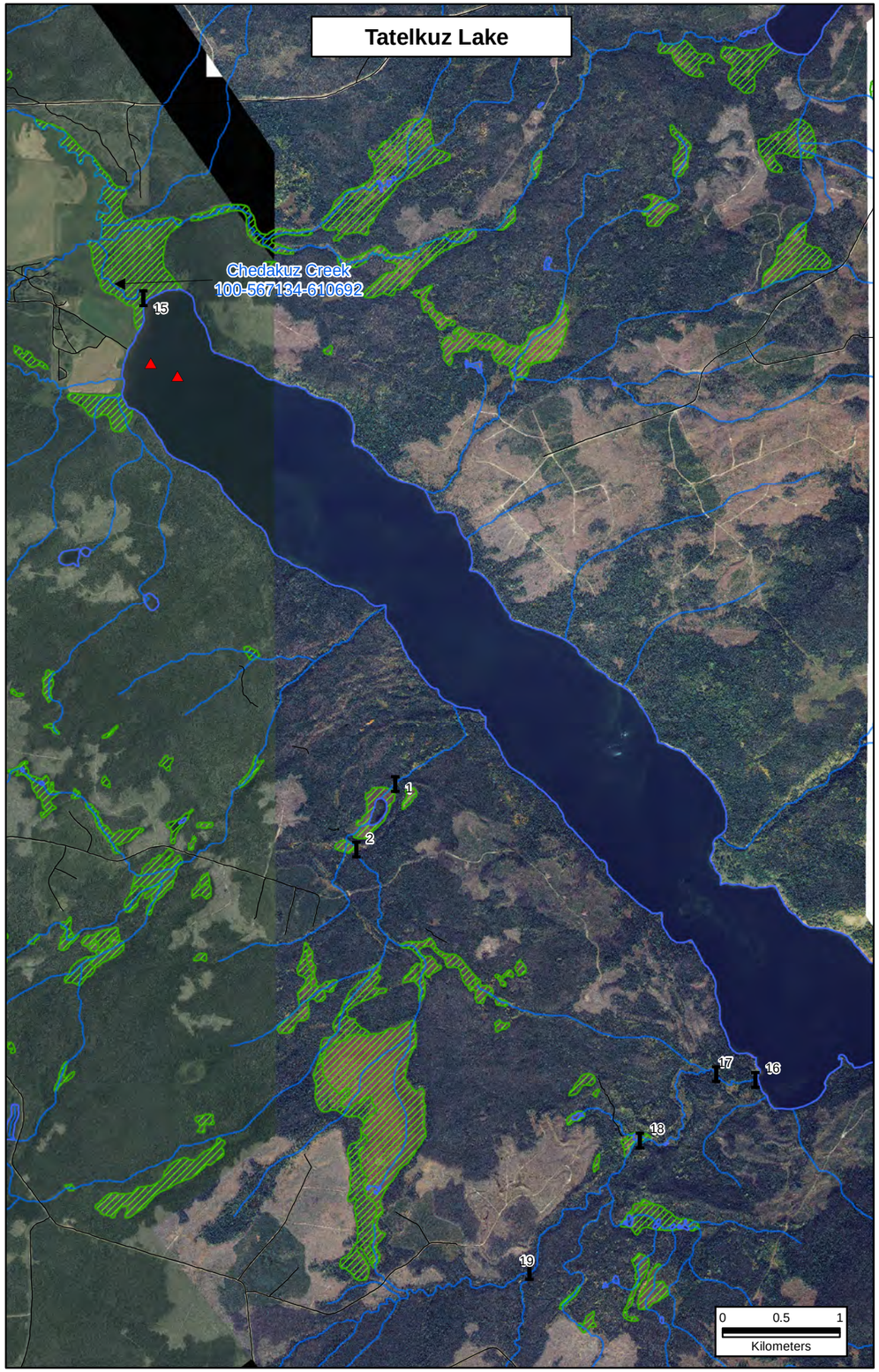
Littoral habitat in the three headwater lakes was assessed during the summer of 2011 following methods described by *Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001). All data were recorded on lake survey forms as per the *Fish and Fish Habitat Inventory: Lake Survey Form Field Guide* (RISC 1999a). Littoral habitat was classified during shoreline cruises of the lakes by boat.

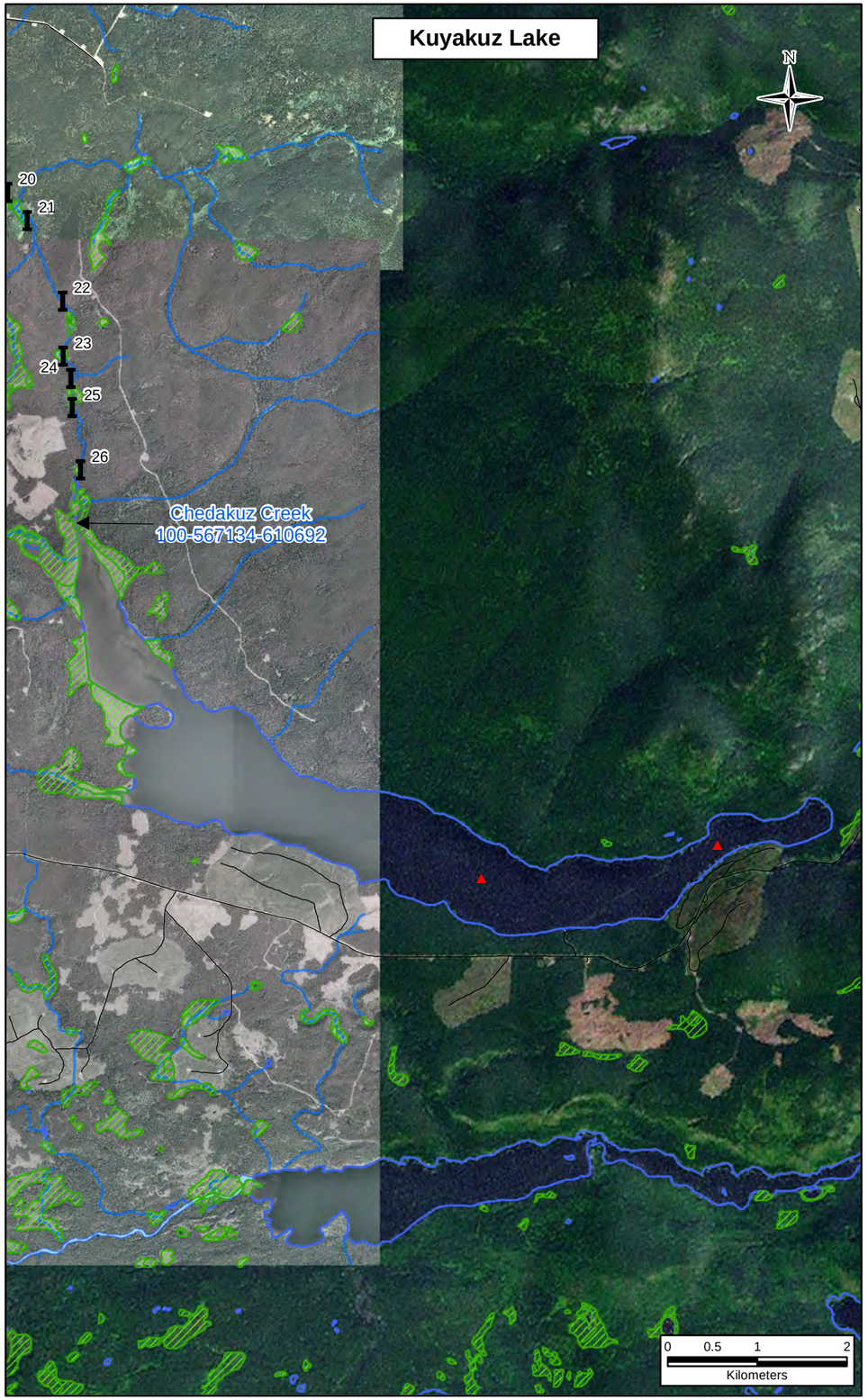
Littoral habitats were classified by dominant and sub-dominant substrate types (i.e., fines, gravel, cobble, bedrock) and depth (<6 m). Organic and inorganic fine substrate materials were not segregated for classification purposes. Substrate types were determined through visual observation, probing with an avalanche probe, and/or collection of samples with an Ekman dredge. Five different habitat classes were identified in the three lakes based on these parameters:

1. **Dominant gravels, subdominant fines (Gf)** – substrates dominated by gravels with fines being subdominant.
2. **Dominant gravels, subdominant boulders and fines (Gbf)** – substrates dominated by gravel with boulders and fines being subdominant.
3. **Dominant cobbles, subdominant boulders and fines (Cbf)** – substrates dominated by cobbles with boulders and fines being subdominant.
4. **Dominant cobbles, subdominant boulders and gravel (Cbg)** – substrates dominated by cobbles with boulders and gravel being subdominant.
5. **Dominant fines, subdominant gravels (Fg)** – substrates dominated by fine substrates, with gravels being subdominant.

Not all five substrate classes were found in each lake. The spatial extent of the littoral zone classification in the field was restricted to the area from the shoreline where the lake bottom could be seen from the surface. These areas were expanded to the 6 m depth contour in the office using GIS after the bathymetric data were processed.

Areas of emergent and submergent aquatic vegetation were identified and any areas of cover provided by overhanging vegetation or LWD were noted. Aquatic vegetation was identified to genus and its distribution was drawn on field maps. A qualitative assessment of littoral habitat quality for fish spawning, rearing, and over-wintering habitat was made.

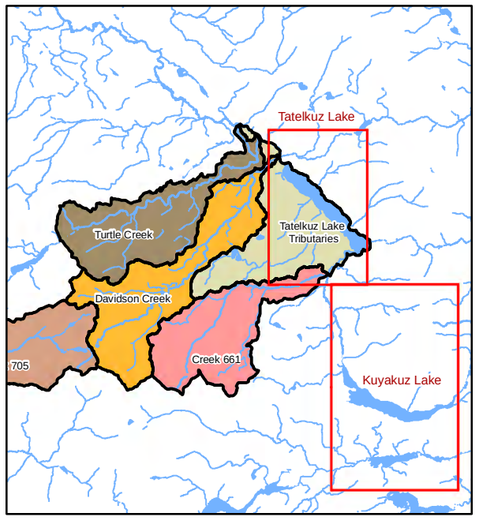




Legend

- Limnology Station
- Reach Break
- Existing Road
- Stream
- Lake
- Wetland

KEY MAP



Reference
BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Limnology Sites, Tatelkuz and Kuyakuz Lakes 2012

DATE: April, 2013	ANALYST: MY	**Figure** 4.8-1
JOB No: VE52277	QA/QC: IM	PDF FILE: 10-100-123_Lake_2012_tatelkuz_kuyakuz.pdf
GIS FILE: 10-100-123_Lake_2012_tatelkuz_kuyakuz.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-123_Lake_2012_tatelkuz_kuyakuz.mxd

In March 2012, habitat surveys were conducted in three of the four headwater lakes to assess their over-wintering habitat potential (**Table 4.8-2**). The same habitat variables were measured as were measured at overwintering stream sites (**Table 4.7-7**). Sites were rated for over-wintering habitat quality based on the mean DO concentration and water depth (**Table 4.7-8**).

Table 4.8-2: Winter Water Quality and Dissolved Oxygen Sampling Locations in Lakes, March 2012

Watershed	Lake	FWA Code	Site Number	Date Sampled	Number of Samples	Habitat Type	UTM Coordinates	
							Easting	Northing
Davidson Creek	Lake 01682LNRS	100-567134-610692-522527	DO-05	08-Mar-12	5	Lake	371262	5894150
Creek 705	Lake 01538UEUT	100-567134-641477-543682-698692	DO-17	08-Mar-12	5	Lake	369323	5893752
Tatelkuz Lake Tributaries	Snake Lake	100-567134-610692-579340	DO-11	07-Mar-12	3	Lake	381510	5900735

Notes: UTM = Universal Transverse Mercator, NAD83 Datum, Zone 10U.

4.8.2 Data Analysis

Bathymetry contours for Lake 01682LNRS, Lake 01538UEUT, and Lake 01428UEUT were prepared from rasterized data using MapInfo Professional 8.0 software and a nearest-neighbour algorithm. Area and volume of each 1-m contour (and for the entire waterbody) were calculated for each lake. Those data were used to calculate mean depth (Z_{avg}), relative depth (Z_r), and the index of shoreline development (D_l) for each lake using the following formulae (Wetzel 2001):

$$Z_{avg} = \frac{\text{Lake Volume}}{\text{Total Surface Area}}$$

$$Z_r = \frac{50 \times Z_{max}\sqrt[x]{\pi}}{\sqrt{\text{Total Surface Area}}}$$

$$D_l = \frac{\text{Shoreline length (m)}}{2\sqrt{\pi \times \text{Total Surface Area}}}$$

Z_r (m) is the ratio of the maximum depth (Z_{max}) as a percentage of the mean diameter of the lake at the surface. Most lakes have a Z_r of less than 2% while deep lakes with small surface areas typically have a Z_r greater than 4% (Wetzel 2001). D_l is the ratio of the length of the shoreline to the circumference of a circle of area equal to that of the lake.

Vertical profiles of water temperature and DO were plotted to show the location of the thermocline, hypolimnion, and epilimnion in each lake and to determine which lakes thermally stratify in summer.

Secchi depth, D_S, was used to calculate the light extinction coefficient (k) for non-turbid water and 1% euphotic depth ($Z_{1\%}$) using the formula (Parsons et al., 1984):

$$k = \frac{1.7}{D_s}$$

$Z_{1\%}$, the depth to which 1% of surface light irradiance extends into the water column, is the point where gross photosynthetic production in the water column is equal to gross respiration and, therefore, is the maximum depth at which photosynthesis and net carbon fixation occurs. $Z_{1\%}$ was calculated according to the formula (Parsons et al., 1984):

$$Z_{1\%} = \frac{4.6}{k}$$

To classify and map littoral habitat in lakes, polygons of each discreet littoral habitat class in each lake were mapped using MapInfo Professional 8.0 software. The spatial extent of the littoral habitat classes were extended to the 6-m depth contour with the assumption that habitat conditions extended unchanged to 6 m, the RISC standard depth for littoral zone delineations (RISC 2009a). Total area of each littoral habitat class in each lake was calculated using GIS software.

4.9 Fish Catch, Effort, and CPUE

The objectives of sampling fish populations in the LSA and RSA were, first, to measure species richness, relative abundance, spatial distribution, and biological characteristics, and, second, to use those data to identify the number of breeding populations, the locations of their critical habitat, and their migration routes. Since rainbow trout was the predominant species in streams and headwater lakes, it was the primary target of investigation. Kokanee, the second most common fish species in streams, but the most numerous fish in the LSA and RSA, was the secondary target. Too few fish of other species were captured to provide much information on their life history or critical habitat.

4.9.1 Field Sampling

Five survey programs were used to sample fish in 2011 and 2012:

- Spring rainbow trout spawning survey in June 2011 with hoop nets installed in four watersheds of the LSA;
- Summer stream inventories in July and August 2011 and August 2012 using backpack electrofishing, minnow traps, and angling in four watersheds of the LSA;
- Summer lake inventory in August 2011 and September 2012 using gillnets, minnow traps, shoreline backpack electrofishing, and angling in four headwater lakes in three watersheds of the LSA;

- Summer survey of fish and fish habitat in streams crossed by the Project transmission line and road access corridors in August and September 2012 using backpack electrofishing and minnow traps; and
- Fall mountain whitefish spawning survey in 2012 using hoop nets, backpack electrofishing, and seine nets in four watersheds of the LSA.

4.9.1.1 Spring Spawning Surveys

In June 2011, spring spawning migrations of rainbow trout were surveyed in the LSA using paired hoop nets (upstream- and downstream-facing) installed at eight sites in the Chedakuz Creek and Fawnie Creek watersheds: three locations in Turtle Creek (including one on Creek 700 of the Turtle Creek Watershed); two locations each in Davidson Creek and Creek 661; and one site in Creek 705 (**Table 4.9-1**, and **Figure 4.9-1** to **Figure 4.9-5**).

Hoop nets had diameters of either 61 cm or 91 cm and a stretched mesh size of 25 mm (**Plate 4.9-1**). The selection of hoop net diameter was site-specific, based on stream size and channel morphology. Upstream and downstream fish passage around the hoop nets was prevented by wings, which were staked and anchored using sandbags and rocks. Hoop nets were checked for fish and cleaned daily, and all fish were identified to species, counted, processed for biological information following protocols described in **Section 4.10.1**, and released live in the same direction in which they were travelling.

In addition, all rainbow trout captured in hoop nets were marked using fin clips unique to each hoop net site (**Table 4.9-2**). The purpose was to identify the original capture locations of any recaptured trout.

Table 4.9-1: Rainbow Trout Fin Clips at Hoop Net Sites, June 2011

Stream	Hoop Net Site	Fin Clip Description
Davidson Creek (lower)	HN-01	Right Pelvic
Davidson Creek (upper)	HN-02	Right Pectoral
Creek 661 (lower)	HN-03	Left Pelvic
Creek 661 (upper)	HN-04	Left Pectoral
Turtle Creek (lower)	HN-05	Right and Left Pelvic
Turtle Creek (upper)	HN-06	Right and Left Pectoral
Creek 700	HN-07	Adipose or Caudal
Creek 705	HN-08	Adipose (Left Pelvic on Suckers)

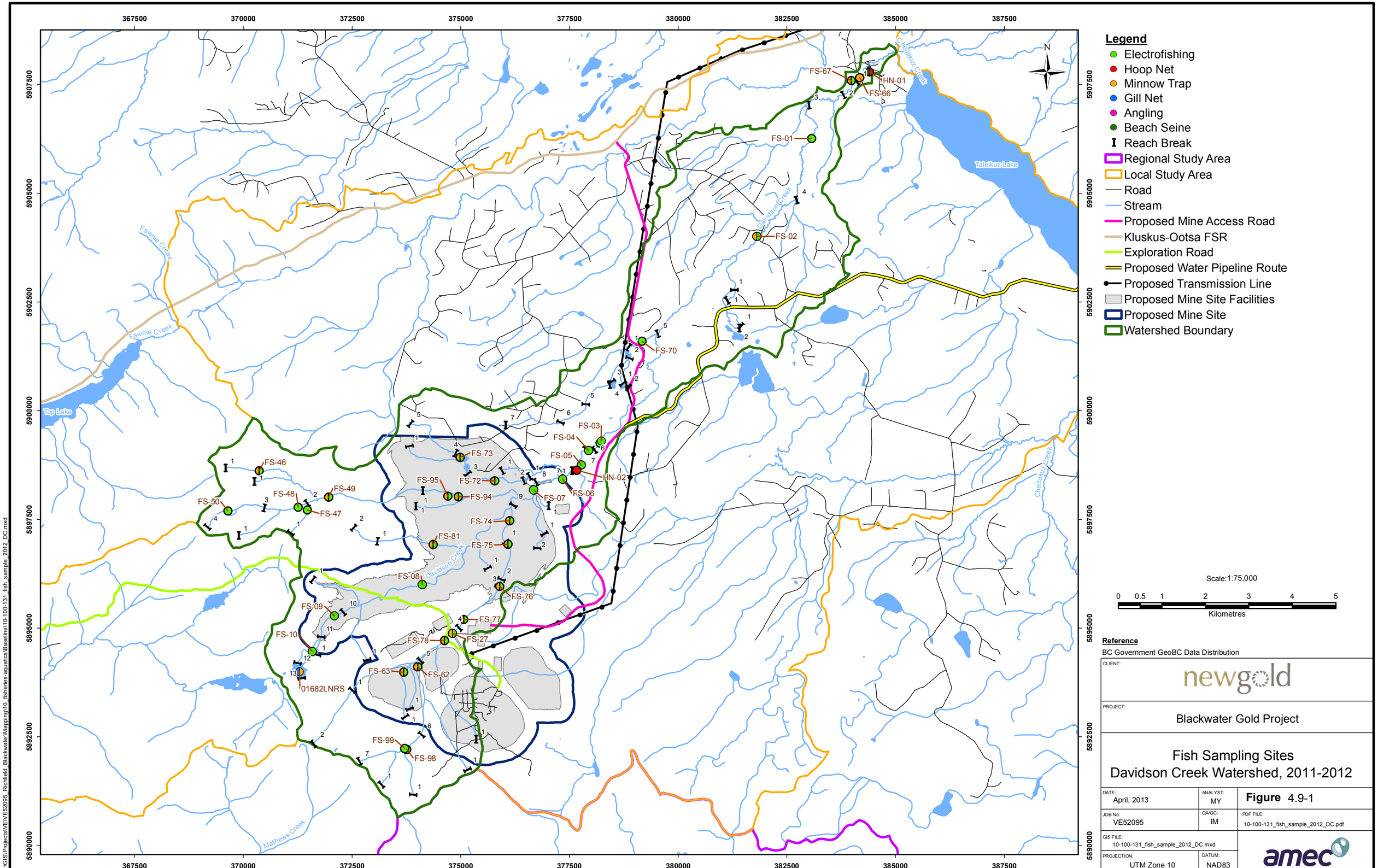
Notes: HN = hoop netting

No surveys were conducted to locate rainbow trout redds during the spring spawning migration of rainbow trout. Instead, the general locations of spawning sites were inferred from the timing of upstream and downstream catches (see **Section 5.10.2.3**).

Table 4.9-2: Hoop Net Sampling Sites and Effort, June 2011

Watershed	Stream	FWA Code	Reach No.	Baseline Map Site ID	Location (UTM[a])		Sampling Dates	Sampling Effort[b]
					Easting	Northing		
Davidson Creek	Davidson Creek	100-567134-610692-522527	1	HN-01	384399	5907792	June 10-28	430 (18)
			8	HN-02	377669	5898633	June 13-27	334 (14)
Turtle Creek	Turtle Creek	100-567134-610692-480511	1	HN-05	383309	5908697	June 7-28	502 (21)
			5	HN-06	374523	5904436	June 9-27	427 (18)
	Creek 700	100-567134-610692-480511-645840	1	HN-07	374343	5904266	June 8-27	452 (19)
Creek 661	Creek 661	100-567134-610692-671007	1	HN-03	388683	5899443	June 8-27	453 (19)
			4	HN-04	381776	5898538	June 8-27	449 (19)
Creek 705	Creek 705	100-567134-641477-543682-698692	2	HN-08	360368	5892635	June 11-28	408 (17)

Notes: [a] North American Datum 83, Zone 10
[b] Hoop net effort in hours (days)
FWA – BC Freshwater Atlas; UTM – Universal Transverse Mercator, HN – hoop netting



Reference

BC Government GeoBC Data Distribution

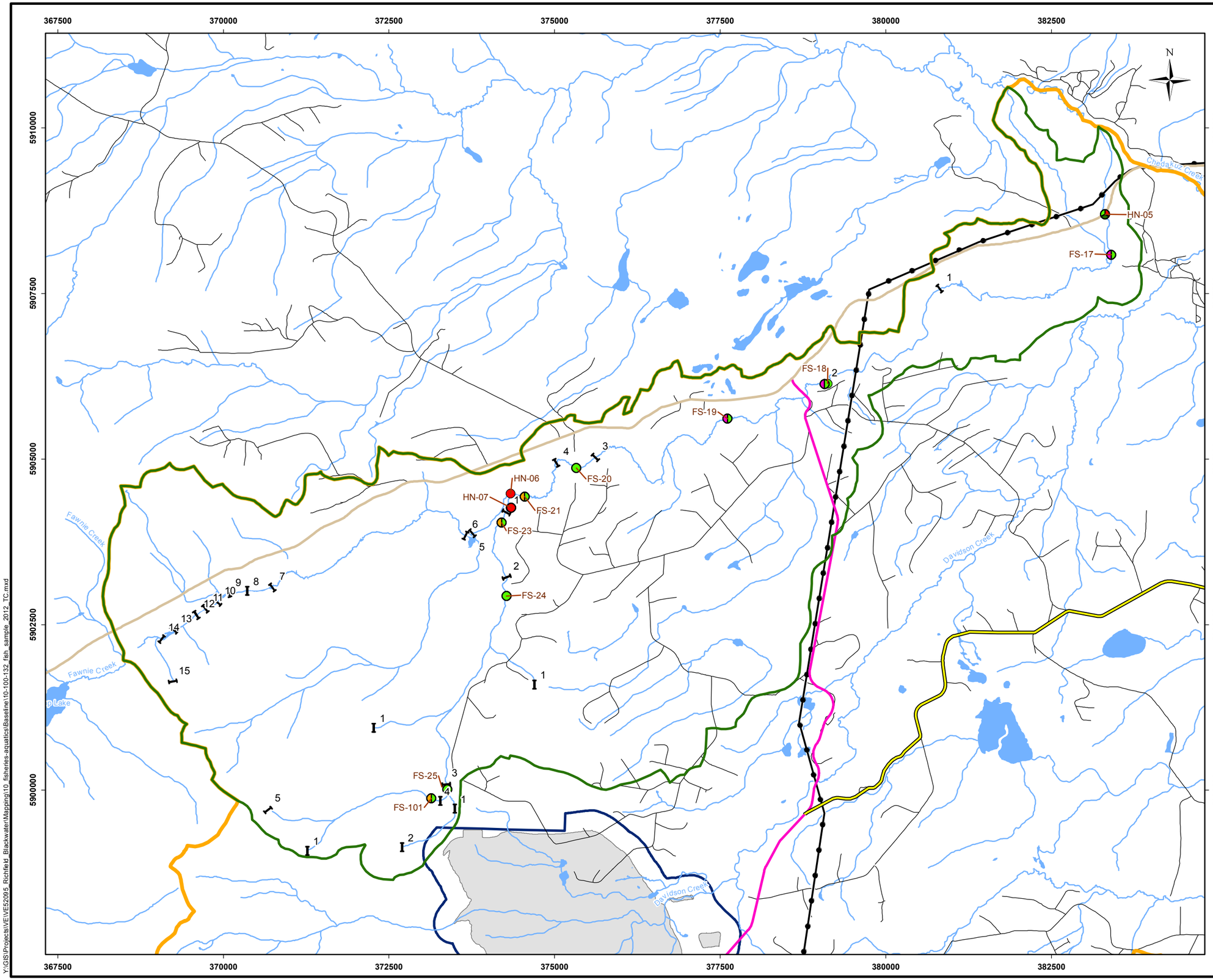
CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish Sampling Sites
Davidson Creek Watershed, 2011-2012

DATE: April, 2013	ANALYST: MY	**Figure** 4.9-1
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-131_fish_sample_2012_DC.pdf
GIS FILE: 10-100-131_fish_sample_2012_DC.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-131_fish_sample_2012_DC.mxd



Legend

- Electrofishing
- Hoop Net
- Minnow Trap
- Gill Net
- Angling
- Beach Seine
- Reach Break
- Local Study Area
- Klusks-Ootsa FSR
- Road
- Stream
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Water Pipeline Route
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Scale:1:55,000

0 0.5 1 2

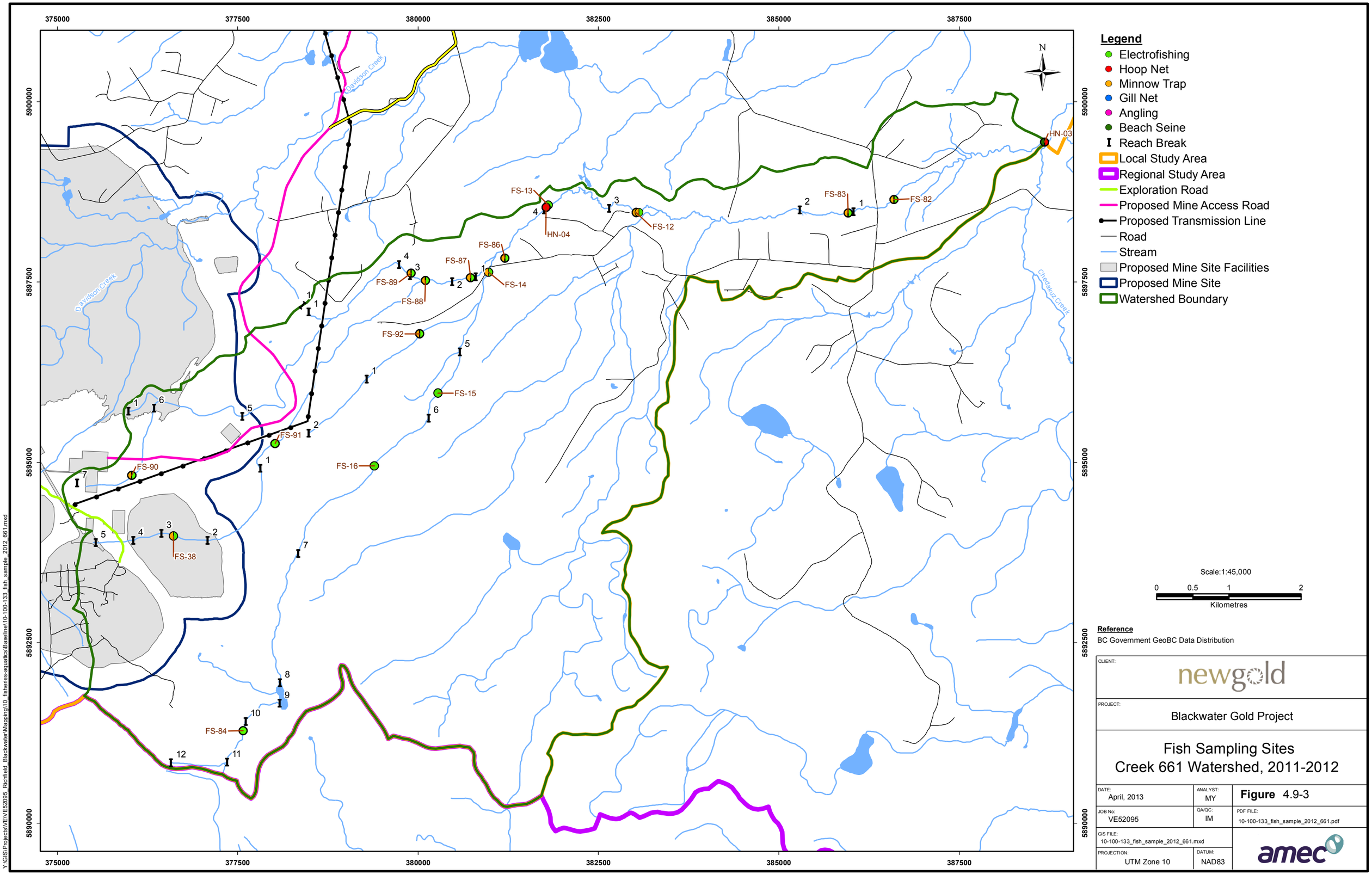
Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold		
PROJECT: Blackwater Gold Project		
Fish Sampling Sites Turtle Creek Watershed, 2011-2012		
DATE: April, 2013	ANALYST: MY	**Figure** 4.9-2
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-132_fish_sample_2012_TC.pdf
GIS FILE: 10-100-132_fish_sample_2012_TC.mxd		amec
PROJECTION: UTM Zone 10	DATUM: NAD83	

Y:\GIS\Projects\VE\VE52095 Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-132_fish_sample_2012_TC.mxd



Legend

- Electrofishing
- Hoop Net
- Minnow Trap
- Gill Net
- Angling
- Beach Seine
- Reach Break
- Local Study Area
- Regional Study Area
- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Scale:1:45,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

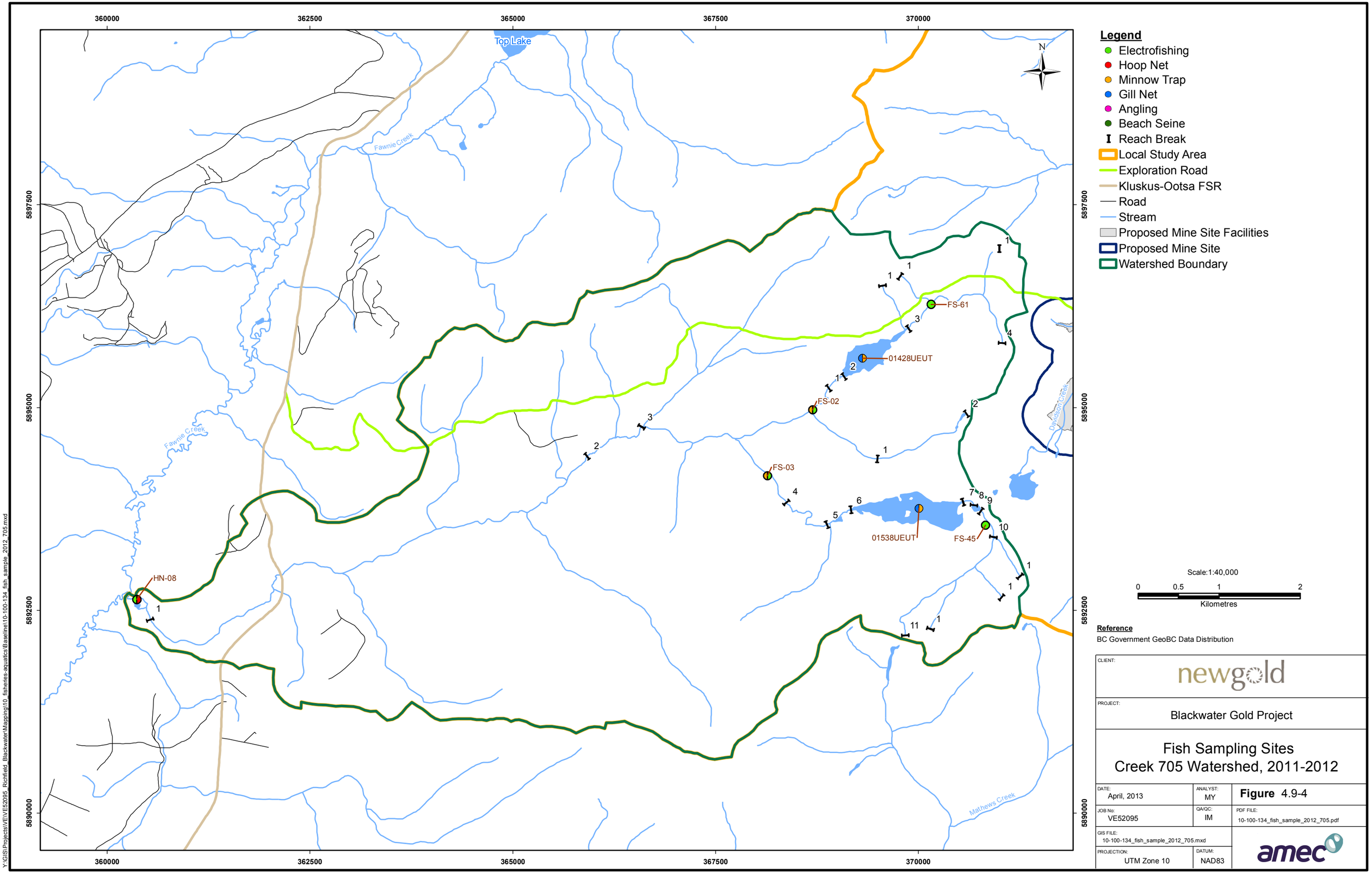
CLIENT: newgold

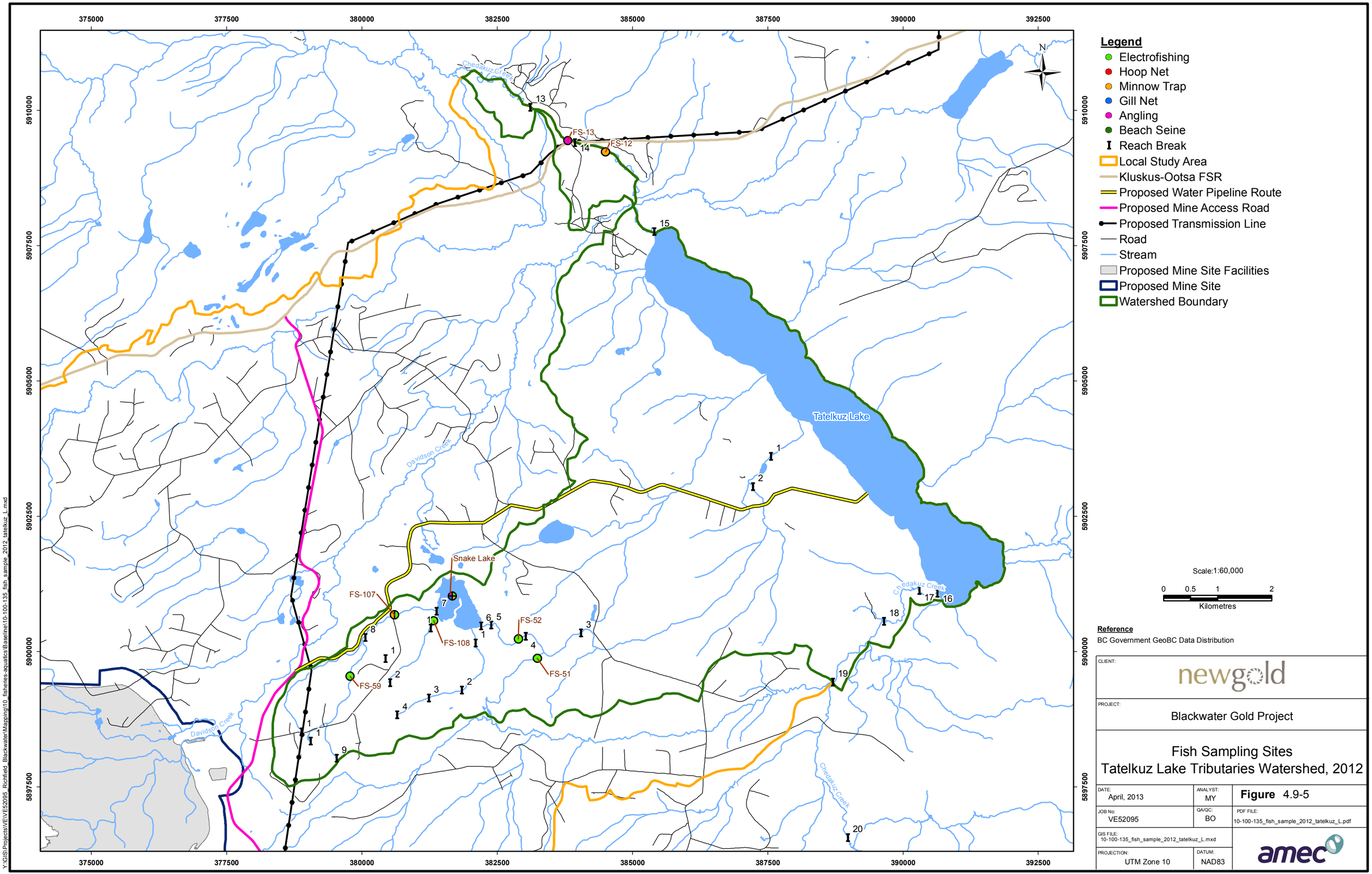
PROJECT: Blackwater Gold Project

Fish Sampling Sites
Creek 661 Watershed, 2011-2012

DATE: April, 2013	ANALYST: MY	**Figure** 4.9-3
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-133_fish_sample_2012_661.pdf
GIS FILE: 10-100-133_fish_sample_2012_661.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-133_fish_sample_2012_661.mxd


360000
362500
365000
367500
370000
5897500
5895000
5892500
5890000
Top Lake
Fawnie Creek
Fawnie Creek
Mathews Creek
Davidson Creek
FS-61
01428UEUT
FS-02
FS-03
01538UEUT
FS-45
HN-08
N
Legend
Electrofishing
Hoop Net
Minnow Trap
Gill Net
Angling
Beach Seine
Reach Break
Local Study Area
Exploration Road
Kluskus-Ootsa FSR
Road
Stream
Proposed Mine Site Facilities
Proposed Mine Site
Watershed Boundary
Scale:1:40,000
0 0.5 1 2
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT: newgold
PROJECT: Blackwater Gold Project
Fish Sampling Sites
Creek 705 Watershed, 2011-2012
DATE: April, 2013
ANALYST: MY
Figure 4.9-4
JOB No: VE52095
QA/QC: IM
PDF FILE: 10-100-134_fish_sample_2012_705.pdf
GIS FILE: 10-100-134_fish_sample_2012_705.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-134_fish_sample_2012_705.mxd



Legend

- Electrofishing
- Hoop Net
- Minnow Trap
- Gill Net
- Angling
- Beach Seine
- Reach Break
- Local Study Area
- Kluskus-Ootsa FSR
- Proposed Water Pipeline Route
- Proposed Mine Access Road
- Proposed Transmission Line
- Road
- Stream
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish Sampling Sites
Tatelkuz Lake Tributaries Watershed, 2012

DATE:	ANALYST:	**Figure** 4.9-5
April, 2013	MY	
JOB No: VE52095	QA/QC: BO	PDF FILE: 10-100-135_fish_sample_2012_tatelkuz_L.pdf
GIS FILE: 10-100-135_fish_sample_2012_tatelkuz_L.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	

amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-135_fish_sample_2012_tatelkuz_L.mxd



Plate 4.9-1: Hoop nets installed in Creek 705 (HN-08), 26 October 2012

4.9.1.2 Summer Fish Inventories – Streams

Backpack electrofishing was conducted at 24 sites in August 2011 and at 54 sites in August and September 2012 (**Figure 4.9-1** to **Figure 4.9-5**, **Plate 4.9-2** and **Table 4.9-3**). (These numbers do not correspond directly to the number of sites shown in **Table 4.9-3** because some sites were re-visited in the same year). Sites in 2011 included nine sites in Davidson Creek, one site in a Davidson Creek headwater tributary (Creek 704454), five sites in Turtle Creek, five sites in Creek 661, one site in a Creek 661 headwater tributary, and one site in Creek 700.

Sites in 2012 included eight sites in Davidson Creek, 21 sites in tributaries to Davidson Creek (including Creeks 688328 and 704454), five sites in Turtle Creek/Creek 700, 11 sites in the Creek 661 watershed, four sites in the Creek 705 watershed, and eight sites in the Tatelkuz Lake Tributaries watershed. Of the additional sites sampled in 2012, five sites in Davidson Creek and two sites in Turtle Creek were at sites originally sampled in 2011.

At each electrofishing site in the LSA, blocking nets were placed at the upstream and downstream ends of the area to be sampled. This area was then electrofished from the downstream blocking net to the upstream blocking net, and then back to the downstream blocking net. Backpack electrofishing was conducted by two- or three-person crews using a Smith-Root Type IV backpack electrofisher. Sites ranged from approximately 100 m to 175 m in length and the entire stream width was sampled.



Plate 4.9-2: Backpack electrofisher

Minnow traps were set at six stream sites in 2011 and at 53 stream sites in 2012 (**Figure 4.9-1** to **Figure 4.9-5**, and **Table 4.9-3**). These sites were places where low electrofishing CPUE was observed relative to other sites. The purpose was to collect additional fish by taking advantage of the ability of minnow traps to fish over longer time periods than a typical electrofishing visit (~1 hour). Minnow traps were also set at one additional site (Davidson Creek, Reach 1, FS-66) where electrofishing did not take place due to the presence of spawning kokanee. Traps were set after blocking nets were removed. They were baited with dry cat food, with the exception of sites in Chedakuz Creek, Lower Davidson Creek, and Turtle Creek, that were baited with a combination of salmon roe and cat food. (Salmon roe was used to attract sculpins that may have been present). Traps were left overnight and retrieved the next day.

Angling was conducted in one site in Chedakuz Creek in September 2012 and three sites in Turtle Creek in October 2012. Chedakuz Creek was angled specifically to obtain adult rainbow trout to be sacrificed for fish tissue metal burdens. Pool habitat in reaches 1, 2, and 3 of Turtle Creek were angled to determine the presence or absence of adult rainbow trout. Spincasting rods were used at all angling sites.

All fish captured were identified to species, counted, processed for biological information following protocols described in **Section 4.10.1**, and released live.

Table 4.9-3: Stream Fish Inventory Sampling Sites and Methods, August 2011 and August 2012

Watershed	Stream	BC FWA Code	Reach No.	Baseline Map Site ID	Location (UTM[1])		Date Sampled	Site Length (m)	Method
					Easting	Northing			
Davidson Creek	Davidson Creek	100-567134-610692-522527	1	FS-66	384175	5907661	4-Aug-12	-	MT
			2	FS-67	383983	5907396	4-Aug-12	100	EF, MT
			4	FS-01	383074	5906262	5-Aug-12	100	EF
			5	FS-02	381812	5904012	6-Aug-11	174	EF, MT
					381812	5904012	10-Aug-12	100	EF
			6	FS-03	378203	5899307	17-Aug-11	100	EF
					378202	5899256	10-Aug-12	100	EF
			7	FS-04	377944	5899087	17-Aug-11	100	EF
			7.1	FS-05	377773	5898759	19-Aug-11	100	EF
			8	FS-06	377343	5898429	11-Aug-11	100	EF
			9	FS-07	376677	5898181	18-Aug-11	100	EF
					376678	5898185	9-Aug-12	100	EF
			10	FS-08	374116	5896003	20-Aug-11	100	EF
			11	FS-09	372092	5895287	13-Aug-11	100	EF
					372097	5895291	8-Aug-12	100	EF
			12	FS-10	371587	5894469	13-Aug-11	100	EF
					371584	5894467	8-Aug-12	100	EF
	Creek 428073	100-567134-610692-522527-428073	1	FS-70	379171	5901598	5-Aug-12	100	EF
	Creek 636713	100-567134-610692-522527-636713	3	FS-72	375780	5898392	1-Aug-12	100	EF, MT
			4	FS-73	374985	5898930	1-Aug-12	100	EF, MT
	Creek 688328	100-567134-610692-522527-688328	1	FS-94	374945	5898027	1-Aug-12	100	EF, MT
			2	FS-49	371970	5898023	7-Aug-12	100	EF, MT
					372000	5898041	15-Sep-12	100	EF
			3	FS-48	371263	5897784	8-Aug-12	100	EF
			4	FS-50	369644	5897698	8-Aug-12	100	EF
	Unnamed Creek	-	1	FS-95	374705	5898037	2-Aug-12	100	EF, MT

Table continues...

Table 4.9-3 (cont'd)

Watershed	Stream	BC FWA Code	Reach No.	Baseline Map Site ID	Location (UTM[1])		Date Sampled	Site Length (m)	Method
					Easting	Northing			
Davidson Creek (cont'd)	Creek 634527	100-567134-610692-522527-688328-634527	1	FS-46	370367	5898621	7-Aug-12	100	EF, MT
	Creek 667871	100-567134-610692-522527-688328-667871	1	FS-47	371471	5897718	8-Aug-12	100	EF
	Creek 704454	100-567134-610692-522527-704454	1	FS-74	376125	5897471	9-Aug-12	100	EF, MT
			2	FS-75	376086	5896933	7-Aug-12	100	EF, MT
			3	FS-76	375893	5895964	7-Aug-12	100	EF, MT
			4	FS-77	375072	5895202	5-Aug-12	100	EF, MT
			5	FS-27	377808	5894882	20-Aug-11	100	EF, MT
			5	FS-78	374624	5894718	5-Aug-12	100	EF, MT
			6	FS-62	374009	5894113	5-Aug-12	100	EF, MT
	Unnamed Creek	-	1	FS-98	373757	5892214	7-Aug-12	100	EF
	Creek 853864	100-567134-610692-522527-704454-853864	1	FS-99	373709	3892235	8-Aug-12	150	EF
	Creek 076095	100-567134-610692-522527-704454-569241-076095	1	FS-63	373689	5893994	4-Aug-12	100	EF, MT
	Creek 776798	100-567134-610692-522527-776798	1	FS-81	374364	5896926	1-Aug-12	100	EF, MT
Turtle Creek	Turtle Creek	100-567134-610692-480511	1	FS-17	383404	5908086	16-Aug-11	100	EF
					381168	5907645	14-Oct-12	-	AG
			2	FS-18	379121	5906138	9-Aug-11	100	EF
					379093	5906134	9-Aug-12	100	EF
					378581	5905922	13-Oct-12	-	AG
							15-Oct-12	-	AG
			3	FS-19	377609	5905611	16-Aug-11	100	EF
					377431	5905551	15-Oct-12	-	AG
			4	FS-20	375328	5904866	15-Aug-11	100	EF
			5	FS-21	374548	5904434	10-Aug-11	100	EF
					374536	5904437	8-Aug-12	100	EF, MT
	Creek 700	100-567134-610692-480511-645840	1	FS-22	374306	5904380	9-Aug-11	100	EF
			3	FS-24	374273	5902933	15-Sep-12	100	EF
					373378	5900015	5-Sep-11	100	EF
			4	FS-25	373378	5900015	15-Sep-12	100	EF
			5	FS-101	373138	5899878	15-Sep-12	100	EF, MT

Table continues...

Table 4.9-3 (cont'd)

Watershed	Stream	BC FWA Code	Reach No.	Baseline Map Site ID	Location (UTM[1])		Date Sampled	Site Length (m)	Method
					Easting	Northing			
Creek 661	Creek 661	100-567134-610692-671007	1	FS-82	386594	5898646	2-Aug-12	100	EF, MT
			2	FS-83	385959	5898462	2-Aug-12	100	EF, MT
			3	FS-12	383063	5898469	11-Aug-11	100	EF, MT
			4	FS-13	381805	5898570	12-Aug-11	100	EF
			5	FS-14	380977	5897639	10-Aug-11	100	EF, MT
			6	FS-15	380277	5895964	15-Aug-11	100	EF
			7	FS-16	397394	5894956	15-Aug-11	100	EF
			11	FS-84	377573	5891285	6-Aug-12	100	EF
	Creek 505659	100-567134-610692-671007-505659	1	FS-86	381021	5897835	3-Aug-12	100	EF, MT
			2	FS-87	380726	5897563	3-Aug-12	100	EF, MT
			3	FS-88	380100	5897525	3-Aug-12	100	EF, MT
			4	FS-89	379902	5897626	3-Aug-12	100	EF, MT
			7	FS-90	376031	5894825	2-Aug-12	100	EF, MT
	Creek 146920	100-567134-610692-671007-505659-146920	1	FS-91	378017	5895265	6-Aug-12	100	EF
			3	FS-38	376609	5893983	20-Aug-11	100	EF, MT
	Creek 543585	100-567134-610692-671007-543585	1	FS-92	380021	5896786	3-Aug-12	100	EF, MT
Creek 705	Creek 705	100-567134-641477-543682-698692	4	FS-103	368140	5894161	15-Sep-12	100	EF, MT
			10	FS-45	370827	5893554	19-Sep-12	100	EF
	Creek 606013	100-567134-641477-543682-698692-606013	1	FS-102	368695	5894975	15-Sep-12	100	EF, MT
			4	FS-61	370141	5896271	19-Sep-12	100	EF
Tatelkuz Lake Tributaries	Chedakuz Creek	100-567134-610692	14	FS-113	383675	5909531	5-Sep-12	100	AG
			15	FS-97	383700	5909521	7-Aug-12	300	EF, MT
			15	FS-112	384502	5909238	18-Sep-12	-	MT
	Creek 549629	100-567134-610692-579340-549629	1	FS-51	383242	5899880	17-Sep-12	100	EF
	Creek 579340	100-567134-610692-579340	5	FS-52	382894	5900236	17-Sep-12	100	EF
			8	FS-107	380610	5900678	17-Sep-12	100	EF, MT
			9	FS-59	379780	5899548	18-Sep-12	100	EF
	Creek 737376	100-567134-610692-579340-737376	1	FS-108	381329	5900573	17-Sep-12	100	EF

Notes: [1] NAD 83, Zone 10
AG = angling; BC FWA - British Columbia Freshwater Atlas Code; EF = backpack electrofishing; ID = identification; MN = minnow trapping; UTM = Universal Transverse Mercator

4.9.1.3 Summer Fish Inventory – Lakes

Sinking and floating gillnet gangs were used to sample pelagic habitats in three of the headwater lakes in August 2011 and 2012, and in Snake Lake in 2012 (**Figure 4.4-1** and **Plate 4.9-3**). Each gillnet consisted of six 15 m-long, 2.5 m-deep panels containing stretched meshes that ranged from 25 to 89 mm. All gillnet gangs had a total area of 225 m^2. Gillnet specifications were consistent with Reconnaissance (1:20,000) *Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001).



Plate 4.9-3: Gillnet installed in Lake 01682LNRS, 14 August 2011

Both sinking and floating gillnet gangs were set for an initial 2 hour soak (to minimize mortality of fish) and were then checked for fish. If no fish were captured, then nets were re-set at new locations and checked the following day. Overnight sets were used only at Snake Lake because no rainbow trout were captured I initial sets. Nets were set at varying angles to the shoreline and at depths ranging from 6 to 15 m (**Table 4.9-4**).

In 2011, minnow traps were also set overnight in all three headwater lakes within three different habitat types: littoral areas, inlets, and outlets (**Plate 4.9-4**). Minnow trapping was conducted again in Lake 01682LNRS, as well as Snake Lake, in 2012. All traps were baited with dry cat food.

Table 4.9-4: Lake Fish Inventory Sampling Sites, Methods, and Effort, 2011 and 2012

Lake	Gear Type/ Number	Total Net Area (m^2) or Total Trap Numbers	Gear Depth (m)	Set No.	Set Date	Removal Date	Effort[1]
Lake 01682LNRS	Sinking Gillnet 1	225	7-15	1	14-Aug-11	14-Aug-11	1.8
	Sinking Gillnet 1	225	8-10	2	15-Aug-11	15-Aug-11	3.8
	Floating Gillnet 1	225	6-9	1	14-Aug-11	14-Aug-11	2.0
	Floating Gillnet 1	225	8-10	2	15-Aug-11	15-Aug-11	4.0
	Sinking Gillnet 2	225	n/a	1	19-Sep-12	19-Sep-12	2.1
	Floating Gillnet 2	225	n/a	1	19-Sep-12	19-Sep-12	2.1
	Floating Gillnet 2	225	n/a	2	19-Sep-12	19-Sep-12	4.0
	Minnow Traps 1	8	>2	1	14-Aug-11	15-Aug-11	192.0
	Minnow Traps 2	7	>2	1	19-Sep-12	19-Sep-12	42.0
	Minnow Traps 3	7	>2	2	19-Sep-12	19-Sep-12	60.0
Lake 01538UEUT	Sinking Gillnet 1	225	10	1	13-Aug-11	13-Aug-11	2.5
	Floating Gillnet 1	225	8	1	13-Aug-11	13-Aug-11	1.5
	Sinking Gillnet 2	225	n/a	1	10-Sep-12	10-Sep-12	1.0
	Sinking Gillnet 2	225	n/a	2	10-Sep-12	10-Sep-12	1.9
	Sinking Gillnet 3	225	n/a	1	11-Sep-12	11-Sep-12	2.8
	Sinking Gillnet 4	225	n/a	1	11-Sep-12	11-Sep-12	2.9
	Minnow Traps 1	10	>2	1	12-Aug-11	13-Aug-11	265.0
Lake 01428UEUT	Sinking Gillnet 1	225	3-5	1	17-Aug-11	17-Aug-11	2.5
	Floating Gillnet 1	225	3-5	1	17-Aug-11	17-Aug-11	2.5
	Sinking Gillnet 2	225	n/a	1	08-Sep-12	08-Sep-12	3.5
	Minnow Traps 1	16	>2	1	16-Aug-11	17-Aug-11	384.0
Snake Lake	Angling 1	-	>1	1	16-Oct-12	-	1.5
	Backpack Electrofisher 1	-	>1	1	16-Oct-12	-	352.0
	Backpack Electrofisher 2	-	>1	1	16-Oct-12	-	487.0
	Floating Gillnet 1	225	2	1	17-Oct-12	17-Oct-12	2.3
	Sinking Gillnet 1	225	2	1	17-Oct-12	17-Oct-12	3.5
	Floating Gillnet 2	225	2	1	17-Oct-12	17-Oct-12	2.8
	Floating Gillnet 1	225	2	2	17-Oct-12	18-Oct-12	15.8
	Sinking Gillnet 1	225	2	2	17-Oct-12	18-Oct-12	15.5
	Floating Gillnet 2	225	2	2	17-Oct-12	18-Oct-12	18.0
	Minnow Traps 1	6	>2	1	16-Oct-12	17-Oct-12	157.8
	Minnow Traps 2	6	>2	2	16-Oct-12	17-Oct-12	153.6
	Minnow Traps 3	7	>2	3	16-Oct-12	17-Oct-12	163.8

Notes: m^2 = metres squared; n/a = not applicable
1. Gillnet and minnow trap effort is in hours. Angling effort is in rod-hours. Backpack electrofishing effort is in seconds.



Plate 4.9-4: Minnow trap set in littoral zone of Lake 01428UEUT, 16 August 2011

Additional gear types used in Snake Lake included angling and backpack electrofishing. Angling effort consisted of one spin-casting rod and one fly rod. Habitat accessible from the shoreline was sampled using a Smith-Root Type IV backpack electrofisher.

All fish captured were identified to species, counted, processed for biological information following protocols described in **Section 4.10.1**, and released live.

4.9.1.4 Transmission Line and Road Access Corridor Survey

Each stream crossing site was visually assessed to decide, first, whether it met the requirements for a stream as per the Forest Practices Code *Fish Stream Identification Guidebook* (BC MOF 1998), and, second, whether it contained enough open water to support fish and was accessible to fish known to be present downstream.

For those sites that met the definition of a stream, fish presence/absence was assessed using single-pass, backpack electrofishing of a 100 m-long section of stream with no blocking nets. (Note that the stream crossings of the transmission line were the only sites that were electrofished without blocking nets. All electrofishing sites visited as part of the summer inventory of the LSA were blocked off, as described in **Section 4.9.1.2**.) The section extended 50 m upstream of the crossing and 50 m downstream. Two minnow traps were then set overnight at each site.

Fish sampling methodology followed the protocols outlined in the *Fish Sampling Procedures* chapter of the Forest Practice Code *Fish Stream Identification Guidebook* (BC MOF 1998). Electrofishing field crews used a Smith-Root Model 12-B backpack electrofisher to catch fish.

All fish captured by electrofishing or minnow trapping were identified to species, counted, and measured for fork length to the nearest 1 mm with a measuring board. Data were recorded on provincial fish data cards. Care was taken to ensure that all captured fish were kept alive in water-filled buckets until the end of processing, and that they were released live back into the stream from which they were captured. Photographs were taken of each species captured at each site.

4.9.1.5 Summer-Fall Kokanee Spawning Surveys

The relative magnitude and spatial extent of kokanee spawning activity in Davidson Creek and Creek 661 were surveyed in August 2011 and 2012 (**Table 4.9-5** and **Table 4.9-6**). In 2011, surveying was conducted up to the upstream extent of the observed spawning distributions in Davidson Creek and Creek 661. In 2012, surveys were conducted to the upstream extent of the observed spawning distribution in Davidson Creek, but only in Reach 1 of Creek 661.

Spawning kokanee and kokanee redds were counted by a two-person crew hiking upstream. Additional information recorded during the stream walks included site location (measured by GPS and hipchain), kokanee behaviour, spawning gravel area, redd habitat type, dominant and subdominant substrate in redds, and average redd depth. Redd habitat types and dominant/subdominant substrate types were based on FHAP and RISC standards, respectively.

Table 4.9-5: Kokanee Spawning Survey in Davidson Creek and Creek 661, August 2011

Stream	FWA Code	Reach	Date Surveyed	Length Surveyed (m)
Davidson Creek	100-267134-610692-522527	1	08-Aug-11	1,375
		2	11-Aug-11	499
		3	11-Aug-11	1,182
		4	11-Aug-11	2,136
Creek 661	100-267134-610692-671007	1	12-Aug-11	3,484
		2	14-Aug-11	824
		3	21-Aug-11	3,043

Notes: FWA = BC Freshwater Atlas; m = metre

Table 4.9-6: Kokanee Spawning Survey in Davidson Creek and Creek 661, August 2012

Stream	FWA Code	Reach	Date Surveyed	Length Surveyed (m)
Davidson Creek	100-267134-610692-522527	1	22-Aug-12	1,375
		2	22-Aug-12	499
		3	22-Aug-12	1,182
		4	22-Aug-12	1,177
Creek 661	100-267134-610692-671007	1	24-Aug-12	2,159
		2	NS	0
		3	NS	0

Notes: FWA = BC Freshwater Atlas; m = metre; NS = not surveyed.

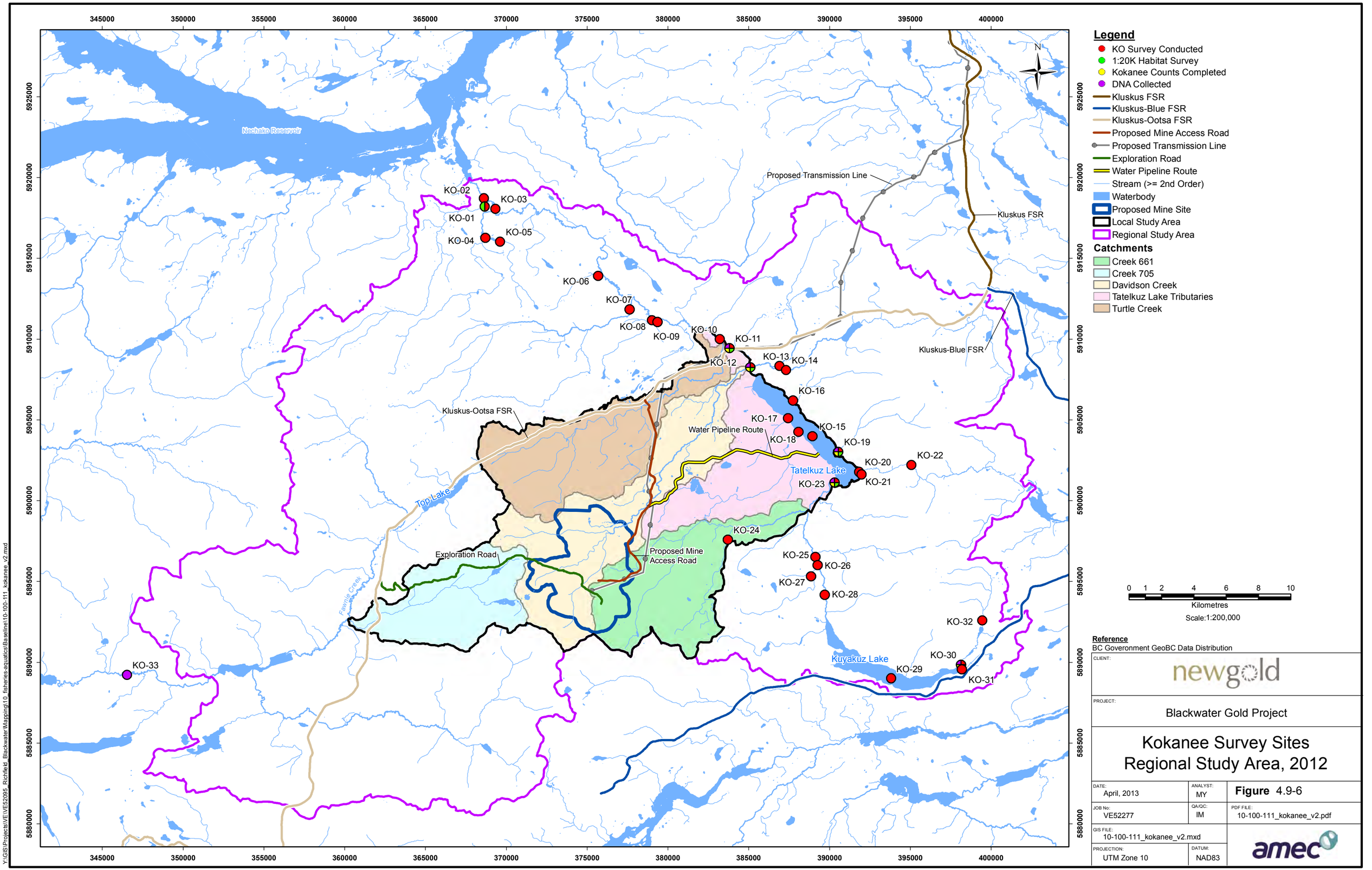
Regional-scale surveys of kokanee use of streams in the LSA and RSA were completed in late summer and fall of 2012 (**Figure 4.9-6**, **Table 4.9-7** and **Table 4.9-8**).

Surveys were limited to Chedakuz Creek and tributaries that are third order or larger. (The Fawnie Creek and Meadow Creek surveys were only for the purpose of collecting kokanee tissue for microsatellite DNA analysis – not counting spawners). Both helicopter and ground reconnaissance was conducted in August 2012.

Sites were surveyed for kokanee presence and the potential for kokanee use based on suitable habitat characteristics. Sites where kokanee or suitable kokanee habitat were observed were revisited on subsequent trips. Stream counts of kokanee and kokanee redds were conducted in lower, middle, and upper Chedakuz Creek, Creek 522107, and Creek 601947 in August and September 2012 following the same protocol as for Davidson Creek and Creek 661 (**Table 4.9-7**). **Table 4.9-8** shows the start and end dates for each of those five surveys, and the length of stream surveyed.

To standardize counts of kokanee spawners and redds for the length of stream surveyed, counts were divided by the length of stream surveyed. This was called “linear density” to distinguish it from the true densities that were calculated for kokanee and redd counts made in Davidson Creek and Creek 661 in August of 2011 and 2012. Linear density was used rather than true density because wetted stream width was not measured during the kokanee surveys of Chedakuz Creek in 2012.

The estimates of linear density shown were used to extrapolate the total number of kokanee spawners and redds over the total accessible length of stream. This extrapolation assumed that the accessible length of stream contained suitable spawning habitat.



Reference
BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Kokanee Survey Sites Regional Study Area, 2012

DATE: April, 2013	ANALYST: MY	**Figure** 4.9-6
JOB No: VE52277	QA/QC: IM	PDF FILE: 10-100-111_kokanee_v2.pdf
GIS FILE: 10-100-111_kokanee_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-111_kokanee_v2.mxd

Tissue samples for analysis of satellite DNA were collected during stream counts in Davidson and Creek 661, as well as in other streams in the RSA where spawning kokanee were present. (Samples were clipped from adipose fins.) In total, tissue samples were collected from kokanee in six locations in the RSA: lower, middle, and upper Chedakuz Creek, Creek 52107, and Creek 601947. Additional tissue samples were collected from Fawnie Creek in the RSA and the Meadow Creek spawning channel in the Kootenays of south-eastern BC. Fawnie Creek samples were collected because they are outside the Chedakuz Creek Watershed, but connected through the Nechako Reservoir. Meadow Creek samples were "outsider" samples that were required to place the Blackwater samples within a regional BC context of kokanee genetic variation.

4.9.1.6 Fall Mountain Whitefish Spawning Survey

To survey any potential mountain whitefish spawning migration, four sites that were sampled during the spring 2011 rainbow trout spawning program were re-sampled in fall 2012 using hoop nets. Sites included Lower Davidson Creek (HN-01), Lower Turtle Creek (HN-05), Lower Creek 661 (HN-03), and Creek 705 (HN-08) (**Figure 4.9-1** to **Figure 4.9-5**, and **Table 4.9-9**).

Sampling effort consisted primarily of installing hoop nets set to capture fish travelling in an upstream direction. Hoop net diameter and mesh size were 61 cm and 25 mm, respectively. Upstream fish passage around the hoop nets was prevented by wings, which were anchored using rocks. Short sets (approximately 5 days in duration) were used at all four sites in three discrete periods that took place during the presumed mountain whitefish spawning season: mid-October, late October, and mid-November.

Where ice conditions and stream morphology permitted, alternative fish sampling techniques were employed in addition to the hoop nets. Seine net hauls were completed using a 10 m-long, 4 m-deep seine net with a mesh size of 0.3 cm in Davidson Creek, Turtle Creek, and Creek 661. Backpack electrofishing was conducted in Turtle Creek and Creek 705 using a Smith-Root Type IV backpack electrofisher. Blocking nets were not used, and sites ranged in length from 80 to 150 m. The entire stream width was sampled. Electrofishing was used in Turtle Creek and Creek 705, but was not conducted in Davidson Creek and Creek 661 due to the presence of incubating kokanee eggs.

Table 4.9-7: Regional Kokanee Study Sites in Streams and Lakes, August through October 2012

Watershed	Waterbody Name	BC Freshwater Atlas Code	Baseline Site ID	Location (UTM)[1]			Survey Dates				Kokanee Counts Completed	DNA Collected
				Zone	Easting	Northing	7-Aug	26-Aug to 27-Aug	8-Sep to 17-Sep	9-Oct		
Chedakuz Creek	Lower Chedakuz Creek	100-567134-610692	KO-01	10U	368604	5918723		x	x	x		
	Lower Chedakuz Creek	100-567134-610692	KO-11	10U	383804	5909445	x	x	x		x	x
	Tatelkuz Lake	100-567134-610692	KO-15	10U	388938	5903997		x				
	Middle Chedakuz Creek	100-567134-610692	KO-23	10U	390308	5901131		x	x		x	x
	Middle Chedakuz Creek	100-567134-610692	KO-28	10U	389698	5894180		x	x	x		
	Kuyakuz Lake	100-567134-610692	KO-29	10U	393802	5889014		x				
	Upper Chedakuz Creek	100-567134-610692	KO-30	10U	398132	5889857		x	x		x	x
	Upper Chedakuz Creek	100-567134-610692	KO-32	10U	399451	5892593						
	Creek 101550	100-567134-610692-101550	KO-02	10U	368657	5918211		x	x	x		
	Creek 116704	100-567134-610692-116704	KO-03	10U	369313	5918068		x				
	Creek 116704	100-567134-610692-116704	KO-04	10U	368697	5916279		x				
	Creek 138219	100-567134-610692-116704-138219	KO-05	10U	369610	5916037		x				
	Creek 302288	100-567134-610692-302288	KO-06	10U	375675	5913916		x				
	Creek 366679	100-567134-610692-366679	KO-07	10U	377623	5911845		x	x			
	Creek 399693	100-567134-610692-399693	KO-08	10U	378999	5911174		x				
	Creek 405454	100-567134-610692-405454	KO-09	10U	379353	5911068	x	x	x			
	Turtle Creek	100-567134-610692-480511	KO-10	10U	383201	5910006		x				
	Creek 522107	100-567134-610692-522107	KO-12	10U	385095	5908260		x	x		x	x
	Creek 063231	100-567134-610692-522107-063231	KO-13	10U	386897	5908353		x	x	x		
	Creek 522107	100-567134-610692-522107	KO-14	10U	387308	5908090		x	x	x		
	Creek 564954	100-567134-610692-564954	KO-16	10U	387734	5906204		x				
	Creek 571602	100-567134-610692-571602	KO-17	10U	387428	5905113		x				
	Creek 579340	100-567134-610692-579340	KO-18	10U	388071	5904270		x	x			
	Creek 601947	100-567134-610692-601947	KO-19	10U	390540	5903032		x	x		x	x
	Creek 622056	100-567134-610692-622056	KO-20	10U	391826	5901788	x	x	x			
	Creek 622056	100-567134-610692-622056	KO-21	10U	391972	5901632	x	x	x			
	Creek 622056	100-567134-610692-622056	KO-22	10U	395060	5902221	x	x	x			
	Creek 564954	100-567134-610692-564954	KO-24	10U	383702	5897592			x			
	Creek 712749	100-567134-610692-712749	KO-25	10U	389126	5896532		x	x			
	Creek 720589	100-567134-610692-720589	KO-26	10U	389258	5896019		x				
	Creek 720589	100-567134-610692-720589	KO-27	10U	388854	5895321		x				
	Creek 878530	100-567134-610692-878530	KO-31	10U	398182	5889564			x			
Fawnie Creek	Fawnie Creek[2]	100-567134-641477-543682	KO-33	10U	346516	5889225			x			x
Meadow Creek	Meadow Creek[3]	300-625474-096683-048787	KO-34	11U	500271	5566860			x			x

Notes: [1] North American Datum 83. [2] DNA samples collected only, no kokanee survey conducted. [3] Out-of-group site = DNA samples collected only, no kokanee survey conducted
UTM = Universal Transverse Mercator; x = denotes survey conducted during date range provided.

Table 4.9-8: Kokanee Stream Count Sites in the RSA, August and September 2012

Stream	BC Freshwater Atlas Code	Baseline Site ID	Date Surveyed	Start Location (UTM[1])		End Location (UTM[1])		Length Surveyed (m)
				Easting	Northing	Easting	Northing	
Lower Chedakuz Creek	100-567134-610692-522527	KO-11	16-Sep	383750	5909461	384502	5909238	1,238
Middle Chedakuz Creek	100-567134-610692-480511	KO-23	28-Aug	390665	5901151	389719	5900563	2,305
Upper Chedakuz Creek	100-567134-610692-480511-645840	KO-30	10-Sep	398132	5889857	398163	5889918	302
Creek 522107	100-567134-610692-671007	KO-12	11-Sep	385054	5908270	385186	5908271	188
Creek 601947	100-567134-641477-543682-698692	KO-19	27-Aug	390345	5903174	391531	5903962	2,001

Notes: FWA = BC Freshwater Atlas; UTM = Universal Transverse Mercator
[1] North American Datum 83, Zone 10

Table 4.9-9: Fall Mountain Whitefish Spawning Survey Sampling Sites, Methods and Effort, 2012

Stream	BC Freshwater Atlas Code	Reach	Site ID	Location (UTM[1])		Sample Date/Range	Method	Site Length (m)	Haul	Effort[2]
				Easting	Northing					
Davidson Creek	100-567134-610692-522527	1	HN-01	384399	5907792	10-Oct-12 - 15-Oct-12	HN	-	-	117.5 (5)
						26-Oct-12 - 01-Nov-12	HN	-	-	144.4 (6)
						14-Nov-12 - 20-Nov-12	HN	-	-	142.8 (6)
						13-Oct-12	BS	-	1	60
						13-Oct-12	BS	-	2	80
						13-Oct-12	BS	-	3	40
						14-Oct-12	BS	-	4	30
						14-Oct-12	BS	-	5	80
Turtle Creek	100-567134-610692-480511	1	HN-05	383309	5908697	10-Oct-12 - 15-Oct-12	HN	-	-	117.8 (5)
						26-Oct-12 - 01-Nov-12	HN	-	-	145.3 (6)
						14-Nov-12 - 20-Nov-12	HN	-	-	142.3 (6)
						11-Oct-12	EF	-	1	851
						12-Oct-12	EF	100	2	191
						12-Oct-12	EF	100	3	629
						13-Oct-12	EF	150	4	1,086
						13-Oct-12	BS	-	1	75
Creek 661	100-567134-610692-671007	1	HN-03	388683	5899443	10-Oct-12 - 15-Oct-12	HN	-	-	116.3 (5)
						26-Oct-12 - 31-Oct-12	HN	-	-	121 (5)
						15-Nov-12 - 20-Nov-12	HN	-	-	118.8 (5)
						13-Oct-12	BS	-	1	12
						13-Oct-12	BS	-	2	60
						14-Oct-12	BS	-	3	30
						14-Oct-12	BS	-	4	20
Creek 705	100-567134-641477-543682-698692	1	HN-08	360368	5892635	11-Oct-12 - 15-Oct-12	HN	-	-	94.7 (4)
						26-Oct-12 - 01-Nov-12	HN	-	-	136.4 (6)
						15-Nov-12 - 20-Nov-12	HN	-	-	118.8 (5)
						12-Oct-12	EF	100	1	734
						13-Oct-12	EF	80	2	489
						14-Oct-12	EF	150	3	976

Notes: [1] North American Datum 83, Zone 10
[2] Hoop netting effort is in hours (days); beach seining effort is in m^2; electrofishing effort is in seconds
BS = beach seine; EF = backpack electrofishing; HN = hoop netting; m = metres; m^2 = metres squared; UTM = Universal Transverse Mercator

4.9.2 Data Analysis

4.9.2.1 Catch per Unit Effort (CPUE)

CPUE of backpack electrofishing was calculated as:

$$\text{CPUE} = \frac{\text{number of fish captured}}{\text{100 seconds of effort}}$$

CPUE of minnow trapping was calculated as the number of fish captured per trap-hour:

$$\text{CPUE} = \frac{\sum_i^n \text{number of fish captured in trap i}}{\sum_i^n \text{soak time of trap i}}$$

where n = total number of minnow traps set at a site, and i = individual traps.

CPUE of hoop nets was calculated as the number of fish captured per day (24 net-hours).

CPUE for gillnetting was calculated as the number of fish captured per 100 m^2 of net per 24 hours of soak time according to the formula:

$$\text{CPUE} = \frac{\left(\frac{(\text{number of fish captured} \times 100\ m^2)}{225\ m^2}\right) \times 24\ \text{hours}}{\text{total soak time (hours)}}$$

4.9.2.2 Stream Residence Time

Rainbow trout spawners migrate to their spawning sites during a brief period in spring soon after water temperatures rise above 5°C and when high freshet flows allow access to spawning sites. After spawning, the survivors return to their overwintering lake. The time spent migrating within a stream, including the time spent spawning, is called “stream residence time.”

Hoop net catches allowed stream residence time to be estimated for each population of rainbow trout. The first step was to calculate the daily cumulative percent catch for each upstream and downstream net at each sampling site. Then, the dates at 50% cumulative catch were identified. Stream residence time was defined as the number of days between the two dates at 50% cumulative catch for upstream and downstream migrants.

4.9.2.3 Fish Density

The density of fish in streams, expressed as the number fish/100 m^2, was calculated for each fish species by dividing the total number of fish of that species that were captured by one bout of electrofishing by the total area of that sampling site. Area was calculated by

multiplying the length of the sampling site, which was almost always 100 m, by the average width of the site.

4.10 Fish Size, Age, Growth, Sex, and Diet

4.10.1 Field Sampling

Fish processing was conducted in accordance with stream sampling protocols in the Reconnaissance (1:20,000) *Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001), and the *BC Fish Collection Methods and Standards* (RISC 1997).

All fish captured in 2011 and 2012 were temporarily stored in live wells prior to processing. During processing, all fish were identified to species, and measured for fork length (mm) with a measuring board and for weight (g) with an electronic balance. Large fish were lightly anaesthetized with clove oil to reduce struggling as they were measured. The exceptions were some small rainbow trout (<60 mm long) collected from Creek 661 in October 2012 that were not measured individually, but were sorted into 10 to 20 mm length ranges (e.g., 40 to 60 mm). For purposes of statistical analysis, those fish were assigned the mid-lengths of the ranges. In August 2011, the electronic balance used for processing of fish caught in Creek 661 would not provide weights for fish less than 1 g. Those fish had to be excluded from weight-length regressions and calculation of condition and mean weight.

In the office, ln(weight) was plotted on ln(length) for each individual of each population of rainbow trout and kokanee, and all outliers were identified and corrected by reviewing field notes. If an outlier could not be corrected, then it was excluded from all subsequent analyses.

Ageing structures were collected from rainbow trout from different size classes in each creek and lake during all fish sampling that took place in 2011 and 2012. Where sufficient numbers existed, a maximum of 10 ageing structures from 25 cm length classes, ranging from 75 to 475 mm in length, were submitted for ageing. These included scales for live-released fish, and scales and/or otoliths from incidental mortalities (those that died during capture or handling) and fish sacrificed for tissue metal concentrations analysis. All scales and otoliths were sent to North/South Consultants Inc. (North/South) of Winnipeg, Manitoba, for age reading.

Sex, sexual maturity, and gonad and liver weights were recorded from all fish that were sacrificed for samples of muscle and liver tissue and for stomach contents. For rainbow trout caught by hoop nets during the spring spawning period, sex was determined by squeezing the belly of each fish lightly and looking for release of eggs or milt. If nothing was released, then the sex of the fish was classified as unknown. Fish were classified as ripe if many eggs and much milt were released, and as spent if the belly was flaccid and only a few eggs or a little milt was released. If length of a fish was less than 150 mm), and if no eggs or milt were released, then they were classified as immature with unknown sex.

All fish were released near their point of capture, except those that died during capture or handling or that were sacrificed for biological information. For fish captured during the spring hoop net program, the direction of travel was documented and fish were released on the opposite side of the hoop nets in which they were captured.

All rainbow trout that were sacrificed in 2011 and 2012 for measurement of tissue metals concentrations, or that died during capture and handling, were dissected for determination of sex, sexual maturity, gonad weight, liver weight, and stomach contents. Gonads and livers were removed and weighed to the nearest 0.01 g, where possible. Five gonad maturity classes were used: immature, mature, ripe, spent, and unknown. Ripe gonads were full of eggs or sperm, spent gonads had only residual numbers of eggs or volumes of sperm. If the gonads were small and neither the development stage nor the presence of eggs or sperm could be distinguished, then they were classified as unknown sex and immature. Stomachs were removed and their contents were squeezed into plastic jars filled with 10% buffered formalin. No estimates of percent stomach fullness were made. Stomach contents were eventually transferred to 70% ethanol before being sent to an analytical laboratory for analysis of diet.

4.10.2 Laboratory Analysis

At North/South, each ageing structure was read by experienced technicians using a compound microscope (otoliths) or a microfiche projector (scales). Otoliths were ground and burnt if necessary to improve differentiation of the annuli. Otoliths were also placed in oil of wintergreen under the microscope for similar reasons.

Each ageing structure was aged blindly (i.e., without looking at fish lengths or previous aging results) three times by the same technician. A fourth reading was conducted if there were less than two readings with the same age or one of the readings was more than one year different than the others. As a final step, a second technician read all of the ageing structures and the two independent ages were compared. Ageing structures were read a fifth time if there was greater than one year discrepancy between the two independent fish ages.

Age data were screened for outliers by plotting length on age for each population of rainbow trout. Outliers that could not be corrected were excluded from calculation of mean age and from length-age plots and growth modelling.

Stomachs from a total of 50 rainbow trout were collected and the contents analyzed for taxonomic composition. In 2011, stomach contents from 24 rainbow trout were preserved for dietary analysis. These included seven fish from Davidson Creek, four fish from Creek 661, eight fish from Lake 01538UEUT, and five fish from Lake 01428UEUT. Stomach contents were sent to EcoAnalysts for taxonomic analysis. In 2012, stomach contents from 26 rainbow trout were preserved for dietary analysis. These included seven fish from Chedakuz

Creek, eleven from Lake 01538UEUT and eight from Lake 01428UEUT. Samples were sent to Cordillera Consultants Inc. (of Summerland, BC) for taxonomic analysis.

At EcoAnalysts and Cordillera, stomach contents of rainbow trout were emptied into a glass dish. The material was sorted under a dissecting microscope (minimum magnification = 10X). Invertebrates were separated from debris and stored in 70% ethanol. Recognizable prey items were identified to family or the lowest taxonomic level possible (worms to class level), and enumerated.

In 2011, EcoAnalysts followed standard procedures to reduce error rates in sample sorting and identification. Errors for sorting were minimized by:

- Use of certified taxonomists at EcoAnalysts;
- Conforming to ITIS to ensure valid classifications, and to meet revisions and additions to species lists;
- Direct data entry to a computer for upload to an electronic database; and
- Eliminating handwritten bench sheets which can cause data entry errors.

Accuracy of taxonomic identification was determined by recounting samples, where all samples were recounted by a second certified taxonomist at EcoAnalysts. All samples were resorted and % S_{Eff} was calculated. The criterion for an acceptable sort was ≥95% of the total number of organisms (McDermott et al., 2010).

In 2012, Cordillera followed the same QA/QC procedures for taxonomic classification of fish stomach contents that were used for classification of samples of stream and lake BMI collected in 2011.

4.10.3 Data Analysis

All analyses of fish biological characteristics were done for populations because populations are the basic unit of modern resource management and conservation biology. All rainbow trout in the RSA were assigned to one of seven populations based on the following sources of information: microsatellite DNA analyses; geographic proximity to overwintering, spawning and rearing habitat; the presence or absence of barriers to fish passage; and observations of fish density from 2011 and 2012 sampling (**Section 5.9.3.1**). All kokanee in the RSA were assigned to one of three populations based on the results of microsatellite DNA analyses and geographic proximity to overwintering habitat. Species of fish other than rainbow trout and kokanee were not assigned to populations because of insufficient data; they made up less than 1% of the total number of fish captured in 2011 and 2012.

Plots of ln(weight) on ln(length) for each population of rainbow trout and kokanee were examined for the presence of outliers. Outliers were then either corrected by re-examination of field data sheets or excluded from further analysis. Weight-length relationships were

calculated for each population of rainbow trout and kokanee by linear regression of ln-transformed weight on ln-transformed length:

$$\ln(\text{Weight, g}) = a + b*\ln(\text{Length, mm})$$

where a = the y-intercept of the regression line and b = slope of the regression line. Ln-transformation normalized the frequency distributions of weight and length and homogenized their variances – the two main pre-requisites of parametric statistics. The purpose of the regressions, apart from screening for outliers, was to test whether the slopes were close enough to the value of 3.0 for condition factor to be a reliable index of condition.

Condition factor, an index of the relative health of fish, was calculated for each fish using the formula (Ricker 1975):

$$\text{Condition} = \frac{\text{weight (g)} \times 10^5}{\text{length (mm)}^3}$$

where weight was multiplied by 10,000 to avoid fractional values. This index of condition assumes that weight is directly proportional to the cube of length.

For rainbow trout, age based on the number of annuli in a scale was compared to age based on the number of annuli in an otolith. This was done because the number of annuli in a rainbow trout scale is often an underestimate of true age for two reasons (Minard and Dye 1998): (1) in some fish the first one or two annuli may be missing or obscured; and (2) the outer annulus may be partially or wholly reabsorbed during those years in which a trout spawns. In contrast, otolith age is considered equivalent to absolute age (Kruse et al., 1997).

A total of 120 rainbow trout were sampled for both ageing structures in 2011 and 2012. A plot of mean scale age on otolith age with a 1:1 line for comparison showed that scale age underestimated otolith age for all eight age classes for which there were data (**Figure 4.10-1**). A linear regression of scale age on otolith age was highly significant ($P<0.001$) and explained 36.9% of the variance in scale age. The intercept had a value of 0.277, which was not significantly ($P>0.05$) different from zero. The slope of the regression was 0.663, which was highly significantly ($P<0.001$) lower than one. These results supported the conclusion that scale age underestimated true age by an average of 34%.

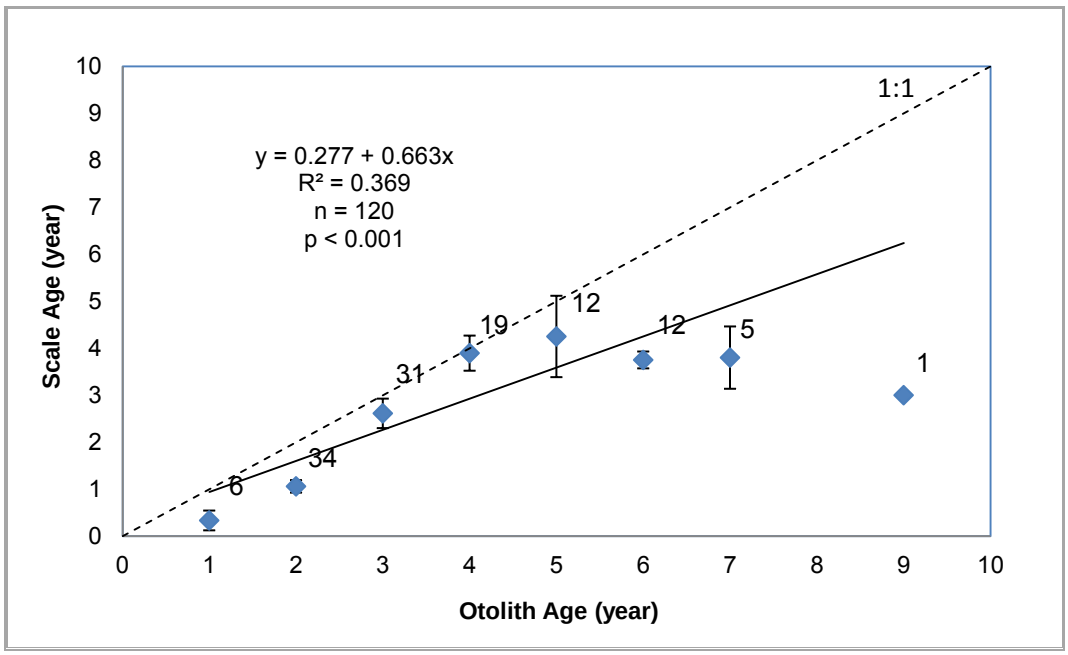


Figure 4.10-1: Linear Regression of Mean Scale Age on Otolith Age for Rainbow Trout, 2011-2012

An attempt was made to correct scale age to true age by dividing it by the regression slope (i.e., corrected age = scale age/0.663). However, correcting scale ages had the unfortunate effect of overestimating the age of the oldest scale-aged fish. Some of the corrected scale ages exceeded the reported life span for rainbow trout in Canada (10+ years; Scott and Crossman 1973). This was less acceptable than using scale ages, so in this report scale age was used as if it was comparable to true age, but only if there was no otolith age available. To the best of our knowledge, there are no published studies in which rainbow trout scale ages were corrected using otolith ages as an index of true age. The over-correction phenomenon may be the reason.

Mean length, weight, condition, and age were calculated for each population of rainbow trout, and mean length, weight, and condition were calculated for each population of kokanee, and for each of the other species of fish. (No age structures were taken from species other than rainbow trout.)

Length frequency distributions were constructed for each population of rainbow trout and kokanee. Their purpose was to show the reasons for differences in mean lengths among populations. Age frequency distributions were constructed for each population of rainbow trout to show the reasons for differences in mean ages among populations.

Plots of mean length on age for each population of rainbow trout were fit with the von Bertalanffy growth model:

$$L_t = L_\infty(1 - \exp(-K(t - t_0)))$$

where L_t = length (mm) at age t (year), L_∞ = asymptotic length (mm) or length at infinite age, K = growth rate ($year^{-1}$), and t_0 = age (year) at which L = 0 mm (Ricker 1975). The model was fit to length-age data using a non-linear regression module in R (Ogle 2012; R Core Team 2012).

For two populations from headwater lakes that were sampled mainly with gillnets, and so were missing length-at-ages for juveniles aged 0 to 2 years, a three-parameter model could not be fit successfully because mean length at age 0 years was predicted to be negative. For those populations, a two-parameter version of the growth curve was fit:

$$L_t = L_\infty(1 - \exp(-K)).$$

By fixing t_0 at 0 years, the curve was forced through the origin. This model was less biologically correct than the three-parameter version, but it provided reasonable estimates of L_∞ and K, the two parameters of greatest biological interest.

For three other populations of rainbow trout, the R program provided estimates of L_∞ and K that were negative and hence biologically unacceptable. This was because a lack of length-at-age for older age classes (7 to 9 years). For those populations, the three-parameter version was fit by iteratively varying the parameters and calculating the r^2 of the model fit within an Excel spreadsheet until a biologically acceptable fit was obtained that maximized r^2.

Sex ratios for each population were calculated as the ratio of the number of females to the number of males. Immatures were excluded from sex ratio calculation.

Lengths at 0%, 50% and 95% sexual maturation were calculated for each population by plotting the percent of rainbow trout that were sexually mature in 50 mm-wide length bins and identifying the lengths at which percent maturity crossed the 0%, 50% and 95% values.

Gonadosomatic indices (GSI) and hepatosomatic indices (HSI) were calculated for rainbow trout that were either sacrificed for tissue metal analysis and stomach contents or that died during capture and handling. GSI's were calculated separately for female and male fish. GSI and HSI were calculated using the formula:

$$\text{GSI or HS I} = 100 \times \frac{\text{gonad or liver weight (g)}}{\text{total body weight (g)}}$$

The first step in analyzing the diet of rainbow trout was to calculate the total number of prey items, relative abundance (i.e., percent of total number), and frequency of occurrence of

each major taxon of prey in each fish of each population, using pooled samples collected in 2011 and 2012. These calculations were shown in tables. The second step was to calculate relative abundance of major taxa for all fish from a population. These percentages were shown in pie charts.

4.11 Fish Tissue Metal Concentrations

Early in 2011, both rainbow trout and sculpin species (e.g., prickly sculpins) were identified as a potential target species for tissue metal sampling. Rainbow trout were found in all waterbodies (with the exception of Snale Lake), but sculpins were not present in any of the streams or headwater lakes of the LSA. Hence, only rainbow trout were sampled for tissue metal concentrations.

Rainbow trout are a good species for tissue metals monitoring for the following five reasons:

- It is present in every watershed of the LSA and RSA;
- It is the predominant fish species in streams and headwater lakes of the LSA and RSA (**Section 5.10-1**);
- It is one of the most common fish species in the large lakes of the LSA (e.g., Tatelkuz Lake) and the RSA (e.g., Kuyakuz Lake) (Burns 1977; Walsh and Hale 1977);
- It is an opportunistic and flexible predator and feeds on both benthic and pelagic prey; and
- It is a valued sport fish species, and is consumed by both humans and piscivorous wildlife.

4.11.1 Field Sampling

Rainbow trout were collected from 20 sites in the summers of 2011 and 2012 (**Table 4.11-1** and **Table 4.11-2** and **Figure 4.11-1**). These included 7 sites in Davidson Creek, 4 sites in Turtle Creek (including one in Creek 700), 5 sites in Creek 661, 1 site in Chedakuz Creek and one site each in headwater lakes 01538UEUT, 01428UEUT, and 01682LNRS. Rainbow trout tissue samples were collected from the same creeks (i.e., Davidson, 661, and Turtle) and lakes (01538UEUT and 01428UEUT) in 2012 to increase sample sizes to a minimum of eight per location.

All rainbow trout that were sampled for tissues from lakes had been killed during capture in gillnets so they tended to be large (>180 mm long) and sexually mature. However, almost all rainbow trout that were sampled for tissues from streams were selected for sacrifice because electrofishing, minnow trapping, and angling are not typically lethal gears. Almost all fish sampled from stream sites were shorter than 180 mm because that was an abundant size class, which is important for repeatability of this study during future monitoring programs.

Table 4.11-1: Number of Fish Tissue Samples for Metals Analysis, 2011

Stream/Lake	Reach ID	Baseline Map Site ID	Location (UTM1)		Number of Samples		
			Northing	Easting	WF	M	L
Davidson Creek	7	FT-01	377944	5899087	1	8	6[2]
	8	FT-02	377669	5898633			
	9	FT-03	376677	5898181			
	11	FT-04	372092	5895287			
Turtle Creek	4	FT-08	375384	5904859	8	0	0
Creek 700	2	FT-09	374201	5904042			
Creek 661	3	FT-05	383023	5898466	1	6	1[3]
	4	FT-06	381805	5898570			
	5	FT-07	380977	5897639			
Lake 01428UEUT	3	FT-11	-	-	10	5	5
Lake 01538UEUT	7	FT-10	-	-	0	8	7
Total					**20**	**27**	**19**

Notes: [1] NAD 83, Zone 10
[2] Eight liver samples collected; five samples analysed individually and three samples analysed as a composite sample
[3] Five liver samples collected and analysed as a composite sample
UTM = Universal Transverse Mercator; ID = identification; L = liver tissue; m = muscle tissue; T = target number of samples; WF = whole fish

Table 4.11-2: Number of Fish Tissue Samples for Metals Analysis, 2012

Stream/Lake	Reach ID	Baseline Map Site ID	Location (UTM[1])		Number of Samples[2]		
			Northing	Easting	WF	M	L
Davidson Creek	4	FT-12	383074	5906262	8	8	3[3]
	1	FT-13	384175	5907661			
	2	FT-14	383983	5907396			
Turtle Creek	2	FT-15	379093	5906134	8	8	3[3]
	5	FT-16	374536	5904437			
Creek 661	1	FT-17	386594	5898646	8	8	2[4]
	2	FT-18	385959	5898462			
Chedakuz Creek	13	FT-19	383675	5909531	8	8	8
Lake 01682LNRS	13	FT-20	-	-	8	8	8
Lake 01428UEUT	3	FT-11	-	-	8	8	8
Lake 01538UEUT	7	FT-10	-	-	8	8	8
Total					**56**	**56**	**40**

Notes: [1] NAD 83, Zone 10
[2] In 2012 fish tissue sampling, 8 whole fish were sacrificed at each site, and individual samples were submitted for muscle and liver tissue. Weights for whole fish and weights/concentrations for muscle and liver tissue were then used to calculate whole fish tissue metals concentration.
[3] Eight liver samples collected; submitted as three composite samples
[4] Eight liver samples collected; submitted as two composite samples
UTM = Universal Transverse Mercator; ID = identification; L = liver tissue; m = muscle tissue; WF = whole fish

A total of 103 rainbow trout were used for tissue sampling. As a general rule, 16 fish were collected from each watershed or lake: 8 in 2011 and 8 in 2012. The exceptions were Davidson Creek where 9 fish were collected in 2011, Creek 661 where 7 fish were collected in 2011, Chedakuz Creek where no fish were sampled in 2011, Lake 01428UEUT where 15 fish were sampled in 2011, and Lake 01682LNRS where no fish were sampled in 2011.

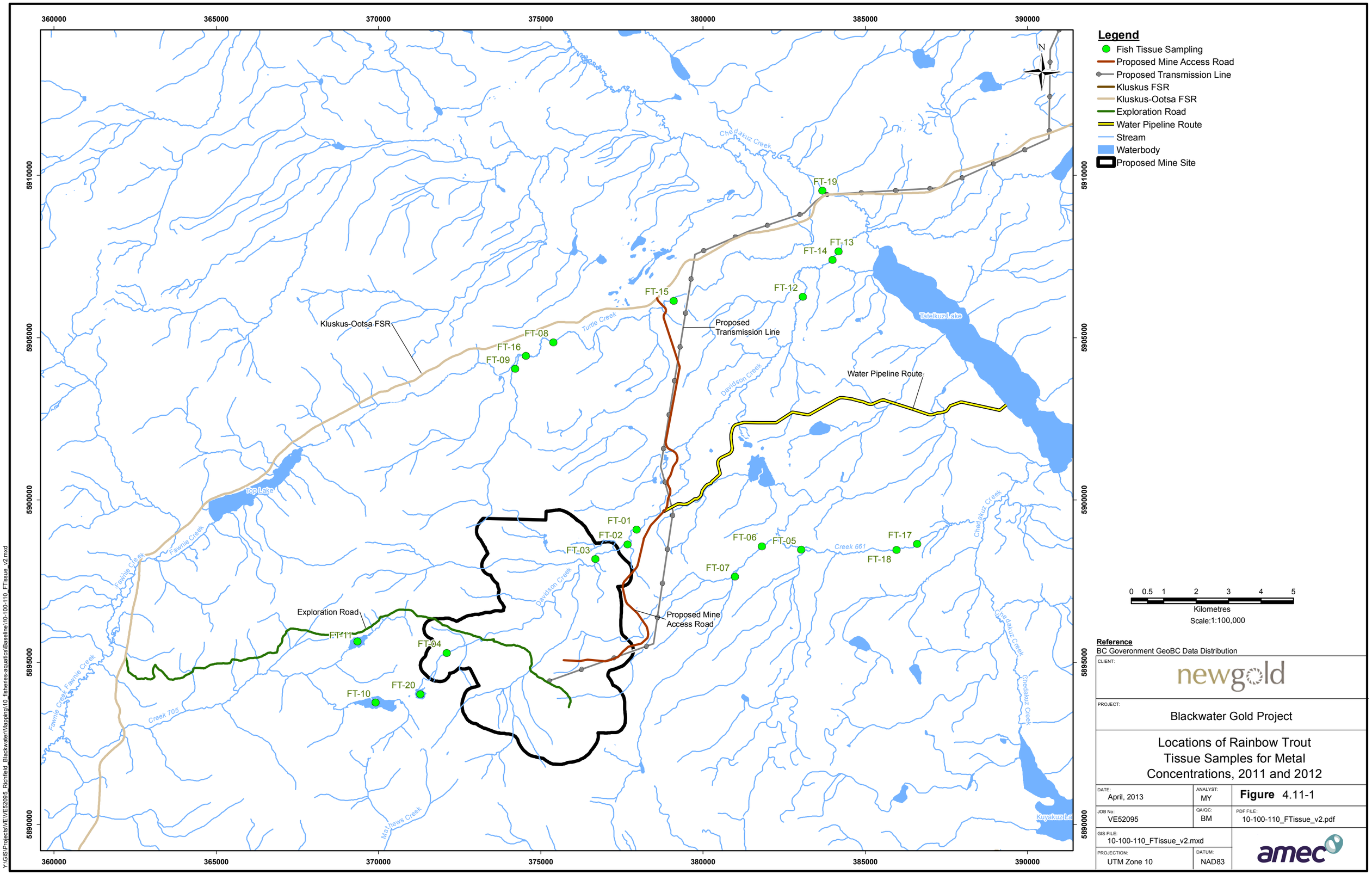
Metal concentrations were required from different parts of fish. Muscle and liver metal concentrations were required to evaluate human health because both parts of the fish are eaten by humans. Whole-body metal concentrations were also required for ecological risk assessment because piscivorous wildlife eat the whole body not just muscle or liver. Therefore, several different protocols were used for preparation of tissue samples.

At each site, each rainbow trout was measured for length and then placed in a labelled plastic bag and stored on ice in a cooler. In the evening, each sample was processed in a laboratory set up at the mine camp. For all fish, total weight was measured with an electronic balance.

In 2011, some of those rainbow trout were then placed in a plastic bag labelled with their sample number and a designation as a “whole-body” sample. Those samples were then frozen for shipment to ALS. At ALS, those fish were processed as a single sample.

In 2011, other rainbow trout were dissected and livers and gonads were removed and weighed. Livers were rinsed with deionised water and placed in a plastic bag labelled with sample number and a designation as “liver” sample. The viscera were removed and carcass weight was measured. The carcass was rinsed with deionised water and placed in a plastic bag labelled with sample number and a designation as “muscle” sample. Those samples were then frozen for shipment to ALS. At ALS, the liver was processed as a separate sample. If the liver was too small, then a composite sample of liver was prepared using fish collected at the same site. Then, ALS removed a filet of muscle tissue from the carcass and analyzed it as a separate sample.

In 2012, each rainbow trout was used to provide three samples: whole-body, muscle, and liver. Each fish was dissected and liver and gonad were removed and weighed separately. Each liver was rinsed with deionised water and placed in a plastic bag labelled with sample number and a designation as “liver” sample. The rest of the viscera were removed and carcass weight was measured. The carcass, gonads, and viscera were placed into a plastic bag labelled with sample number and a designation as “whole fish-muscle” sample. All samples were then frozen for shipment to ALS. At ALS, the liver was treated as a separate sample. If the liver was too small to support required laboratory analyses, then a composite sample of liver was prepared using fish collected at the same site. For muscle samples, ALS removed both filets of muscle tissue from the carcass for analysis. The remainder of the fish (minus the liver and the muscle fillets) was treated as a separate sample.



Reference
BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Locations of Rainbow Trout Tissue Samples for Metal Concentrations, 2011 and 2012

DATE: April, 2013	ANALYST: MY	**Figure** 4.11-1
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-110_FTissue_v2.pdf
GIS FILE: 10-100-110_FTissue_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095 Richfield Blackwater\Mapping\10 fisheries-aquatics\Baseline\10-100-110 FTissue_v2.mxd

4.11.2 Laboratory Analysis

At ALS, all tests were conducted within ALS recommended hold times. A total of 218 tissue samples (excluding splits) were analyzed by ALS over the 2 years of sampling: 76 whole-body, 83 muscle, and 59 liver. Each sample was analyzed for percent moisture and concentrations of 41 metals. In 2012, samples were also analyzed for percent lipid content, and sub-samples were analyzed for methyl-mercury. The metals analyzed and their methods detection limits (MDL) were consistent with BC MOE requirements. The number of parameters, analytical methods, and detection limits were the same as for benthic macroinvertebrate tissue samples (**Section 4.4.3.2)**. Methyl-mercury and percent lipids were measured in 2012 only. Results were reported as total metal concentrations per wet weight (milligrams per kilogram wet weight (mg/kg wwt).

QA/QC for fish tissue metal concentrations followed the same methods as for benthic macroinvertebrate tissue metal analysis (**Section 4.4.3.2**). Standard QA/QC procedures required by CALA included the following.

- Analysis of method blanks (digested blank in de-ionized water). A total of 3,930 metal concentrations were produced from method blanks testing, of which 109 exceeded ALS's Data Quality Objectives (DQO). This was an exceedance frequency of 2.8%, which was considered acceptable by ALS.
- Analysis of certified reference material ("TORT 2" and "DOLT 4"). A total of 1,396 metal concentrations were produced from tests of reference material. All concentrations fell within acceptable measurement ranges.
- Comparison of replicates. A total of 1,712 RPD were calculated between metal concentrations in two replicate samples, of which 684 or 40% could not be calculated because one or both values were below the MDL, and 117 or 6.8% fell outside ALS' DQO of 30% due to sample heterogeneity. This exceedance frequency was considered acceptable by ALS.

4.11.3 Data Analysis

The same analyses used for BMI tissue metal concentrations (**Section 4.4.3.3**) were used for fish tissue metal concentrations.

4.12 Microsatellite DNA Analyses

4.12.1 Field Sampling

Samples of adipose fin were collected from rainbow trout captured in streams and lakes during the spring and summer of 2011, and from kokanee captured in streams in 2012. Tissue samples were preserved in vials filled with non-denatured ethanol. A representative sub-sample of both stream and lake samples were submitted to Dr. Eric Taylor of the

Department of Zoology of the University of British Columbia (UBC) for microsatellite DNA analysis, using his advice on sample size (n ~ 30 for each watershed).

Thirty rainbow trout tissue samples were submitted to UBC from each of the four main watersheds sampled in spring 2011: Davidson Creek, Turtle Creek, Creek 661, and Creek 705 (**Table 4.12-1** and **Table 4.12-2**). Samples from the Turtle Creek Watershed were collected from Turtle Creek and Creek 700. Additional rainbow trout tissue samples were collected from the same four watersheds in summer 2011. Creek 705 Watershed samples were taken from Lake 01538UEUT and Lake 01428UEUT.

Table 4.12-1: Number of Rainbow Trout Tissue Samples for Microsatellite DNA Analysis, 2011

Watershed	Stream/Lake	Number of Samples		Total
		Spring 2011	Summer 2011	
Davidson Creek	Davidson Creek	30	10	40
Turtle Creek	Turtle Creek	26	2	40
	Creek 700	4	8	
Creek 661	Creek 661	30	3	33
Creek 705	Creek 705	30	0	59
	Lake 01538UEUT	0	13	
	Lake 01428UEUT	0	16	

Table 4.12-2: Location of Rainbow Trout Tissue Samples for Microsatellite DNA Analysis, 2011

Watershed	Stream/Lake	Reach ID	DNA Site ID	Location (UTM[1])		No. of Samples
				Northing	Easting	
Davidson Creek	Davidson Creek	1	RD-01	384399	5907792	13
		8	RD-02	377669	5898633	17
		8	RD-03	377343	5898429	2
		11	RD-04	372092	5895287	3
		7	RD-05	377944	5899087	1
		9	RD-06	376677	5898181	3
		10	RD-07	374116	5896003	1
Turtle Creek	Turtle Creek	1	RD-08	383309	5908697	19
		5	RD-09	374523	5904436	7
		4	RD-10	377609	5905611	2
	Creek 700	1	RD-11	374343	5904266	4
		2	RD-12	374201	5904042	8
Creek 661	Creek 661	1	RD-13	388683	5899443	22
		4	RD-14	381776	5898538	8
		3	RD-15	383063	5898469	1
		5	RD-16	380977	5897639	2
Creek 705	Creek 705	2	RD-17	360368	5892635	30
	Lake 01428UEUT	-	RD-18	-	-	16
	Lake 01538UEUT	-	RD-19	-	-	13

Notes: [1] NAD 83, Zone 10
UTM = Universal Transverse Mercator; ID = identification

Kokanee DNA samples were collected at nine stream sites in August and September 2012 (**Table 4.12-3**). These sites included three in the LSA (Davidson Creek, Creek 661, and Lower Chedakuz Creek), four in the RSA (Middle and Upper Chedakuz Creek, Creek 522107, and Creek 601947), one site in Fawnie Creek, and one out-of-group sampling site in the East Kootenays (Meadow Creek). The site in Fawnie Creek was chosen because it is outside of the Chedakuz Creek Watershed. The Meadow Creek site was chosen because it represents a population with a significant spatial separation from Chedakuz Creek. A target sample of 30 kokanee was captured using gillnets, seine nets, or dip nets at each site. Adipose and caudal fin clips were taken and preserved in non-denatured ethanol. Kokanee tissue samples were submitted to Dr. Eric Taylor of the University of British Columbia for microsatellite DNA analysis.

Table 4.12-3: Number and Location of Kokanee Tissue Samples for Microsatellite DNA Analysis, 2012

Stream/Lake	Reach	Baseline Map Site ID	Location (UTM[a])			No. of Samples
			Zone	Northing	Easting	
Davidson Creek	1	-	10	384253	5907741	31
Creek 661	1	-	10	388488	5899318	31
Lower Chedakuz Creek	14	KO-11	10	383804	5909445	35
Middle Chedakuz Creek	17	KO-23	10	390308	5901131	30
Upper Chedakuz Creek	28	KO-30	10	398132	5889857	30
Creek 522107	1	KO-12	10	385095	5908260	31
Creek 601947	1	KO-19	10	390540	5903032	7
Fawnie Creek	-	KO-33	10	346516	5889225	33
Meadow Creek	-	KO-34	11	500256	5566845	30

Notes: [a] NAD 83 Datum
UTM = Universal Transverse Mercator

4.12.2 Laboratory Analysis

In the laboratory, ten microsatellite loci were chosen for inclusion in the analysis of rainbow trout samples, based on clarity of resolution and degree of polymorphism: *Ots*3, 100, and 103, *Ssa*85, 197, and 456, *Omy*77, *Oki*3a, *One*8 *and* 14, which have been derived from *Oncorhynchus tshawytscha (Ots), Salmo salar (Ssa), O. mykiss (Om), O. kisutch (Oki), and O. nerka (One)* genomic libraries, respectively (Tamkee et al., 2010). Polymerase chain reactions (PCR) were carried out with fluorescent dye-labelled primers in 10 µL volumes of 10 mM Tris-HCl (pH 8.3), 1.5 mM $MgCl_2$, 0.8 mM dNTPs, and 0.1 units of *Taq* polymerase (*One*8) or by using the Qiagen PCR Multiplex Kit (all other loci) in 20 L volumes in MJ PTC 100 and 200 thermocyclers following Taylor et al., 2007. The PCR products were visualized using a Beckman-Coulter CEQ 8000 automated genotyper.

For kokanee, extraction of DNA used Qiagen Spin Columns. Samples were stored at -20°C until analysis. Six microsatellite loci were chosen for inclusion based on clarity of resolution and degree of polymorphism: *Ots*100, 103, and 108, *Omy*77, *Oki*10, and 29, which have

been derived from *Oncorhynchus tshawytscha (Ots), O. mykiss (Om), and O. kisutch (Oki)* genomic libraries, respectively (Taylor and Gow 2007; Tamkee et al., 2010). Polymerase chain reactions (PCR) were carried out with fluorescent dye-labelled primers in 20 µL volumes using the Qiagen PCR Multiplex Kit in MJ PTC 100 thermocyclers following Taylor et al., 2007. The PCR products were visualized using a Beckman-Coulter CEQ 8000 automated genotyper.

Standard methods (e.g., Redenbach and Taylor 2003) were used to conduct all microsatellite DNA analysis.

4.12.3 Data Analysis

The following tests on the results of genetic sequencing were performed using GENEPOP version 3.3 (Raymond and Rousset 2001). First, tests for deviations from Hardy-Weinberg equilibrium were performed for each locus-population combination using an exact test in which probability (P) values were estimated using a Markov chain method. Second, tests for genotypic linkage disequilibrium for all combinations of locus pairs within a population were also made using a Markov chain method with GENEPOP default values. Third, tests for population differentiation between all pairs of populations were performed using FST estimated as θ (Weir and Cockerham 1984) as implemented in GENETIX (Belkhir et al., 2004). Significance levels were determined correcting for multiple simultaneous tests following Narum (2006).

Basic descriptive statistics of sample size (N), number of alleles (NA), observed (HO) and expected (HE) 5 were compiled using FSTAT version 2.9 (Goudet 2001). A factorial correspondence analysis (FCA) was used to depict genetic similarity amongst all individuals in genetic space as inferred from variation in allele frequencies using GENETIX. A hierarchical partitioning of allele frequency variation to that between drainages, among localities within drainages, and within localities was conducted using the analysis of molecular variance approach as implemented in ARLEQUIN (Excoffier et al., 2006).

The model-based Bayesian clustering analysis within STRUCTURE (Pritchard et al., 2000) was used to assess population structure employing the admixture model with correlated allele frequencies and a run of 50,000 iterations followed by an additional 100,000 iterations, replicated three times. The simulations were run with hypothesized numbers of populations (*K*) ranging from *K* = 1 to *K* = s + 2 where s = the number of localities sampled (i.e., a total of *K* = 9). STRUCTURE HARVESTER was used to process the results from multiple runs of STRUCTURE (Earl 2011). Given the relatively small spatial scale of the study (and an expected low level of genetic differentiation) and that fish were sampled largely within what are likely to be spawning tributaries, the STRUCTURE analysis also used the locality prior option which employs prior knowledge of where each sample was collected to assist in clustering. The LOCPRIOR model works on the principle that individuals from the same sampling site often come from the same genetic population. Therefore, the LOCPRIOR

operate to assume that the sampling sites can be informative about ancestry (Hubisz et al., 2009).

The STRUCTURE analyses for kokanee were also run with and without the Kootenay Lake sample (aka the Meadow Creek sample) to allow for more sensitive assessment of population structure within the Tatelkuz/Chedakuz system. STRUCTURE HARVESTER was used to process the results from multiple runs of STRUCTURE (Earl and vanHolt 2011).

The program GENECLASS (Piry et al., 2004) was used for the multilocus genotypes to test for migration between populations by calculating the likelihoods of individuals being first-generation migrants in a modification of the basic assignment test procedure (Hansen et al., 2001). Using variation across loci, the likelihood score was calculated as *Lh/Lmax*, where *Lh* is the likelihood of drawing a particular individual's genotype from the population residing in the locality from which it was sampled given the observed set of allele frequencies, and *Lmax* is the maximum likelihood of membership across all potential sources (Paetkau et al., 2004). We chose to calculate *Lh/Lmax* because the samples probably included all potential source populations for all species (Paetkau et al., 2004).

To test the null hypothesis that each individual was actually born in the population from which it was sampled, we used the genotype resampling procedure recommended by Paetkau et al., 2004. An individual fish was rejected as a member of the population from which it was sampled if the observed likelihood of population membership was represented by 1% or fewer of those generated from simulating genotypes of 10,000 fish generated randomly from allele frequencies found in the sample population.

5.0 RESULTS AND DISCUSSION

This section describes the results of the baseline studies conducted in 2011 and 2012, and identifies key findings.

5.1 Stream Water Temperature

Annex 5.1-1 shows mean monthly water temperatures for streams in the LSA.

Mean daily stream temperatures exhibited three clear patterns: (1) the expected dome-shaped variation with season; (2) a gradient of decreasing temperature with increasing elevation; and (3) warmer summer temperatures in 2012 than in 2011 (**Figure 5.1-1** to **Figure 5.1-5**). Mean daily temperatures rose from near 0°C in early April to a maximum of between 10°C and 22°C in mid-July and early August and then fell to near 0°C in early November.

Monitoring sites higher in a watershed (e.g., upper and middle Davidson Creek, Creek 704454, Creek 688328) had consistently lower stream temperatures than sites further downstream (e.g., lower Davidson Creek and lower Chedakuz Creek). Creek 428073, a lower elevation tributary flowing through a series of shallow ponds, exhibited the highest summer temperatures of all sites (**Figure 5.1-1**).

Creek 704454 is a tributary to Davidson Creek and enters the mainstem upstream of the middle Davidson Creek station. Creek 704454 drains the northern flanks of Mount Davidson and had the lowest summer stream temperatures recorded in the Davidson Creek Watershed. Likely as a result of these colder water inputs, stream temperatures at the middle Davidson Creek site were marginally lower than at upper Davidson Creek.

In Turtle Creek, mean daily stream temperatures were similar at both the middle Turtle Creek and lower Turtle Creek sites (**Figure 5.1-2**). Temperatures were consistently colder in Creek 700, a small tributary stream with steeper gradients, greater canopy closure (and hence less solar heating), and gravel/cobble substrates that drains higher elevations than the mainstem of Turtle Creek. The mainstem is low-gradient, with fine bed materials and open wetland complexes, all of which contributes to the higher recorded temperatures.

In Creek 661, mean daily stream temperatures were marginally higher in the lower site compared to the middle site (**Figure 5.1-3**), but differences between the two sites were generally within 2°C.

In Creek 705, as in the other watersheds, mean daily stream temperatures were higher in summer 2012 than in summer 2011 (**Figure 5.1-4**).

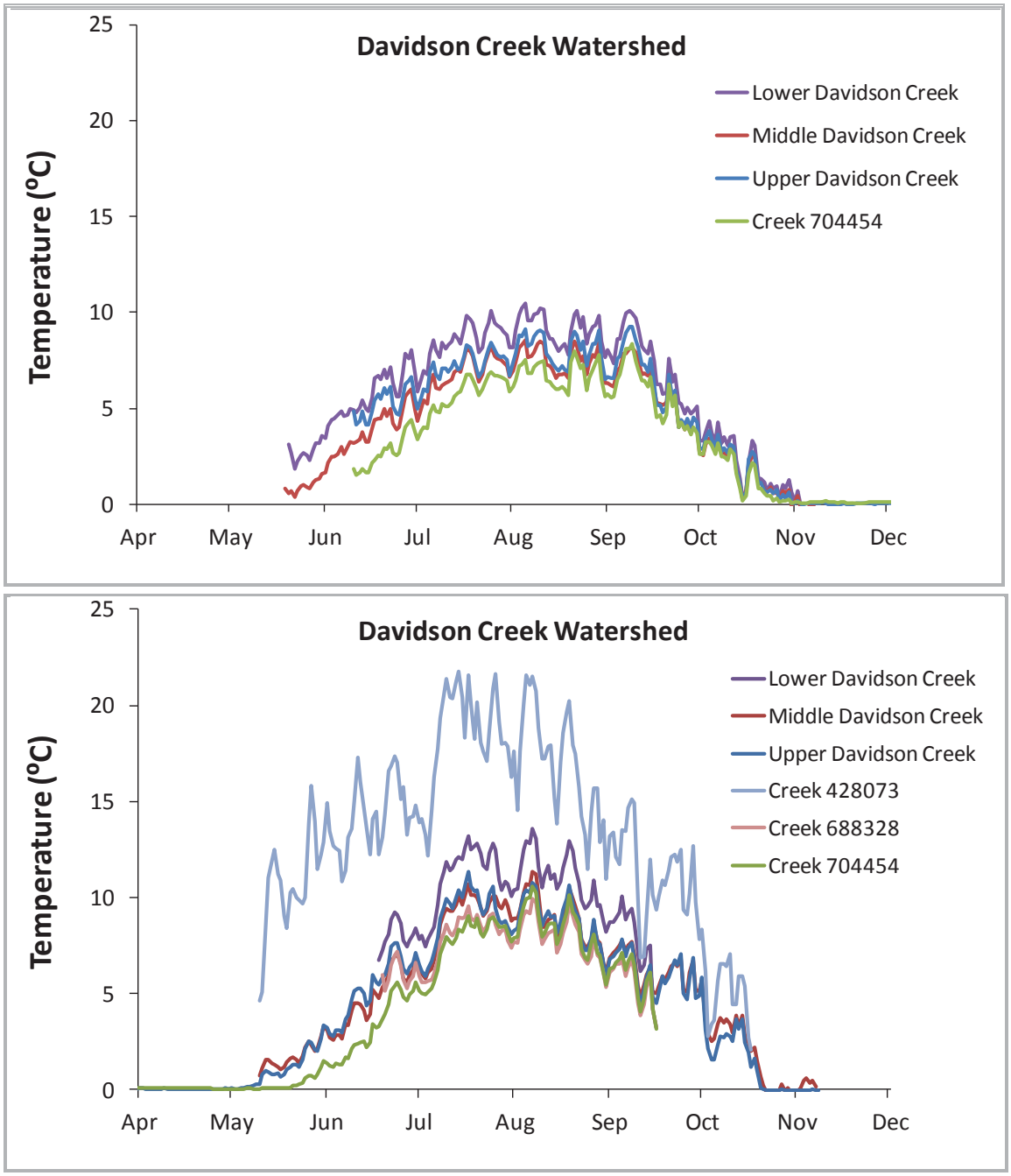


Figure 5.1-1: Mean Daily Stream Temperatures in the Davidson Creek Watershed, 2011 (top) and 2012 (bottom)

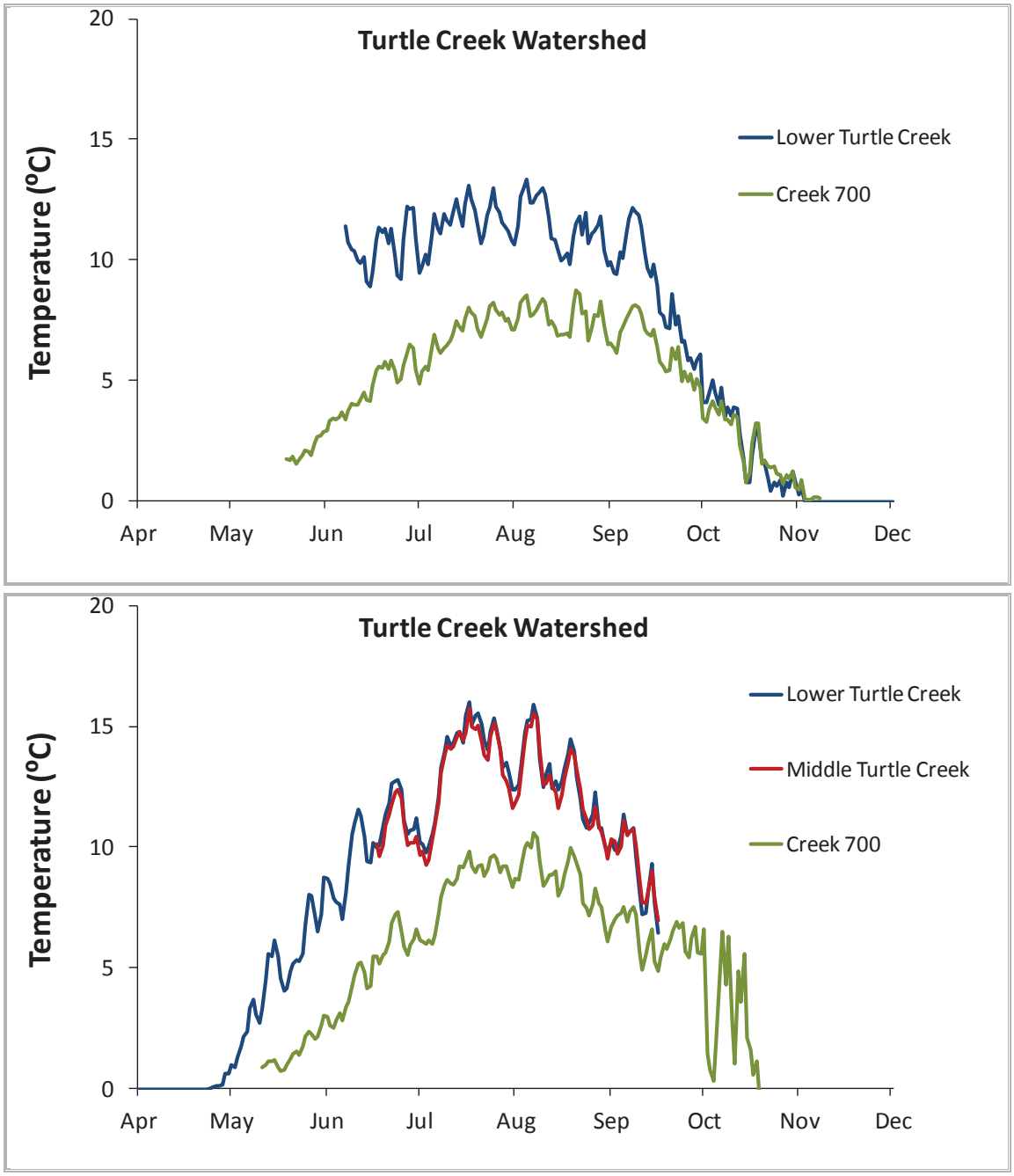


Figure 5.1-2: Mean Daily Stream Temperature in the Turtle Creek Watershed, 2011 (top) and 2012 (bottom)

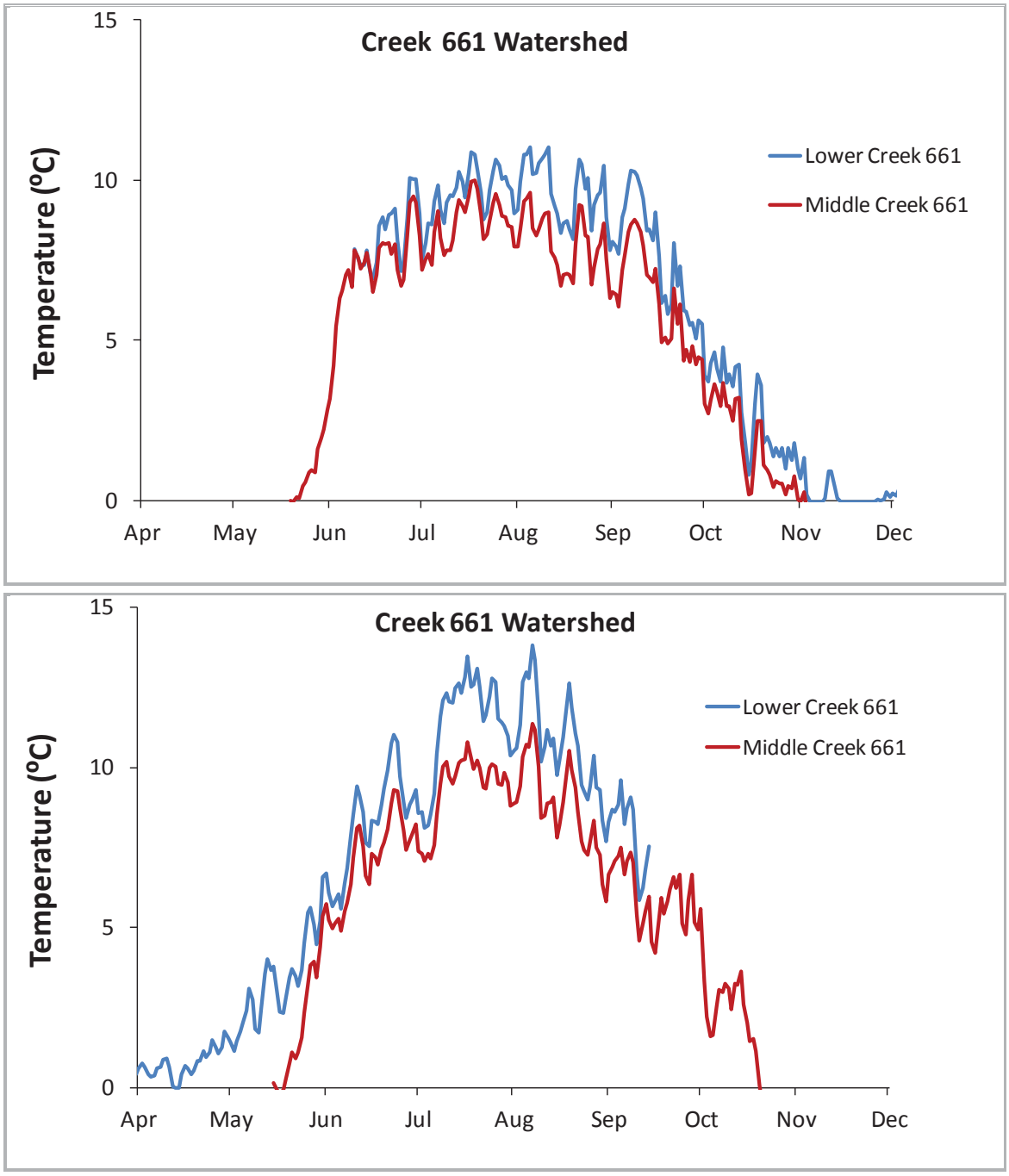


Figure 5.1-3: Mean Daily Stream Temperature in the Creek 661 Watershed, 2011 (top) and 2012 (bottom)

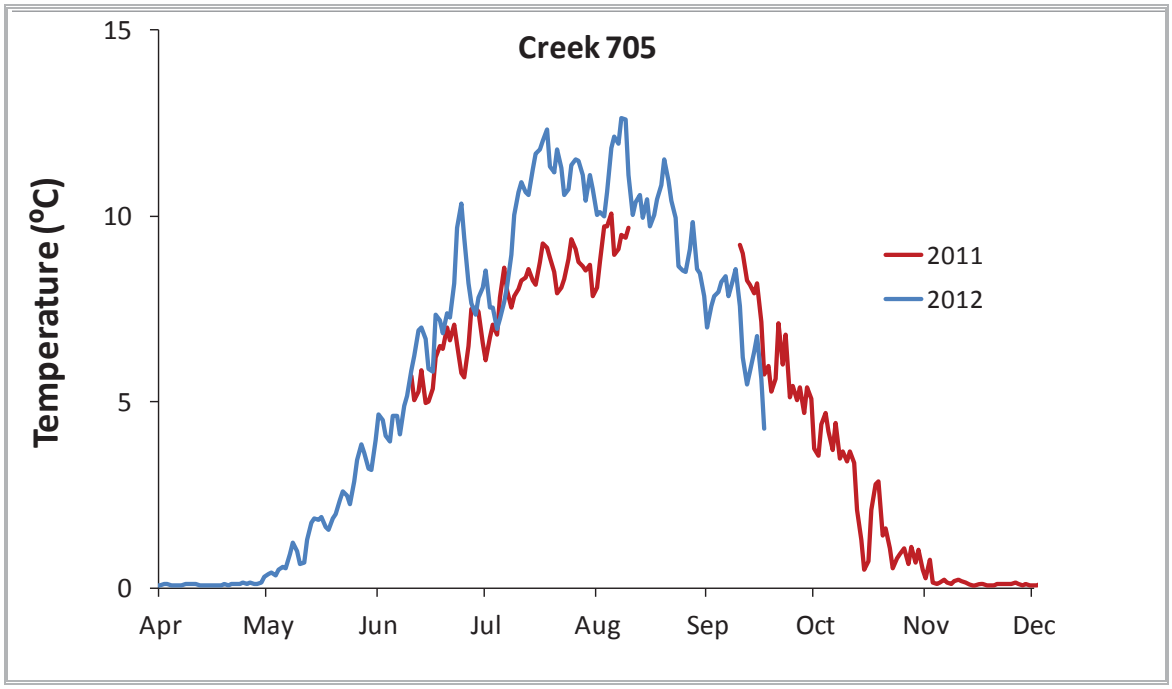


Figure 5.1-4: Daily Stream Temperature in Creek 705, 2011 and 2012

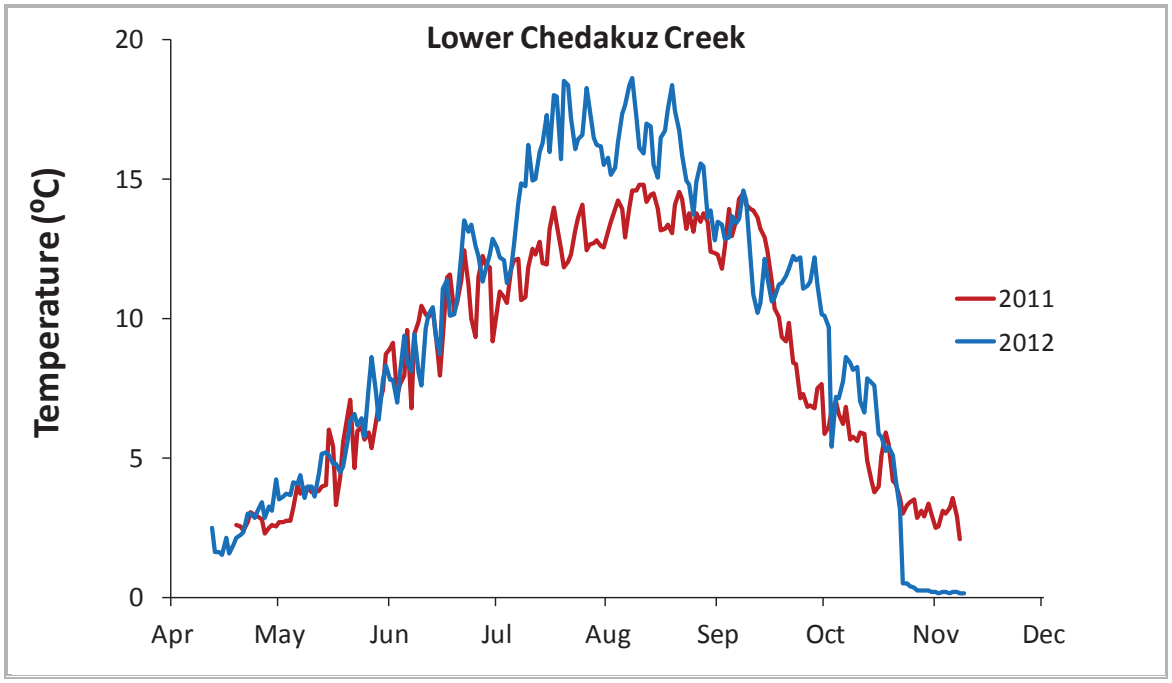


Figure 5.1-5: Stream Temperature in Lower Chedakuz Creek, 2011 and 2012

In lower Chedakuz Creek, mean daily stream temperatures were also warmer in 2012 than in 2011 (**Figure 5.1-5**). Temperatures in lower Chedakuz Creek are influenced by Tatelkuz Lake, which is immediately upstream. Hence, temperatures in lower Chedakuz Creek remain above freezing throughout the winter (S. Sinclair 2013, personal communication).

In summary, streams in the LSA are generally cool; hence, aquatic biological processes are likely more limited by low temperatures in fall and winter than by high summer temperatures.

In general, stream temperatures in the LSA fall below the BC MOE optimal temperature ranges for rainbow trout and kokanee (BC MOE 2001) (**Table 5.1-1**).

Table 5.1-1: Optimal Temperature Ranges for Sockeye and Rainbow Trout (BC MOE 2001)

Species	Incubation	Rearing	Migration	Spawning
Sockeye	4.0-13.0	10.0-15.0	7.2-15.6	10.6-12.8
Rainbow	10.0-12.0	16.0-18.0	-	10.0-15.5

Notes: Sockeye ranges are assumed to represent optimal ranges for kokanee

Rainbow trout are found in streams throughout the LSA. During their spawning period in May and June, mean monthly temperatures fall within the optimal ranges for migration and spawning only for Turtle Creek and Creek 428073 (**Annex 5.1-1**). Mean monthly temperatures are below the optimal range for spawning at all other sites.

Turtle Creek, Creek 428073, and Chedakuz Creek experience warmer temperatures than other sites during the summer incubation and rearing period, with monthly average temperatures approaching or within the optimal ranges. However, stream temperatures in the mainstem of Davidson Creek, in headwater tributaries, and in Creeks 661 and 705 are below the optimal ranges for rainbow trout rearing.

Kokanee spawn in Davidson Creek, Creek 661, and Chedakuz Creek and rear and overwinter in Tatelkuz Lake. Stream temperatures in Davidson Creek and Creek 661 during August, when kokanee spawn, are within the optimal ranges (**Table 5.1-1**). Temperatures in Chedakuz Creek, where spawning occurs later, do not decrease until September. For Davidson Creek and Creek 661, temperatures for egg incubation fall below the optimal range by October.

Temperature data are not yet available for the winter kokanee embryo incubation period for Chedakuz Creek. The stream remains open through the winter due to the influence of Tatelkuz Lake, but temperatures fall below 3°C.

5.2 Periphyton Communities

Annex 5.2-1 shows the values of the habitat variables measured at each of the periphyton and BMI sampling sites visited in 2011 and 2012, and **Annex 5.2-2** shows photographs of each sampling site taken in 2011 and 2012. **Annex 5.2-3** shows periphyton biomass (i.e.,

chlorophyll a concentration), and **Annex 5.2-4** shows the taxonomic classification of the samples.

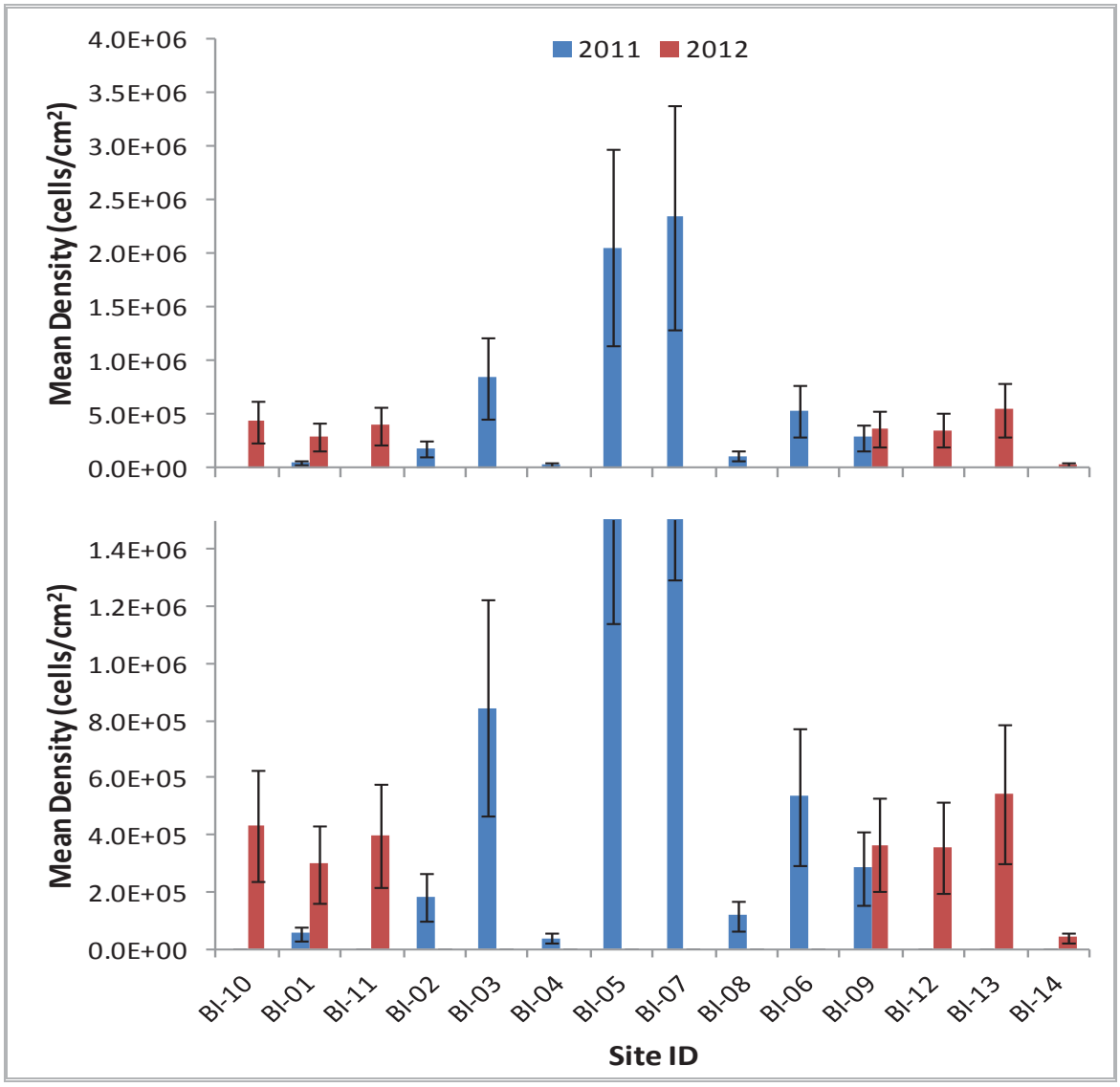
5.2.1 Density and Biomass

Mean periphyton density ranged from a low of 40,558 cells/cm^2 (SE = 18,138) measured at site BI-04 in lower Creek 661 in 2011 to a high of 2,339,582 cells/cm^2 (SE = 1,046,293) measured in Turtle Creek (BI-07) in 2011 (**Figure 5.2-1**). (Note that **Figure 5.2-1** has two panels in order to show detail at both the lower mean density range (lower panel) and the higher mean density range (upper panel)). In 2011, the three highest mean periphyton densities were measured in Turtle Creek (BI-07), upper Creek 661 (BI-05), and Creek 704454 (BI-03), and the three lowest mean periphyton densities were measured in lower Davidson Creek (BI-01), lower Creek 661 (BI-04), and in Creek 700 (BI-08).

Two sites, lower Davidson Creek (BI-01) and lower Creek 705 (BI-09), were sampled in both 2011 and 2012 (**Figure 5.2-1**). At both sites, mean periphyton densities were higher in 2012 than in 2011, but the differences were greater at site BI-01 than at site BI-09. This indicates among-year variation and suggests that growing conditions for periphyton were more favourable in LSA streams in 2012 than in 2011. This was likely due to higher water temperatures in 2012 than in 2011. Between-year variation in solar radiation may have played a role, but there has not been sufficient solar radiation data recorded from the Project area to test if there was lower cumulative radiation in 2011 than in 2012 (Knight Piésold Ltd. 2013).

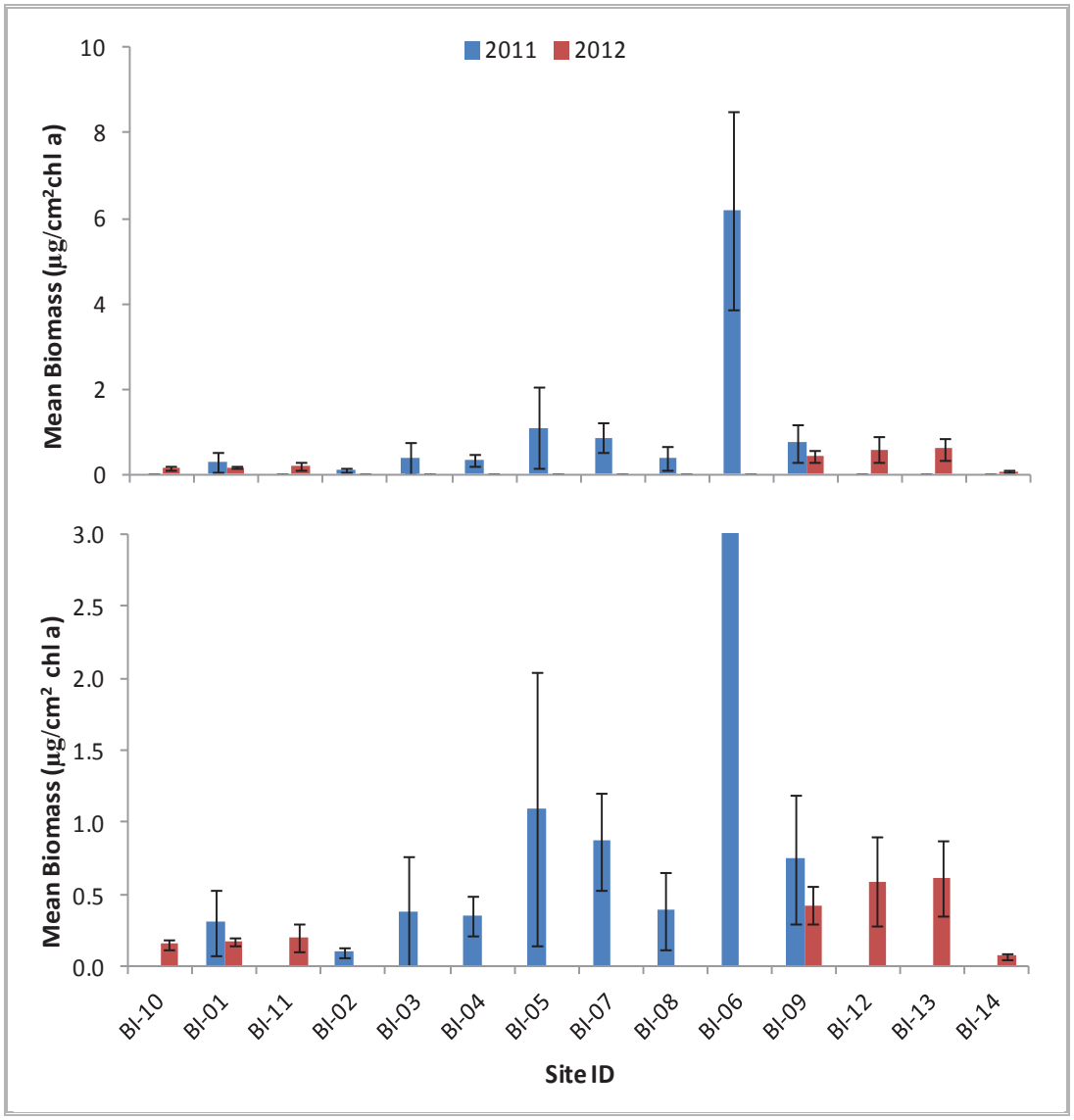
Mean periphyton biomass, as indexed by chlorophyll *a* concentration, also showed substantial among-site variation, but a different spatial distribution than mean density (**Figure 5.2-2**). (Note that **Figure 5.2-2** also has two panels in order to show detail at both the lower mean biomass range (lower panel) and the higher mean biomass range (upper panel).) Mean biomass ranged from a low of 0.10 µg/cm^2 (SE = 0.02) in upper Davidson Creek (BI-02) in 2011 to a high of 6.18 µg/cm^2 (SE = 1.25) in Chedakuz Creek (BI-06) in 2011. The Chedakuz Creek site was the only site that approached an exceedance of the BC guideline for the protection of aquatic life in streams (10 µg/cm^2; BC MOE 2007). This site is located adjacent to livestock pasture, and the high biomass probably reflects elevated nutrient loadings from land run-off.

Excluding the Chedakuz Creek site, the distribution of periphyton biomass among sites is similar to the distribution of density among sites. For example, mean biomass was highest at the Turtle Creek (BI-07) and upper Creek 661 (BI-05) sites. This correlation between biomass and density was expected – any variation from that correlation probably reflects differences in taxonomic composition caused by differences in physical characteristics of stream habitat.



Notes: cm^2 = centimetres squared; ID = identification; error bars are SE of the mean

Figure 5.2-1: Mean Periphyton Density at Stream Sites, LSA and RSA, 2011 and 2012



Notes: µg = microgram; cm^2 = centimetres squared; ID = identification; error bars are SE of the mean

Figure 5.2-2: Mean Periphyton Biomass at Stream Sites, LSA and RSA, 2011 and 2012

5.2.2 Taxonomic Composition

In both 2011 and 2012, periphyton communities were dominated by diatoms and cyanobacteria (**Table 5.2-1**). Diatoms were the dominant taxa at 10 of the 14 sites and cyanobacteria at the other four sites. The highest proportion of diatoms was measured at the two sites with the highest density in 2012: middle Davidson Creek (BI-11) and Turtle Creek (BI-07). Those two communities were dominated by the cyanophyte species, *Leptolyngbya* sp. and *Nostoc commune*, respectively (**Annex 5.2-4**). These taxa are tolerant of environments with high nutrient concentrations.

Table 5.2-1: Mean Relative Abundance of Periphyton Phyla at Streams Sites, 2011 and 2012

Stream	Baseline Map Site ID	Diatoms (%)		Cyanobacteria (%)		Chlorophytes (%)		Other (%)		Phylum Richness	
		2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Davidson Creek near the Mouth	BI-10	n/a	85.0	n/a	12.3	n/a	2.7	n/a	0	n/a	3
Lower Davidson Creek	BI-01	61	97.7	16	2.3	20	0	2	0	6	2
Mid Davidson Creek	BI-11	n/a	98.6	n/a	0.8	n/a	0.6	n/a	0.1	n/a	4
Upper Davidson Creek	BI-02	42	n/a	56	n/a	2	n/a	0	n/a	4	n/a
Creek 704454	BI-03	43	n/a	30	n/a	25	n/a	2	n/a	4	n/a
Lower Creek 661	BI-04	56	n/a	34	n/a	9	n/a	2	n/a	4	n/a
Upper Creek 661	BI-05	26	n/a	72	n/a	2	n/a	1	n/a	3	n/a
Turtle Creek	BI-07	24	n/a	68	n/a	4	n/a	4	n/a	4	n/a
Creek 700	BI-08	52	n/a	47	n/a	0	n/a	0	n/a	3	n/a
Chedakuz Creek	BI-06	95	n/a	2	n/a	3	n/a	0	n/a	4	n/a
Lower Creek 705	BI-09	36	92.9	64	5.8	0	1.4	1	0	2	3
Upper Creek 705	BI-12	n/a	94.8	n/a	2.1	n/a	2.6	n/a	0.5	n/a	4
Fawnie Creek Tributary	BI-13	n/a	97.1	n/a	2.8	n/a	0.1	n/a	0	n/a	4
Blackwater River Tributary	BI-14	n/a	93.5	n/a	2.7	n/a	0.6	n/a	3.3	n/a	4

Notes: ID = identification; % = percent; n/a = not applicable; each value is the mean of five replicate samples

Green algae (chlorophytes) were relatively less abundant at most sites except in Creek 704454 (BI-03) and lower Davidson Creek (BI-01), where they comprised 25% and 20% of the total periphyton densities, respectively, in 2011. The “Other” category, which included rhodophytes, euglenozoans, non-diatom ochrophytes, chrysophtes, and cryptophytes, comprised less than 5% of the total density across all the stream sampling sites in both 2011 and 2012.

Overall, there was high variability in species composition and cell counts among replicates at each site (**Annex 5.2-4**).

Motile diatom species (i.e., species in the genera *Nitzschia, Navicula, Gyrosigma*, and *Surirella*) – which serve as indicators of siltation – were present in the periphyton samples collected from the LSA and RSA. They comprised less than 50% of the total diatoms at all stream sampling sites in 2011 (**Annex 5.2-4**). In 2011, lower Davidson Creek had the highest proportion of motile diatoms (48%), and lower Creek 661 had the lowest proportion (15%). However, in 2012 motile diatom species had a greater representation of the total diatoms within streams, ranging from 36% in lower Creek 705 (BI-09) to 85% near the mouth of Davidson Creek (BI-10). Motile diatoms were more than 50% of the total diatoms at Lower Davidson Creek (BI-01), upper Creek 705 (BI-12), and a Blackwater River Tributary (BI-14). These results indicate higher siltation in 2012 than in 2011.

5.2.3 Taxa Richness, Diversity, and Evenness Indices

Taxa richness (S) at the 14 stream sites sampled in 2011 and 2012 ranged from a low of 8 genera in the Blackwater River Tributary (BI-14) to a high of 18 genera in upper Creek 705 (BI-12) with a mean over all 16 values of 14 genera (SE = 1) (**Table 5.2-2**). Taxa richness at the two sites sampled in both years did not show any clear trends between years, decreasing from 16 to 12 genera at site BI-01 (lower Davidson Creek) and increasing from 11 to 17 genera at site BI-09 (lower Creek 705).

Table 5.2-2: Taxa Richness, Diversity, and Evenness Metrics for Periphyton Communities at Stream Sites, 2011 and 2012

Stream	Baseline Map Site ID	Taxa Richness (*S*)		Shannon-Weaver Index (*H'*)		Pielou's Evenness (*J*)	
		2011	2012	2011	2012	2011	2012
Davidson Creek near the Mouth	BI-10	-	16	-	1.8	-	0.38
Lower Davidson Creek	BI-01	16	12	2.0	1.5	0.49	0.45
Mid Davidson Creek	BI-11	-	17	-	1.8	-	0.39
Upper Davidson Creek	BI-02	14	-	1.6	-	0.40	-
Creek 704454	BI-03	16	-	2.0	-	0.47	-
Lower Creek 661	BI-04	10	-	1.5	-	0.44	-
Upper Creek 661	BI-05	13	-	1.3	-	0.32	-
Turtle Creek	BI-07	13	-	1.3	-	0.30	-
Creek 700	BI-08	12	-	1.8	-	0.51	-
Lower Chedakuz Creek	BI-06	14	-	2.1	-	0.62	-
Lower Creek 705	BI-09	11	17	1.7	2.0	0.56	0.45
Upper Creek 705	BI-12	-	18	-	2.1	-	0.47
Fawnie Creek Tributary	BI-13	-	17	-	2.0	-	0.45
Blackwater River Tributary	BI-14	-	8	-	1.2	-	0.57

Note: Dashes indicate no data available.

Diversity (i.e., *H'*) ranged from a low of 1.3 in Turtle Creek (BI-07) and upper Creek 661 (BI-05) to a high of 2.1 in lower Chedakuz Creek (BI-12) and upper Creek 705 with a mean over all 16 values of 1.7 (SE = 0.1) (**Table 5.2-2**). H' at the two sites sampled in both years did not show any clear trends between years, decreasing from 2.0 to 1.5 at site BI-01 (lower Davidson Creek) and increasing from 1.7 to 2.0 at site BI-09 (lower Creek 705).

Evenness (J) ranged from a low of 0.30 in Turtle Creek (BI-07) to a high of 0.81 in lower Chedakuz Creek (BI-12) with a mean over all 16 values of 0.45 (SE = 0.02). J decreased from 2011 to 2012 at both of the two sites sampled in both years, decreasing from 0.49 to 0.45 at site BI-01 (lower Davidson Creek) and from 0.56 to 0.45 at site BI-09 (lower Creek 705).

In summary, the two indices of diversity, S and H', were positively correlated ($r = 0.76$, $P<0.001$) among all sites and years, as expected. In contrast, J was not significantly ($P<0.05$) correlated with either index of diversity. The coefficient of variation (i.e., the ratio of standard deviation of the mean to the mean) was greatest for S (CV = 93%), followed by H' (CV = 75%) and J (CV = 70%), indicating that diversity varies more among sites than does evenness.

5.3 Stream Benthic Macroinvertebrate Communities

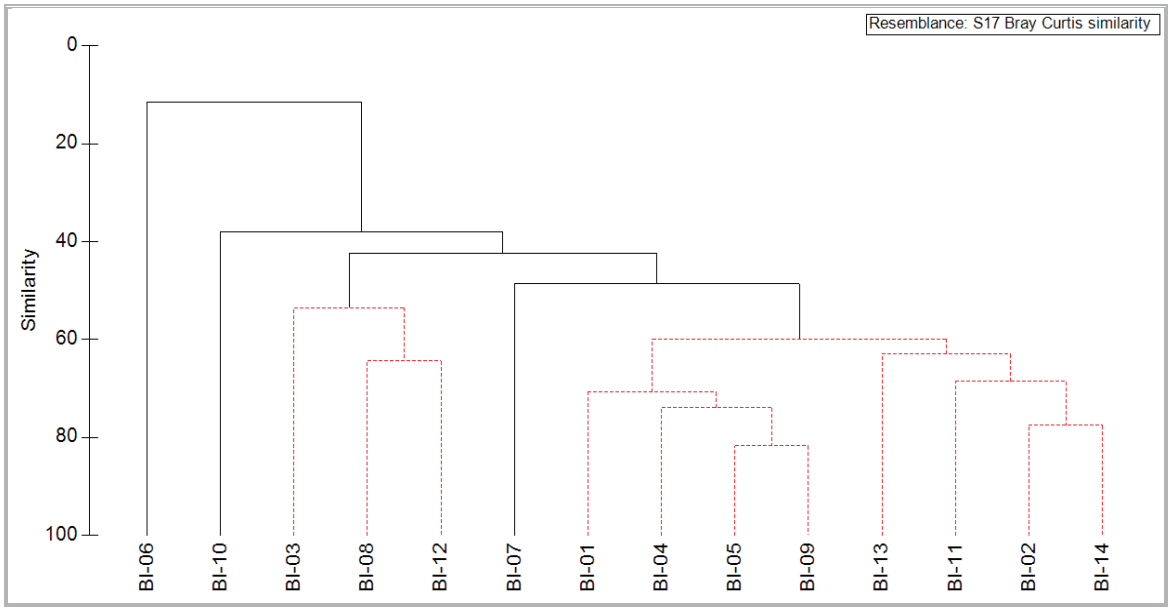
Annex 5.3-1 shows the density and taxonomy of BMI samples collected from stream sites in 2011 and 2012. **Annex 5.3-2** shows the mean abundance of BMI taxa among Project BMI groups (for SIMPER analysis). **Annex 5.3-3** shows the BMI metrics (e.g., total abundance, EPT individuals, taxa richness, EPT family richness, and the Shannon-Wiener diversity index) for sites in the LSA and RSA. **Annex 5.3-4** shows the results of the CABIN analysis.

5.3.1 BMI Community Characteristics

Based on Bray-Curtis indices, Project BMI communities in the LSA and RSA clustered into five significantly different groups (**Table 5.3-1**, **Figure 5.3-1**, and **Figure 5.3-2**). (Note that taxonomic data were averaged across all replicates and years.) Sites within groups did not differ statistically distinct from other group members, but groups of sites are statistically distinct. Of the five groups, only two represented multiple sites (Group A and B), and over half of all sites sampled in the LSA and RSA area are found in Group A (8 of 14).

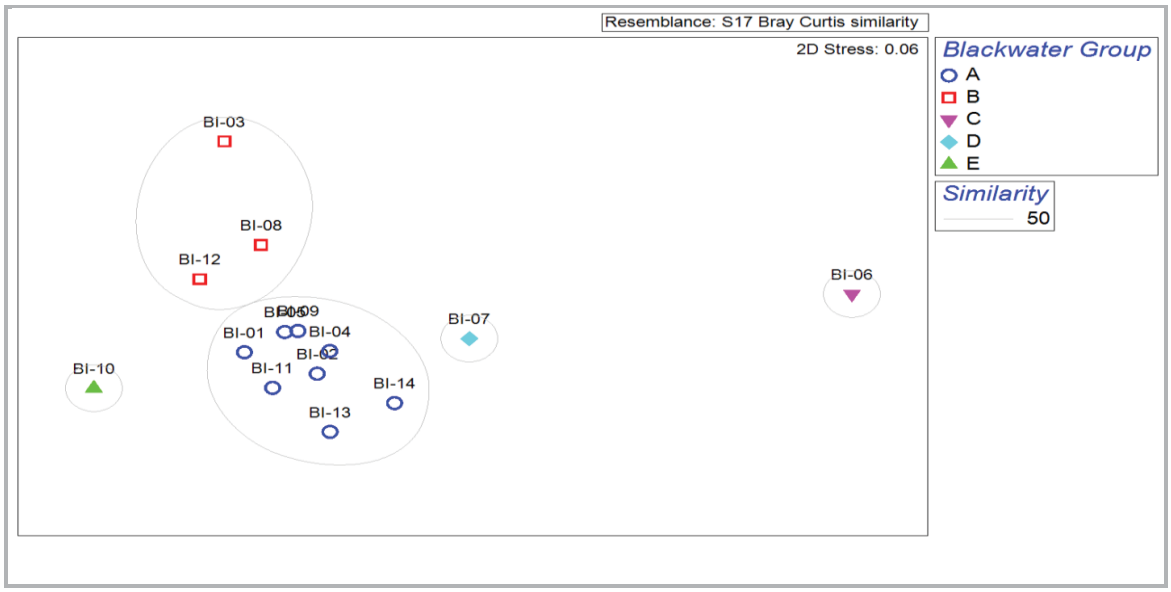
Table 5.3-1: Habitat Characteristics Associated with Project BMI Groups

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



Note: Sites joined via solid black lines are statistically distinct, while those joined directly by pink dotted lines are not. These groups are reflected in **Figure 5.3-2**.

Figure 5.3-1: Clustering of Project Sites According to BMI Communities



Note: Proximity of points in the ordination reflects BMI community similarity.

Figure 5.3-2: A MDS Ordination Representing Taxonomic Groupings of Project BMI Sites

Habitat conditions in Group A sites (n = 8) have relatively minimal anthropogenic impact, exist at moderate altitudes, and have moderate conductivity and larger substrate relative to other groups (**Table 5.3-2**). Group B sites (n = 3) are at high altitude, are small, and have low conductivity. Reflective of these low productivity habitat characteristics, Group B communities have low abundance of most common taxa, with the exceptions of Nemourids and Leptophlebiids. (**Annex 5.3-2** provides the results of the SIMPER analysis, which characterizes the key differences of each BMI group relative to Group A.)

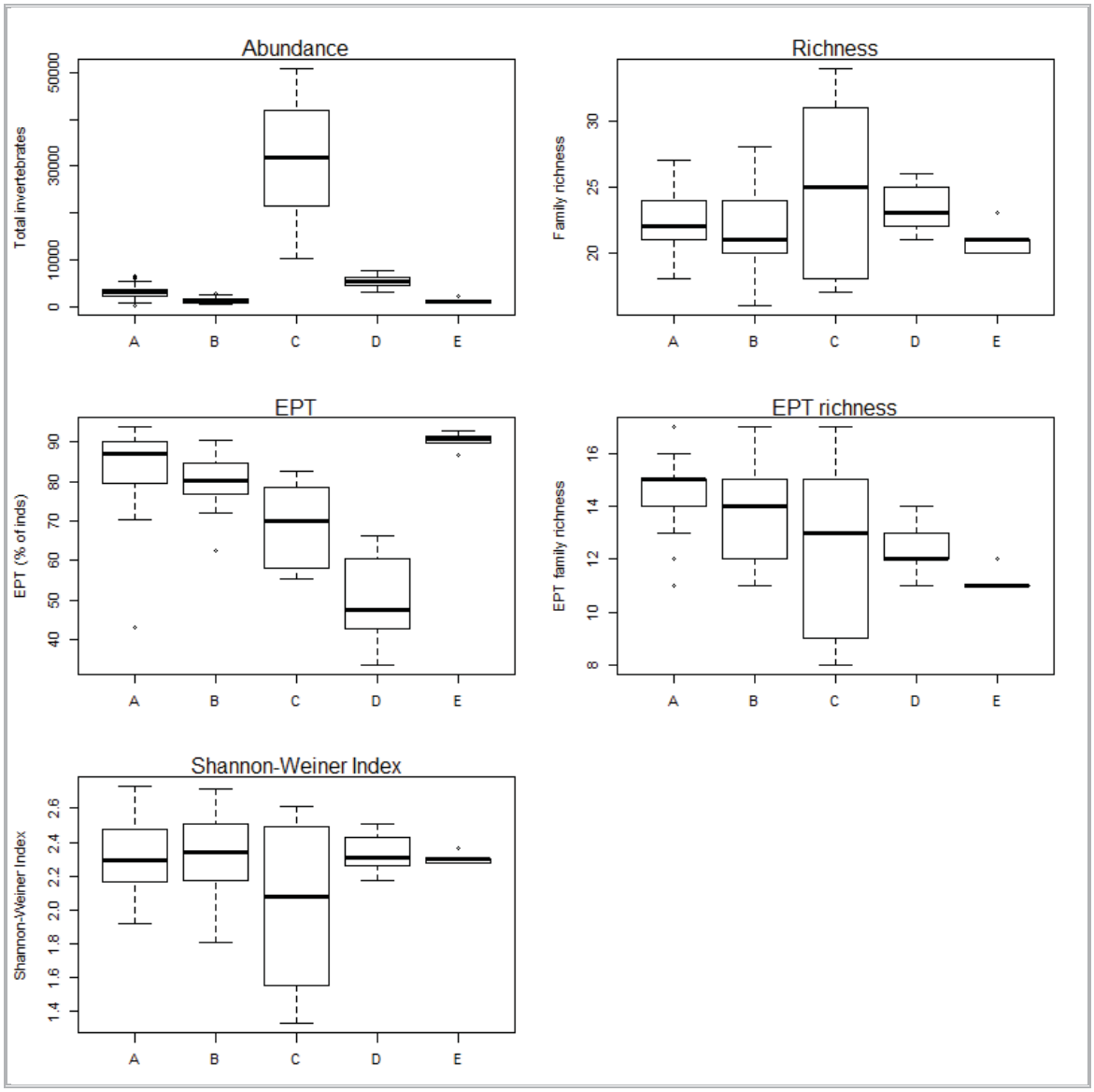
Table 5.3-2: Habitat Summary Statistics Associated with Each Project BMI Group

Model Group	Sample IDs	Statistic	Altitude	Stream Order	Substrate (%)							Dominant (Category 0-9)	Wolman D50 (median size) (cm)	Velocity		Wetted width (m)	Channel Depth - avg (cm)	Habitats - riffles (Binary)	General			Landcover			Periphyton coverage (Category(1-5))	Canopy - % coverage (PercentRange)
					Bedrock	Boulder	Cobble	Gravel	Pebble	Sand	Silt / Clay			Avg (m/s)	Max (m/s)				Dissolved oxygen (DO) (mg/L)	pH (pH)	Specific Conductance (@ 25 C) (uS/cm)	Ice (%)	Lake (%)	Wetland (%)		
A	BI-01, BI-02, BI-04, BI-05, BI-	Mean	3605	3	0	2	46	5	46	0	0	6	6.74	0.23	0.38	3.89	11.5	1	11.10	8.03	87	0	0	2	1	2
		Min	3389	2	0	0	0	0	20	0	0	4	2.80	0.05	0.21	2.10	0.2	1	9.71	7.20	45	0	0	1	1	1
		Max	3828	4	1	16	77	18	83	5	2	7	10.20	0.43	0.58	5.50	21.4	1	12.90	8.70	157	0	1	2	3	3
B	BI-03, BI-08, BI-12	Mean	4056	2	0	3	49	7	40	0	0	6	6.36	0.11	0.23	1.84	9.3	1	10.68	7.87	56	0	1	2	1	2
		Min	3550	2	0	0	26	1	23	0	0	5	4.30	0.05	0.09	0.70	7.6	1	9.91	6.84	21	0	0	1	1	1
		Max	4557	3	0	11	68	17	62	1	1	6	8.60	0.18	0.40	2.30	13.8	1	11.75	8.60	96	0	2	3	3	4
C	BI-06	Mean	3044	6	0	0	23	12	65	0	0	5	4.08	0.40	0.59	12.33	26.5	1	10.30	7.71	139	0	0	2	4	1
		Min	3044	6	0	0	18	5	63	0	0	5	3.35	0.33	0.57	10.55	15.4	1	10.28	7.61	137	0	0	2	4	0
		Max	3044	6	0	0	28	19	67	0	0	5	4.80	0.47	0.60	14.10	37.6	1	10.31	7.80	142	0	0	2	4	1
D	BI-07	Mean	3336	4	0	0	3	39	56	1	2	4	1.85	0.18	0.31	3.65	16.9	1	10.25	8.10	179	0	0	3	3	2
		Min	3336	4	0	0	2	35	55	0	0	3	1.75	0.14	0.20	3.50	15.1	1	9.97	7.80	176	0	0	3	2	1
		Max	3336	4	0	0	3	43	57	2	3	4	1.95	0.22	0.42	3.80	18.7	1	10.52	8.40	182	0	0	3	3	2
E	BI-10	Mean	3034	3	0	0	1	41	50	1	7	3	1.75	0.24	0.31	5.10	13.7	1	10.89	8.80	107	0	0	2	1	2
		Min	3034	3	0	0	1	41	50	1	7	3	1.75	0.24	0.31	5.10	13.7	1	10.89	8.80	107	0	0	2	1	2
		Max	3034	3	0	0	1	41	50	1	7	3	1.75	0.24	0.31	5.10	13.7	1	10.89	8.80	107	0	0	2	1	2

Both Group C and D sites (n = 1 in each) are characterized by high conductivity and periphyton coverage, but are distinguished from one another based on altitude and stream width, where Group C (BI-06, lower Chedakuz Creek) is larger and at a lower elevation than Group D (BI-07, Turtle Creek). Congruent with notably high levels of conductivity and periphyton, these sites are characterized by high invertebrate abundance, particularly Group C (**Figure 5.3-3**).

Both Group C and D have a lower percentage of pollution sensitive EPT taxa, suggestive of anthropogenic nutrient inputs (Barbour et al., 1999) (**Figure 5.3-3**). However, both sites maintain most of the pollution sensitive species (as defined for northwest US by Barbour et al., 1999) found at other Project sites including Ephemerellids, which were 60 times more abundant at lower Chedakuz Creek (Group C) than the Group A mean (**Annex 5.3-2**). The only pollution sensitive species that was present in most Project sites, but absent from lower Chedakuz Creek, was the Leuctricid stoneflies. Leuctricid stoneflies were also absent from BI-07 (Turtle Creek).

Lastly, Group E (n = 1) is most similar to Group A relative to other groups, but is differentiated in habitat by its relatively low altitude and small substrate. Similar to the low productivity sites in Group B, most taxa were at low abundance, except Ameletid mayflies, which occurred at higher levels than any other group. **Annex 5.3-3** shows site-specific values for BMI metrics.



Note: Solid horizontal bar is mean, box is 25% to 75% percentile, and dotted vertical line is range

Figure 5.3-3: Metric Comparisons of Project Benthic Invertebrate Site Groupings (A – E)

5.3.2 Environmental Drivers of BMI Communities

The subset of site variables that were best correlated with the variation observed in BMI communities included altitude, stream width, the amount of periphyton, and the importance of silt as a substrate. These four variables are well aligned with the habitat characterizations of the five significant BMI groupings observed in the LSDA and RSA (Spearman correlation coefficient score = 0.82).

5.3.3 Spatial and Temporal Variability of BMI Communities

BMI community structure at the two sites that were sampled in both 2011 and 2012 (sites BI-01 to BI-09) was significantly different between sites (PERMANOVA pseudo F = 27.3; P<0.001) and between years (PERMANOVA pseudo F = 26.3; P<0.001) (**Table 5.3-3**). However, a significant year x site interaction term indicated that not all sites had the same degree of interannual variation. Despite the significant interannual differences, the components of variation indicate that differences associated with site were six times greater those related to year of sampling, which in turn was more important than variability found between replicates within a site.

Table 5.3-3: PERMANOVA Assessment of Spatial and Temporal Variability of BMI Communities Sampled in 2011 and 2012 (BI-01 and BI-09)

Source	df	SS	MS	Pseudo-F	P(perm)	Estimates of Components of Variation
Site	8	117,520	14,689.00	27.3	0.0001	1,415.00
Year	1	10,458	10,458.00	26.3	0.0001	223.57
Replicate	36	19,405	539.04	1.4	0.0112	70.828
Site x Year	8	33,488	4,186.10	10.5	0.0001	757.73
Residual	36	14,306	397.38	-	-	397.38
Total	**89**	**195,170**	**-**	**-**	**-**	**-**

5.3.4 CABIN Assessment of Project BMI Communities

All but two BMI sites (BI-10 and BI-12) were classified to Group 2 based on the Skeena 2010 reference model. Group 2 is characterized by moderately productive sites with low intrusive bedrock and relatively low levels of precipitation. Both of the remaining sites were classified to Group 4, which are typically influenced by wetlands and lakes and characterized by relatively high productivity in their unimpacted state. The reference group assignment probability was strong for site BI-12. However, site BI-10 showed nearly equal probabilities of belonging to Group 2 and Group 4.

From the BEAST analysis, half of the sites had BMI communities similar to their assigned reference group for all their samples (**Figure 5.3-4**). (Note that assessments were done for each of five replicates collected at each site in each year of sampling, and that sites BI-10, BI-11, BI-12, BI-13, and BI-14 were only sampled in 2012.). Given the limited environmental effects associated with most sites, this result was not unexpected. Only two sites had no samples that were “similar to reference”: BI-06 (lower Chedakuz Creek) and BI-10 (lower Davidson Creek).

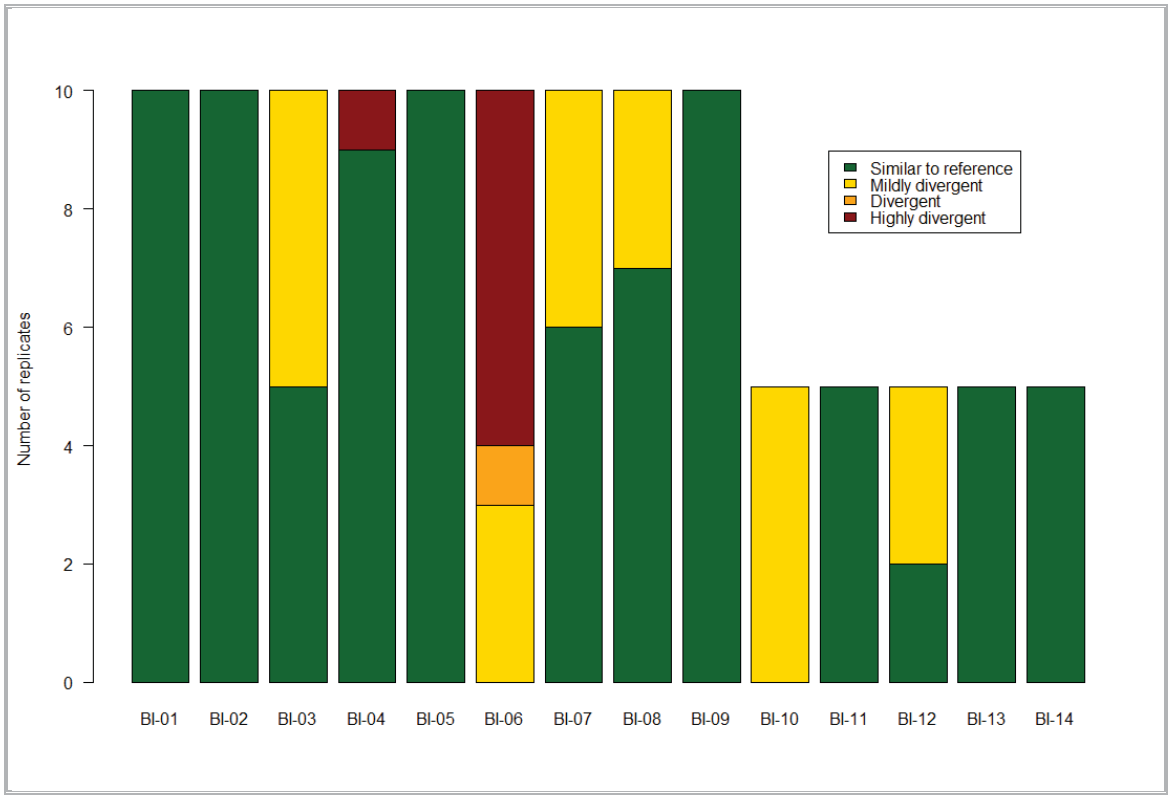


Figure 5.3-4: CABIN Reference Model Assessments (Skeena 2010) of BMI communities, 2011 and 2012

The BI-10 assessment (all sites mildly divergent from reference group) must be considered in the context that the site classification had poor confidence. In contrast, site BI-06 (lower Chedakuz Creek) had 60% of its samples that were 'Highly divergent' and was responsible for 87% of the "Highly divergent" samples in the LSA and RSA. These results support previous analyses presented above that suggest lower Chedakuz Creek BMI communities are currently stressed by anthropogenic activities such as ranching. **Annex 5.3-4** shows CABIN scores for each replicate.

The RIVPACS analysis was complimentary to the BEAST analysis and was based exclusively on the taxa present in reference and Blackwater BMI communities. The results were similar to the BEAST analysis in that only four of ten samples from lower Chedakuz Creek (BI-06) showed signs of current impairment (**Figure 5.3-5**). One sample from Creek 704454 (BI-03) also crossed the guidelines for impairment. No other sample crossed the guidelines for impairment.

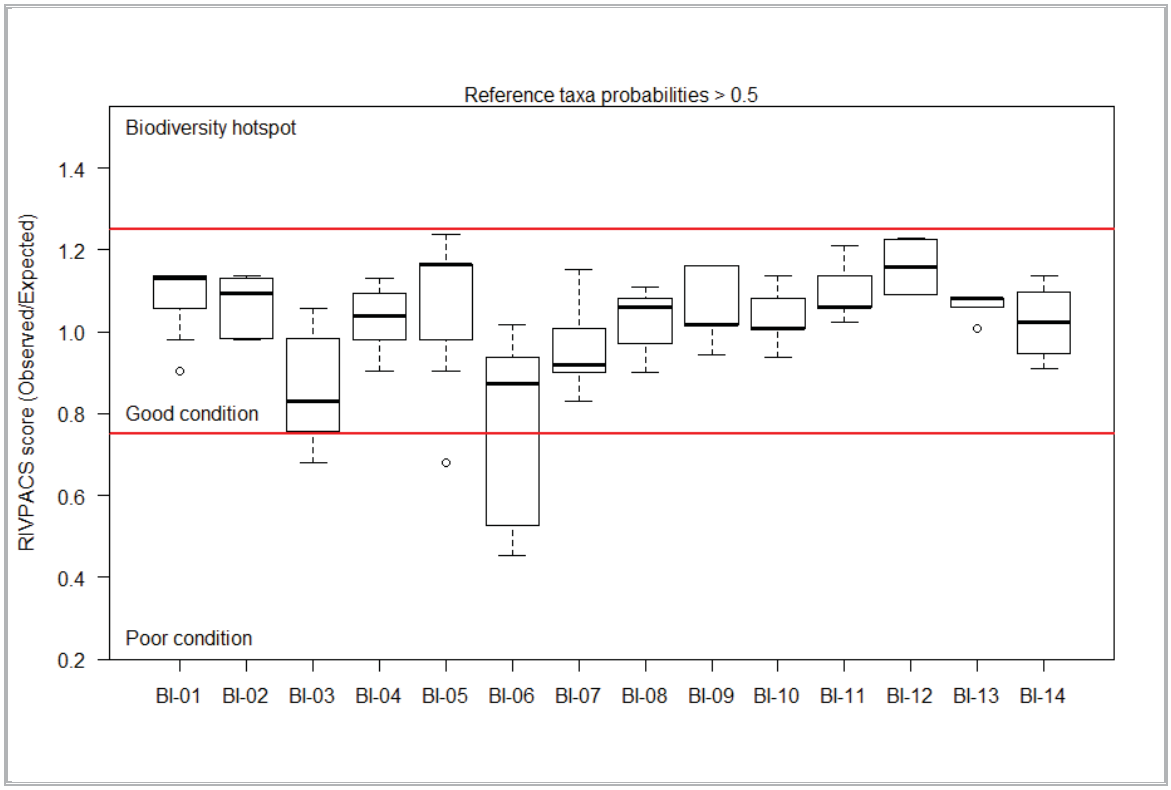


Figure 5.3-5: RIVPACS Analysis of BMI Communities using the Skeena 2010 Reference Model

The red lines in **Figure 5.3-5** represent the normal limits of healthy systems (Hargett et al., 2005; Feldman, 2006; de Zwart et al., 2006; Hubler, 2008). Mid-quartiles are represented by the box, while the whiskers represent the data falling within 1.5 times the interquartile range. Bolded lines within each box represent the median value for a site. Assessments were done for each of five replicates collected at each site in each year of sampling. Sites BI-10, BI-11, BI-12, BI-13, and BI-14 were only sampled in 2012.

To guide future investigations, BMI communities were plotted against both Skeena 2010 Group 2 and the Fraser 2005 Group 5 reference communities and compared statistically using a PERMANOVA test. BMI communities were largely mutually exclusive of Fraser Group 5 communities. However, they showed considerable overlap with Skeena Group 2 (**Figure 5.3-6**).

The differences between Blackwater sites and Fraser Group 5 were at least partially attributable to higher invertebrate abundance of most taxa at Blackwater sites. PERMANOVA analysis indicated that there were significant differences between Blackwater sites and both reference groups, though the strength of the differences was considerably smaller between the Skeena 2010 Group 2 and the Blackwater sites than between the Fraser 2005 Group 5 and the Blackwater sites (Skeena: $t = 1.66$, $P = 0.005$; Fraser: $t = 4.47$, $P<0.001$).

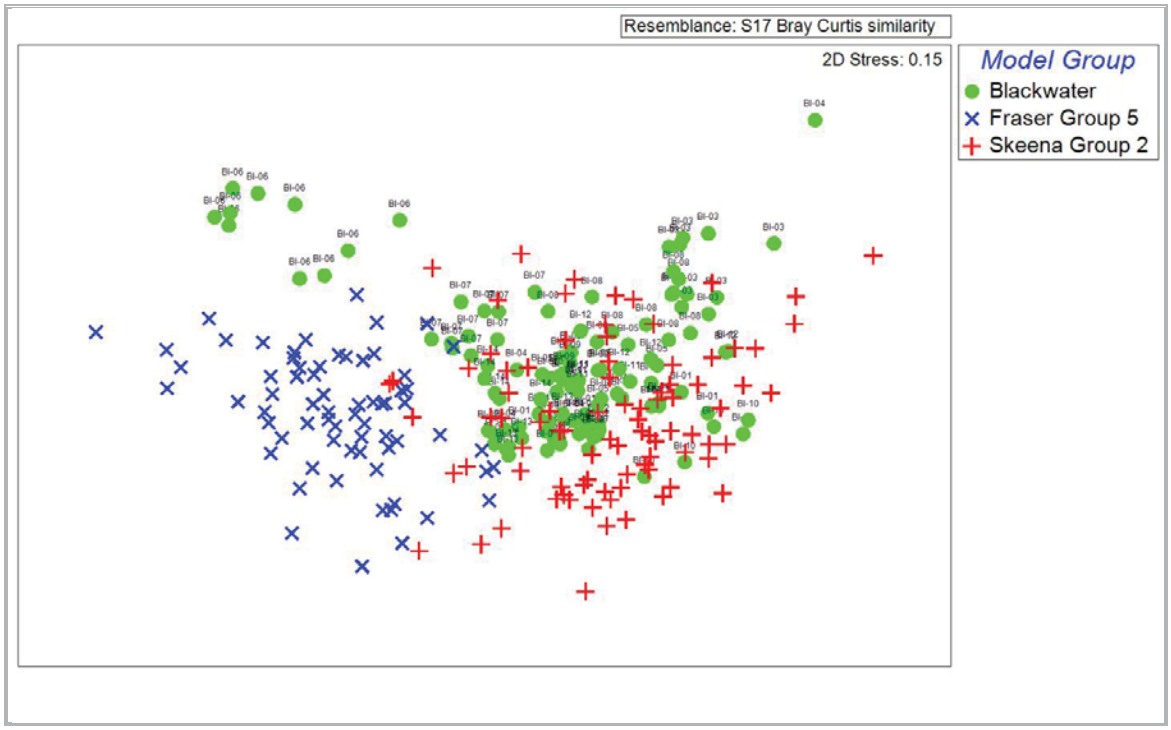


Figure 5.3-6: An MDS Ordination Comparing Project BMI Communities to those of the Skeena and Fraser Reference Condition Models

As potentially impacted sites were not removed from the Blackwater dataset for this analysis, it is possible that the observed differences between Skeena 2005 Group 2 and the Blackwater sites were at least partially driven by anthropogenic impacted sites (e.g., lower Chedakuz Creek or BI-06), which would be expected to differ from reference. Furthermore, assuming that most Project sites are indeed comparable to reference conditions, the methodological differences associated with the Skeena reference model collections did not appear to cause large disparities in the measured community structure.

5.3.5 Monitoring Considerations Going Forward

Over half of the Blackwater BMI communities are of similar character (Group A) and will thus be useful for determination of potential Project effects going forward. Sites immediately downstream of the proposed mine (e.g., Davidson Creek sites BI-01, BI-02, and BI-11), as well as those expected to experience altered hydrology (e.g., Creek 661 sites BI-04 and BI-05), are contained within this group. The availability of comparable control sites within this group beyond the LSA (i.e., BI-13 and BI-14) will permit Before-After, Control-Impact (BACI) comparisons that can be used to account for significant interannual differences that may be observed in Blackwater sites during this study.

Unfortunately, some Blackwater sites are statistically unique in terms of their BMI communities (BI-06 lower Chedakuz, BI-07 Lower Turtle, and BI-10 Davidson Creek at

mouth). While inferences of environmental effects can still be obtained from comparisons of temporal change with other sites, there will remain some doubt related to whether the response of the BMI communities at these sites is reflective of their unique site characteristics rather than the presence or absence of a stressor.

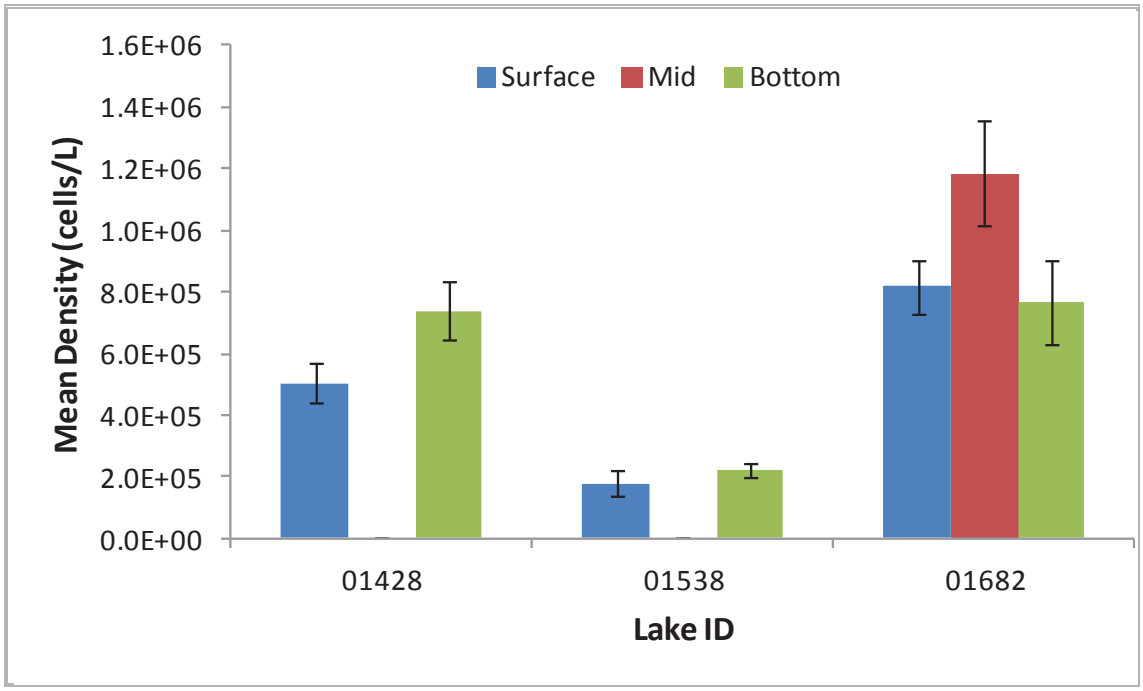
CABIN reference condition assessments are an alternate method of monitoring going forward. Existing CABIN models (Skeena 2010 and Fraser 2005) both have limitations in terms of their suitability for the Project BMI sites, based on the time of collections (Fraser 2005) or the laboratory sorting methods (Skeena 2010). The concordance of the Blackwater BMI communities with the Skeena 2010 reference condition suggest that this model can be useful for measuring qualitative changes in community integrity going forward. Furthermore, updated models currently under development may provide improved alternatives. Nonetheless, where possible, these analyses should augment and not replace BACI style analyses, as the latter will be specific to the LSA and RSA and will benefit from improved statistical power.

5.4 Phytoplankton

Annex 5.4-1 shows photographs of each lake sampling site. **Annex 5.4-2** shows the biomass (i.e., chlorophyll a concentrations) of each sample, and **Annex 5.4-3** shows the density and taxonomy of samples. **Annex 5.4-4** shows similarity metrics calculated for the phytoplankton communities. Lake habitat data are shown in **Section 5.9**.

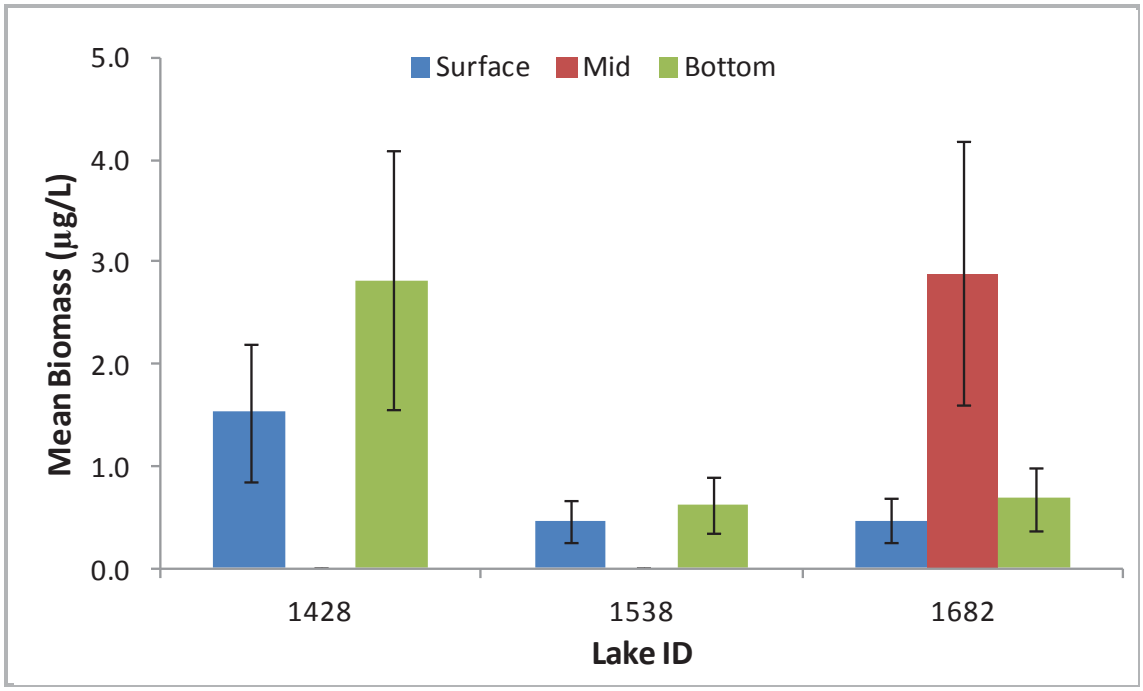
Mean phytoplankton cell density and biomass were highest in Lake 01682LNRS and lowest in Lake 01538UEUT (**Figure 5.4-1** and **Figure 5.4-2**). This rank order did not follow the rank order of transparency, as indicated by Secchi depth. Lake 01682LNRS had the deepest Secchi depth (5.6 m) and greatest transparency, and Lake 01428UEUT had the lowest Secchi depth (mean = 3.5 m) and lowest transparency. Lake 01538UEUT had an intermediate Secchi depth (4.8 m).

With one exception, mean densities and biomasses were similar among depths in each lake. (Note the error bars of the means are SE and that most of them within a lake overlap each other.) The exception was the mid-depth samples taken from below the thermocline of Lake 01682LNRS. Those had higher density and biomass than surface and bottom samples, indicating that nutrients were concentrated immediately below the thermocline resulting in elevated phytoplankton density and biomass.



Notes: Mid = sample taken at bottom of thermocline; L = litres; ID = identification; error bars are SE of the mean

Figure 5.4-1: Phytoplankton Density at Headwater Lake Sites, 2012



Notes: Mid = sample taken at bottom of thermocline; mg/L = milligram per Litre; ID = identification; error bars are SE of the mean

Figure 5.4-2: Phytoplankton Biomass at Headwater Lake Sites, 2012

Chrysophytes (i.e., golden algae and diatoms) were the predominant major taxa in Lakes 01428UEUT and 01538UEUT and in the surface and deep samples from Lake 01682LNRS (**Table 5.4-1**). However, Cryptophytes were the predominant major taxa below the thermocline of Lake 01628LNRS. *Cryptomonas marssonii* was the single most abundant species of algae within all samples (**Annex 5.4.4**). Green algae (Chlorophyta) were present in all lakes, but never made up more than 29% of total community density (**Table 5.4-1**). This taxon is a preferred food for higher aquatic organisms, and grazing may be one reason for its lack of numerical dominance. Blue-green algae (cyanobacteria) were not abundant in any of the samples, and dinoflagellates and euglenoids were uncommon to absent (**Table 5.4-1**). Blue-green algae and dinoflagellates typically dominate the algal community in poor water quality environments. The relative paucity of these taxa from the samples collected in 2012 indicates that these lakes have good water quality. This conclusion was confirmed by the results of water quality sampling program – all nutrient concentrations were below guidelines for BC waters (AMEC 2013a).

Table 5.4-1: Mean Density and Relative Abundance of Major Phytoplankton Taxa in Lakes 01428UEUT, 01538UEUT, and 01682UEUT, 2012

	01428UEUT [1]				01538UEUT [2]				01682LNRS [3]					
	Surface		Bottom		Surface		Bottom		Surface		Mid		Bottom	
Taxa	Density (cells/L)	(%)	Density (cells/L)	(%)	Density (cells/L)	(%)	Density (cells/L)	(%)	Density (cells/L)	(%)	Density (cells/L)	(%)	Density (cells/L)	(%)
Chlorophyta	77,784	15.4	98,202	13.3	48,724	27.2	65,341	29.3	216,105	26.4	56,881	4.8	150,232	19.6
Chrysophyta[4]	216,832	42.9	345,185	46.6	86,117	48.2	102,681	46.1	268,617	32.8	274,695	23.2	310,675	40.6
Cryptophyta	107,935	21.3	149,746	20.2	32,679	18.3	38,506	17.3	165,549	20.2	634,970	53.6	39,380	5.1
Cyanobacteria	93,345	18.5	143,909	19.4	10,260	5.7	15,168	6.8	166,277	20.3	49,589	4.2	252,333	33.0
Dinoflagellates	6,806	1.3	972	0.1	1,069	0.6	583	0.3	1,945	0.2	0	0.0	0	0.0
Euglenophyta	2,917	0.6	1,944	0.3	0	0.0	583	0.3	0	0.0	168,710	14.2	13,127	1.7

Notes: [1] surface samples taken from 1 m depth; bottom samples taken from 4.5 m depth
[2] surface samples taken from 1 m depth; bottom samples taken from 8.5 m depth
[3] surface samples taken from 1 m depth; mid samples taken from 10.5 m; bottom samples taken from 13 m
[4] including diatoms

Genus richness (S) ranged from a low of 16 genera in the bottom of Lake 01682LNRS to a high of 36 in the bottom of Lake 01428UEUT (**Table 5.4-2**). In both Lakes 0142UEUT and 01538UEUT, mean S was higher at the bottom than at the surface, but the trend was reversed in Lake 01682LNRS. Diversity (H') followed the same rank order as S, but evenness (J) did not follow the same rank order as index of diversity.

Table 5.4-2: Mean Diversity and Evenness of Phytoplankton Communities in Headwater Lakes, 2012

Sampling Site	Genus Richness (S)		Shannon's Diversity (*H'*)		Evenness (*J*)	
	Mean	SE	Mean	SE	Mean	SE
Lake 01428UEUT Surface	29	3	2.9	0.03	0.62	0.01
Lake 01428UEUT Bottom	36	3	2.9	0.04	0.50	0.01
Lake 01538UEUT Surface	26	3	2.8	0.05	0.66	0.01
Lake 01538UEUT Bottom	28	2	2.9	0.03	0.68	0.01
Lake 01682LNRS Surface	27	2	2.6	0.03	0.45	0.01
Lake 01682LNRS Middle	24	1	2.4	0.04	0.49	0.01
Lake 01682LNRS Bottom	16	2	2.1	0.05	0.53	0.03

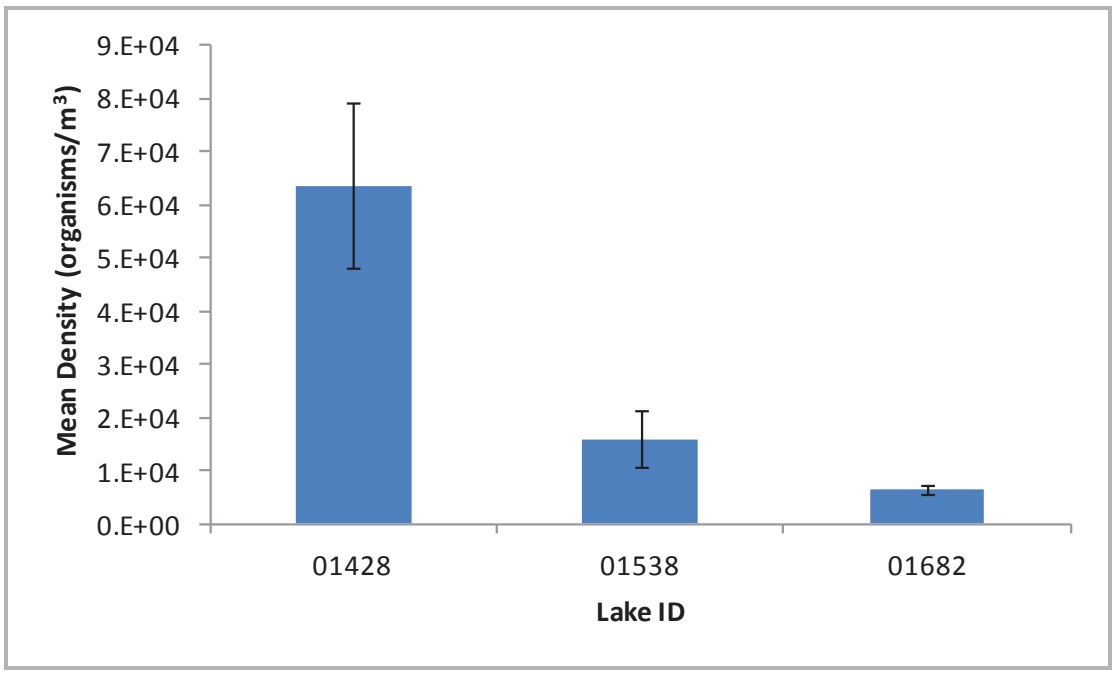
Notes: SE = standard error

5.5 Zooplankton

Annex 5.5-1 shows the density and taxonomy of zooplankton samples, and **Annex 5.5-2** shows metrics calculated for the zooplankton communities. Lake habitat data are shown in **Section 5.9**.

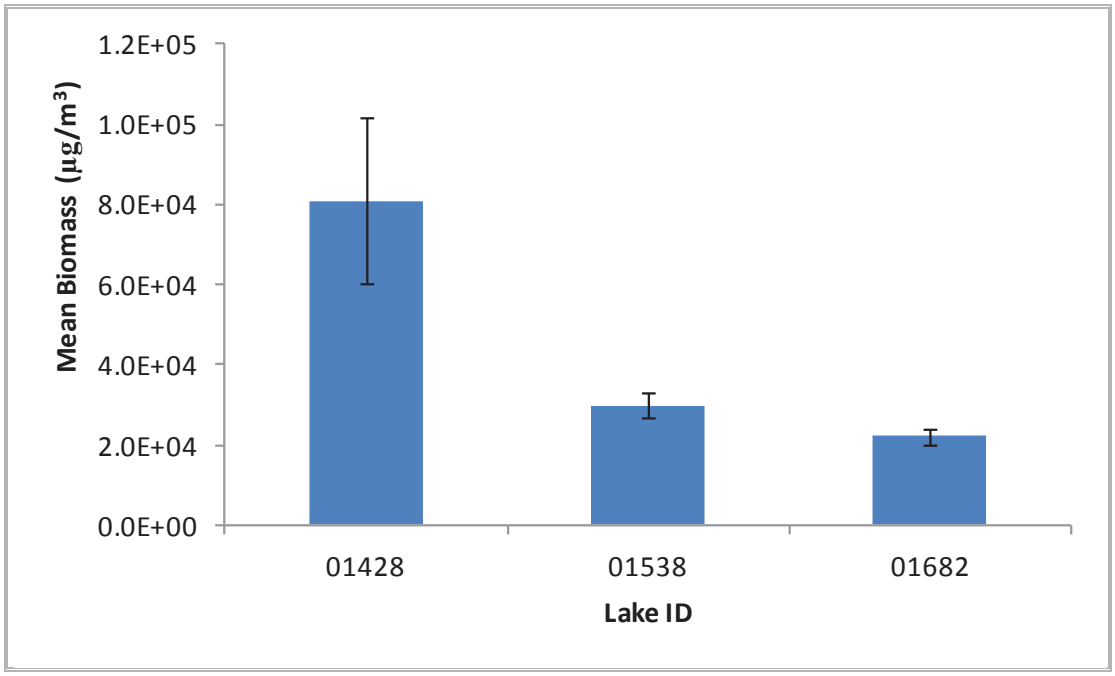
Mean zooplankton density and biomass were highest in Lake 01428UEUT and lowest in Lake 01682LNRS (**Figure 5.5-1** and **Figure 5.5-2**). Lake 01428UEUT is the shallowest lake (maximum = 7.6 m, mean = 3.1 m) and Lake 01682LNRS is the deepest lake (maximum = 16.3, mean = 5.5) (**Table 5.9-1**). Lake 01428UEUT also has the highest percent of littoral zone habitat (97%) compared to Lake 01682LNRS (62%) and Lake 01538UEUT (52%).

Perhaps most important, Lake 01428UEUT has the lowest Secchi depth (mean = 3.5 m), compared to Lake 01538UEUT (4.8 m) and Lake 01682LNRS (5.6 m) (**Table 5.9-2**). This suggests that zooplankton abundance in these headwater lakes is driven by lake morphometry, with shallow, turbid lakes composed mainly of littoral zone producing the most dense populations of zooplankton and deep, clear lakes with lower percent littoral zone producing less dense populations.



Notes: m^3 - cubic meter; ID – identification; error bars are SE of the mean

Figure 5.5-1: Zooplankton Density from Headwater Lakes, 2012



Notes: $\mu g/m^3$ = microgram per cubic meter; ID = identification; error bars are SE of the mean

Figure 5.5-2: Zooplankton Biomass from Headwater Lakes, 2012

Rotifers were the predominant zooplankton taxon by density in all three lakes (**Table 5.5-1**). In Lake 01428UEUT, the main rotifer species was *Keratella cochlearis*. In Lake 01682LNRS, the dominant rotifer species was *Kellicottia longispina*. Copepods were the second most common taxon, being predominant in Lake 01682LNRS and second-ranked in Lake 01428UEUT, and third-ranked in Lake 01538UEUT. Ciliophors were the third most common group, being second ranked in Lake 01538UEUT. Cladocerans were the least common taxon in the lakes, only making up between 1% and 9% of the communities by density.

Table 5.5-1: Mean Density and Relative Abundance of Major Zooplankton Taxonomic Groups in Headwater Lakes, 2011

Taxonomic Group	Lake 01428UEUT		Lake 01538UEUT		Lake 01682LNRS	
	Density (org./m^3)	(%)	Density (org./m^3)	(%)	Density (org./m^3)	(%)
Rotifers	14,053	88.24	2,600	74.49	579	47.58
Copepods	358	2.25	617	14.59	666	42.13
Cladocerans	188	0.95	334	5.82	157	8.94
Ciliophors	200	8.56	1,363	5.09	142	1.00

Note: m^3 = cubic metre

Zooplankton species richness (S) ranged from 9 to 16 taxa and mean richness was similar among lakes (**Table 5.5-2**). As with S, H' was highest for Lake 01682LNRS and lowest for Lake 01428UEUT. Evenness (J) was correlated with both indices of diversity. Evenness followed the same trend as diversity.

Table 5.5-2: Richness, Diversity and Evenness of Zooplankton Communities in Headwater Lakes, 2012

Lake	Richness (*S*)		Shannon's Diversity (*H'*)		Evenness (J)	
	Mean	Range	Mean	SE	Mean	SE
01428UEUT	12	9 – 16	1.2	0.1	0.28	0.02
01538UEUT	12	10 – 14	1.5	0.1	0.41	0.03
01682LNRS	13	11 – 15	1.9	0.1	0.51	0.05

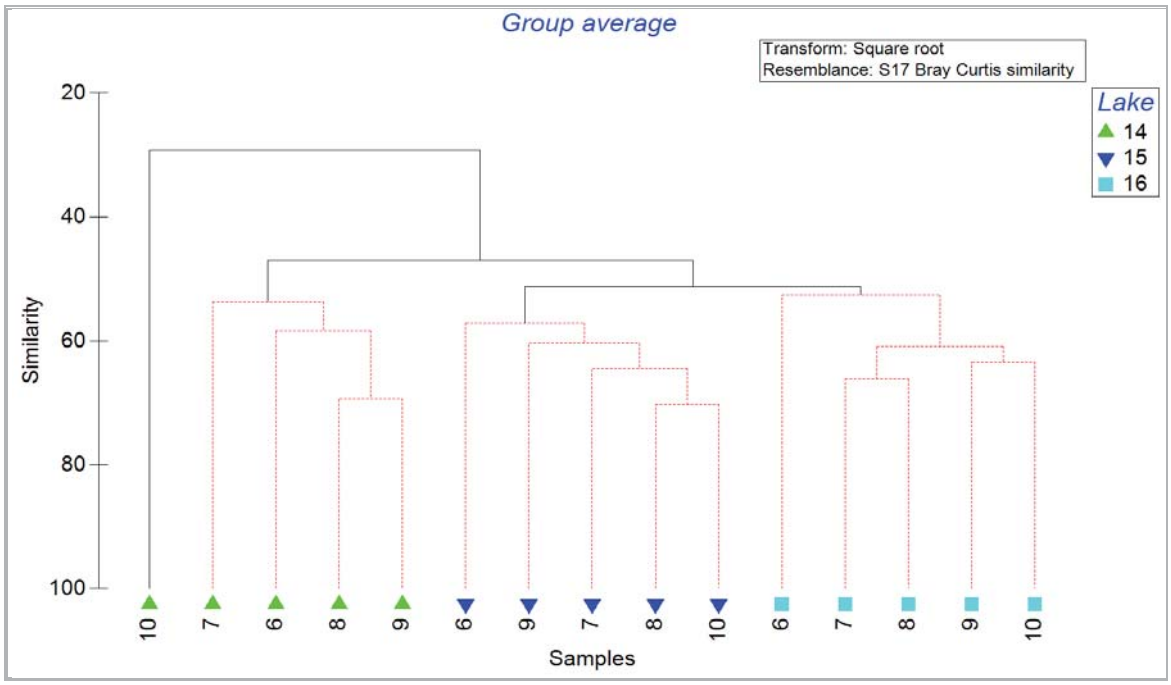
Notes: SE = standard error

5.6 Lake Benthic Macroinvertebrates

Annex 5.6-1 shows the density and taxonomy of lake BMI samples (both littoral and profundal), and **Annex 5.6-2** shows metrics calculated for the BMI samples. Lake habitat data are shown in **Section 5.9**.

5.6.1 Littoral Habitats

Littoral BMI community structure was best correlated with differences associated with Secchi depth (Spearman's Rho = 0.506; P = 0.002) – a similar finding to that of lake zooplankton (**Section 5.5**). BMI communities in the littoral zones of the three lakes differed significantly (ANOSIM Rho = 0.672, P<-0.001; Rho>0.64, P = 0.008) for all pairwise comparisons and individual replicates within lakes grouped together (**Figure 5.6-1** and **Figure 5.6-2**).

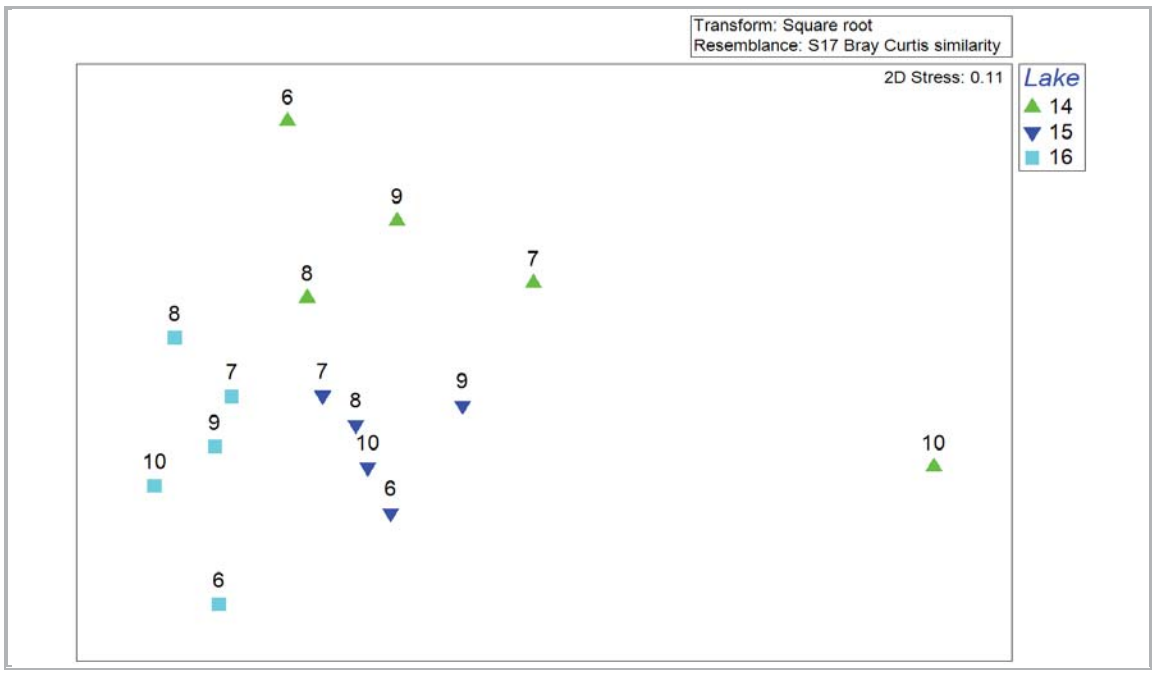


Notes: Samples joined by solid black lines indicate samples with statistically significant differences. Those joined directly by dashed pink lines indicate non-significant differences. Sample labels correspond to labels in **Figure 5.6-2**.
Lake 14 = Lake 01428UEUT, Lake 15 = 01538UEUT, and Lake 16 = Lake 01682LNRS.

Figure 5.6-1: Cluster Analysis of Littoral BMI Communities of Headwater Lakes

The only exception to this pattern was sample number 10 in Lake 01682LNRS, which did not group with any other sample. Despite the strength of statistical differences, littoral BMI communities of all lakes were dominated by Paraleptophlebeid mayflies and Sphaerid (fingernail) clams and shared many taxa (**Annex 5.6-1**).

Lower water clarity in Lake 01428UEUT indicates higher productivity and this was reflected in the lake's relatively abundant and rich littoral BMI community (same as it was for its rich and abundant zooplankton community). This lake also had the highest proportion of EPT individuals and lowest percentage of Chironomids relative to other lakes (**Annex 5.6-1** and **Figure 5.6-3**).



Notes: Proximity between points indicates community similarity among samples. Sample labels correspond to labels in **Figure 5.6-1**.
Lake 14 = Lake 01428UEUT, Lake 15 = 01538UEUT, and Lake 16 = Lake 01682LNRS.

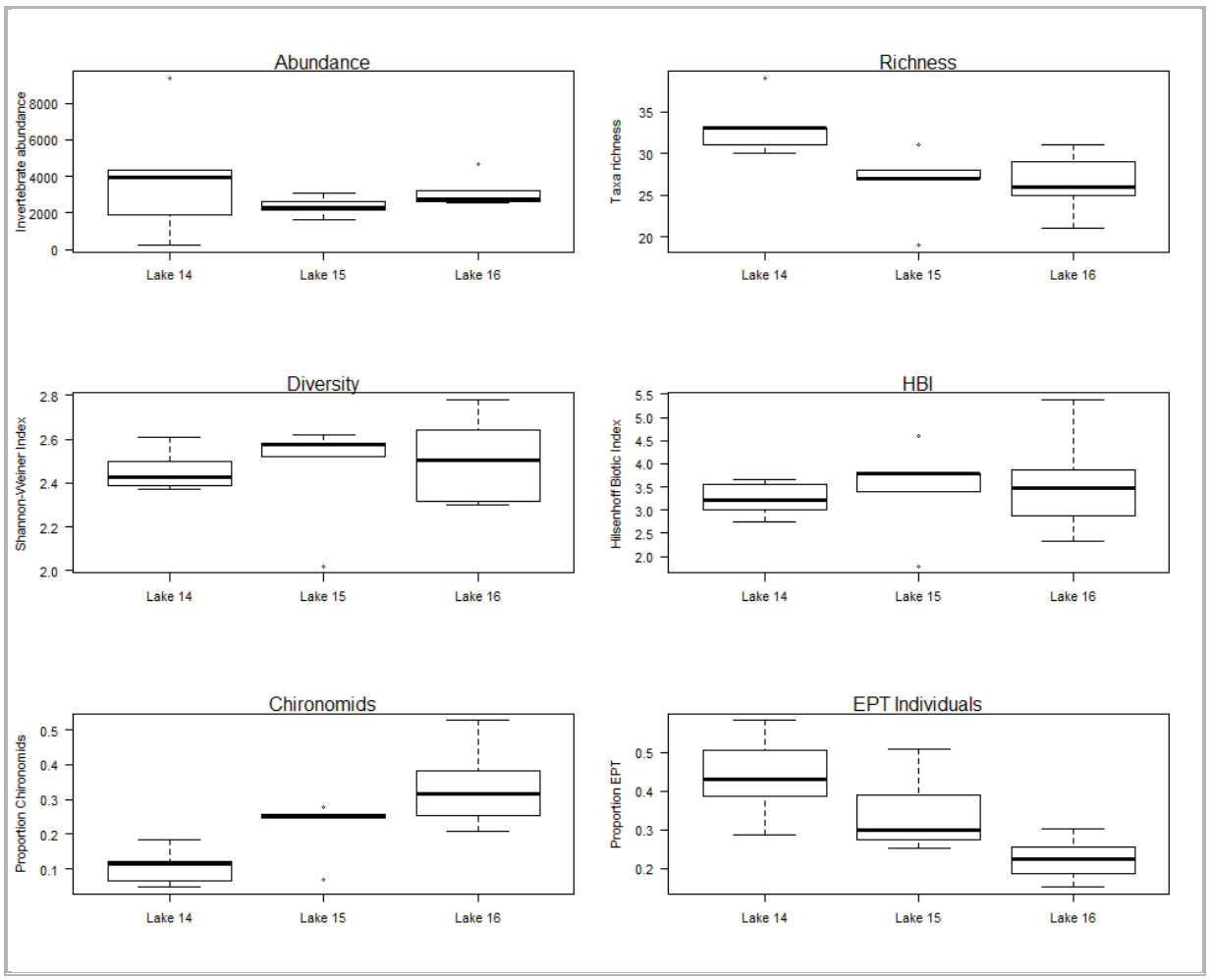
Figure 5.6-2: MDS Ordination of Littoral BMI Communities in Headwater Lakes

Median HBI scores of less than for indicated that littoral zones BMI communities in all three lakes were dominated by taxa that are intolerant to nutrient pollution and suggest 'very good' to 'excellent' water quality according to the Hilsenhoff Biotic Index (Mandaville 2002).

5.6.2 Profundal Habitats

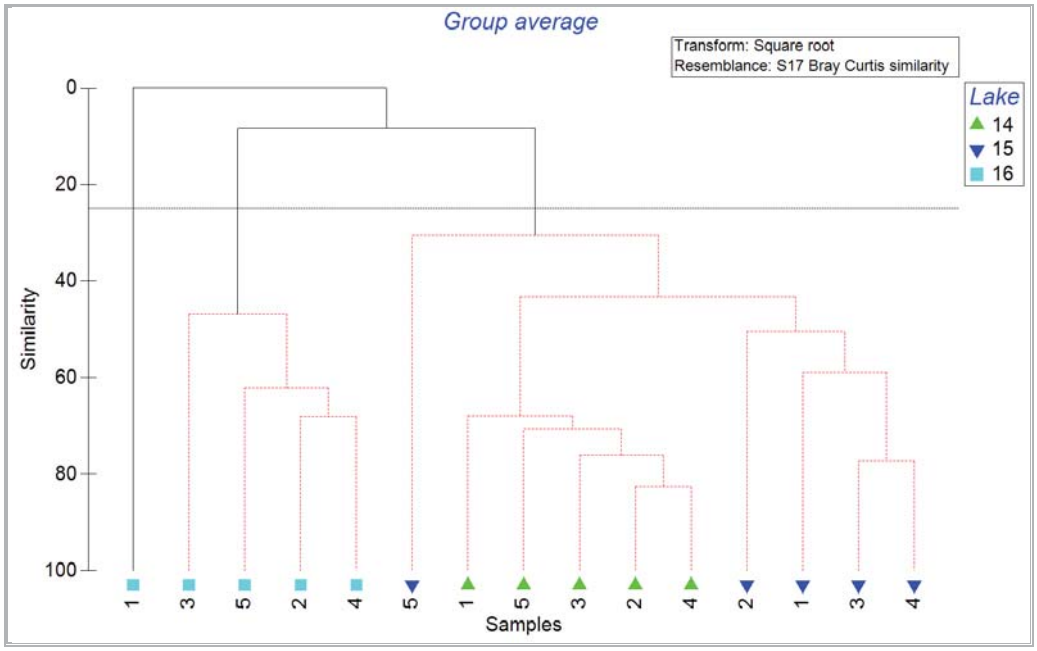
Variation in profundal BMI communities was strongly correlated with conductivity and DO concentration (Spearman's Rho = 0.845, P<0.001). Lake 01682NLRS had highest levels of conductivity and the lowest DO concentrations (most likely because of its greater depth). Profundal zones of lakes 01428UEUT and 01538UEUT were more similar in terms of these variables when compared to Lake 0628LNRS.

Like the littoral BMI communities, profundal BMIs differed significantly among lakes (ANOSIM Rho = 0.574, P<0.001; pairwise comparisons: all Rho>0.536, P = 0.008) (**Figure 5.6-4** and **Figure 5.6-5**). All Lake 01682NLRS replicates were significantly different from those of the other two lakes, while replicates of lakes 01428UEUT and 01538UEUT did not significantly differ from one another (**Figure 5.6-4**), despite grouping separately in the MDS plots (**Figure 5.6-5**). Of the three lakes, only Lake 01682LNRS exhibited anoxic conditions during the time of sampling. However, the high HBI scores of all three lakes (ratings of 'fairly poor' to 'poor' water quality; Mandaville 2002) indicate that anoxic conditions may also occur periodically in the other two lakes.



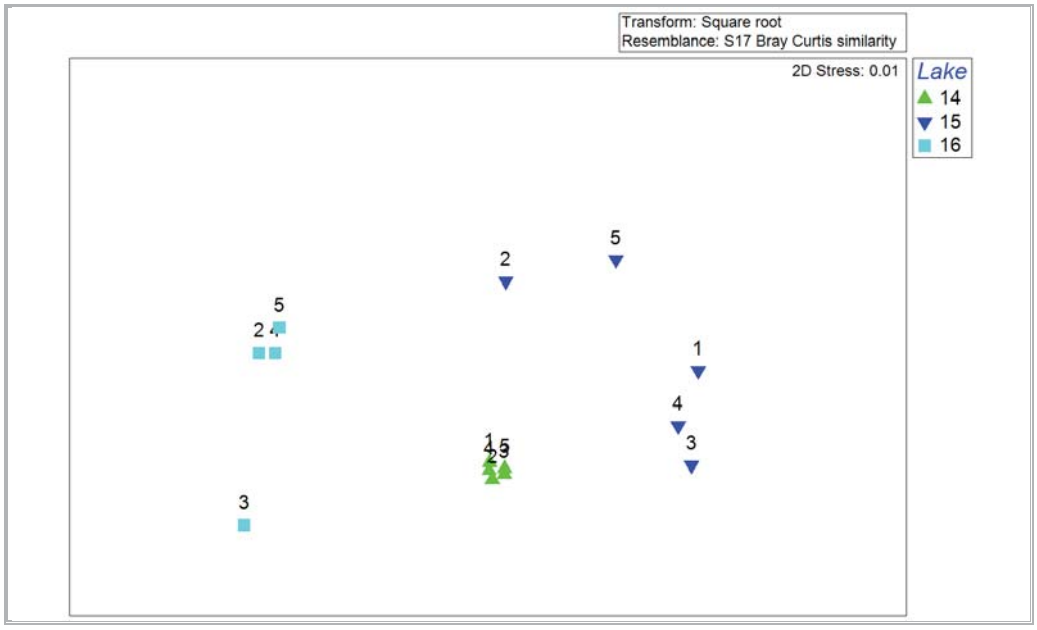
Notes: Mid-quartiles are represented by the box, while the whiskers represent the data falling within 1.5 times the interquartile range. Bolded lines within each box represent the median value for a site.
Lake 14 = Lake 01428UEUT, Lake 15 = 01538UEUT, and Lake 16 = Lake 01682LNRS.

Figure 5.6-3: Metrics of Littoral BMI Communities from Headwater Lakes, 2012



Notes: Samples joined by solid black lines indicate samples with statistically significant differences. Those joined directly by dashed pink lines indicate non-significant differences. Sample labels correspond to labels in **Figure 5.6-4**.
Lake 14 = Lake 01428UEUT, Lake 15 = 01538UEUT, and Lake 16 = Lake 01682LNRS.

Figure 5.6-4: Cluster Analysis of Profundal BMI Communities of Headwater Lakes, 2012



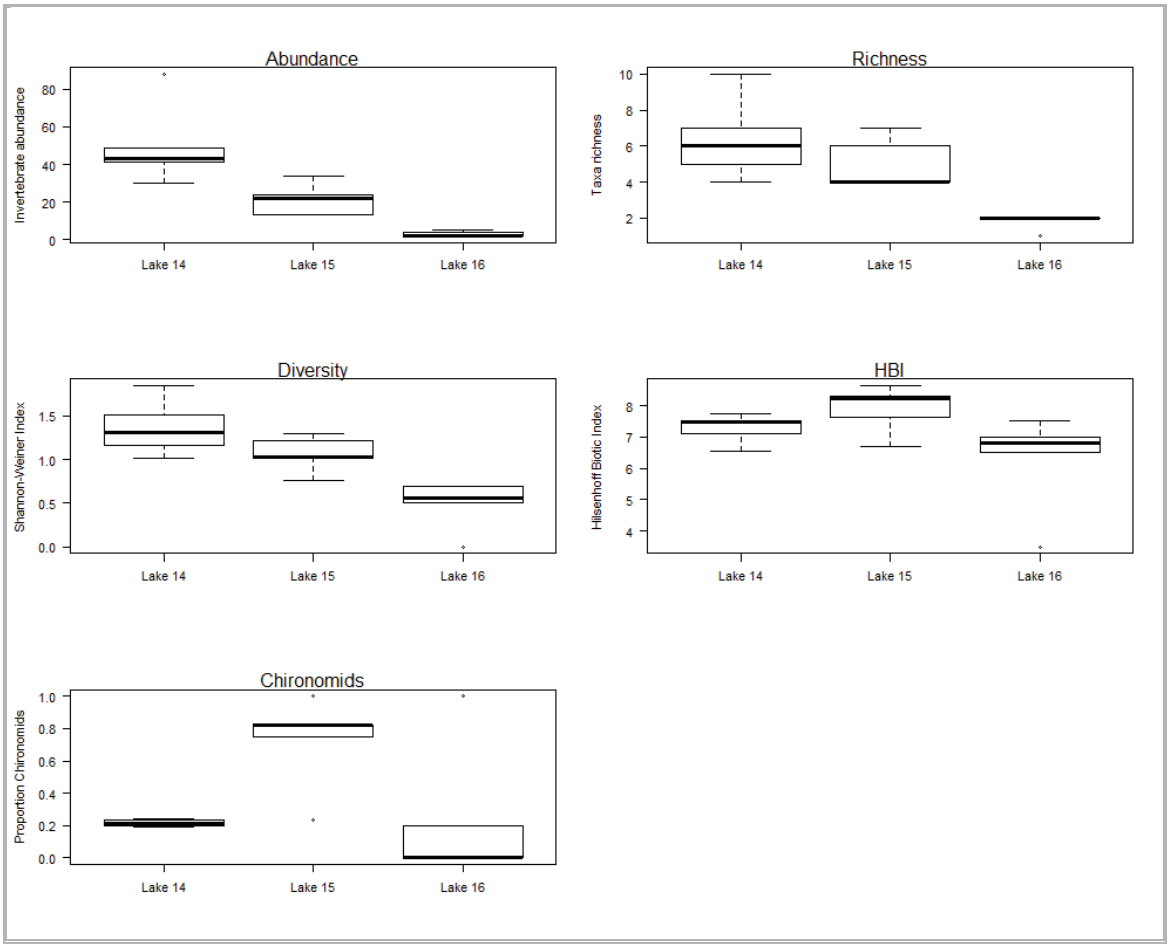
Notes: Proximity between points indicates community similarity among samples. Sample labels correspond to labels in **Figure 5.6-4**.
Lake 14 = Lake 01428UEUT, Lake 15 = 01538UEUT, and Lake 16 = Lake 01682LNRS.

Figure 5.6-5: MDS Ordination of Profundal BMI Communities in Headwater Lakes, 2012

Lake 01428UEUT's profundal community was taxonomically richer, had higher or comparable abundance of most species compared to the other two lakes, and was dominated by *Pisidium* fingernail clams and Chironomids of the genus *Procladius* (**Figure 5.6-4** and **Figure 5.6-5** and **Annex 5.6-1**).

In contrast, Lake 01682NLRS had fewer profundal invertebrates by an order of magnitude (mean abundance was three individuals per sample), was comprised of relatively few taxa, and was dominated by Phantom midge larvae (*Chaoborus* sp.; **Annex 5.6-1**).

The profundal community of Lake 01538UEUT was intermediate in terms of abundance and taxa richness, but it had no taxa in common with Lake 01682NLRS. It also had proportions of chironomids that were over four times higher than the other two lakes (**Figure 5.6-6**).



Notes: Mid-quartiles are represented by the box, while the whiskers represent the data falling within 1.5 times the interquartile range. Bolded lines within each box represent the median value for a site.

Figure 5.6-6: Metrics of Profundal BMI Communities of Headwater Lakes, 2012

5.7 Benthic Macroinvertebrate Tissue Metal Concentrations

This section describes the tissue metal concentrations of samples of both stream and lake BMI communities. **Annex 5.7-1** shows the concentrations of 41 total metals, as well as lipid content, measured from 18 BMI tissue samples collected from 14 stream sites, and **Annex 5.7-2** shows the same data measured from seven BMI samples collected from three headwater lakes.

5.7.1 Stream Benthic Macroinvertebrate Metal Concentrations

Table 5.7-1 shows the percent moisture, lipid content, and total metal concentrations of BMI samples collected from each of the 14 stream sites. Concentrations for site B1-04 were the means of five replicate samples. Concentrations were above method detection limits (MDL) for 33 of the 41 metals. Concentrations of rhenium and tellurium were all below detection limits. The remaining six metals with concentrations below MDLs had the following number of non-detects: one (boron, lithium, and sodium), two (tin), three (beryllium), and eleven (bismuth). Methyl-mercury concentrations were measured at 7 of the 14 sites.

The purpose of collecting and analyzing the replicate BMI samples from lower Creek 661 was to estimate the within-site variability of metal concentrations. The simplest measure of that variability is the coefficient of variation (CV) – the ratio of the standard deviation to the mean multiplied by 100 to obtain a percentage. The CV of percent moisture was 2.2%. CVs for four metals – bismuth, methyl-mercury, rhenium, and tellurium – could not be calculated either because all values were below detection levels or, in the case of methyl-mercury, there was only one replicate value available. For the remaining 37 metals, the CVs of mean concentrations ranged from 4.0% for zirconium to 46.2% for antimony with a mean of 27.7% (SE = 2). The CV for lipid content was 35.2%.

5.7.2 Lake Benthic Macroinvertebrate Metal Concentrations

Table 5.7-2 shows the percent moisture, lipid content, and concentrations of total metals for samples of Gammarus and Hyallela collected from the littoral zones of each of the three lakes. Concentrations for Lake 0158UEUT were the means of the five replicate samples. Concentrations were above MDLs for 27 of the 41 metals. Concentrations were all below MDLs for seven of the metals: bismuth, boron, gallium, lithium, mercury, rhenium, and tellurium. The remaining seven metals had the following number of non-detects: one (potassium and sodium), three (beryllium), and six (antimony, thorium, and zirconium). Methyl-mercury only had one value out of seven potential values.

Table 5.7-1: Concentrations of Metals in Tissues of Benthic Macroinvertebrates from Fourteen Stream Sites, 2012

Stream		Lower Davidson Creek	Upper Davidson Creek	Creek 704454	Lower Creek 661	Upper Creek 661	Chedakuz Creek	Turtle Creek	Creek 700	Lower Creek 705	Mouth of Davidson Creek	Mid Davidson Creek	Upper Creek 705	Tributary Project River	Tributary Fawnie Creek
Site Map ID		**BI-01**	**BI-02**	**BI-03**	**BI-04**	**BI-05**	**BI-06**	**BI-07**	**BI-08**	**BI-09**	**BI-10**	**BI-11**	**BI-12**	**BI-13**	**BI-14**
Date Sampled	**Unit**	**05-SEP-12**	**13-SEP-12**	**08-SEP-12**	**09-SEP-12**	**11-SEP-12**	**11-SEP-12**	**06-SEP-12**	**08-SEP-12**	**08-SEP-12**	**10-SEP-12**	**14-SEP-12**	**12-SEP-12**	**15-SEP-12**	**21-SEP-12**
Physical Tests															
Percent moisture	%	81.9	90.2	88.6	82.7	85.9	81.8	86.1	87.3	82.1	83.0	86.1	89.7	83.7	89.2
Metals															
Aluminum	mg/kg wwt	118	88.8	372	192	78.7	186	480	287	89.0	89.5	99.0	120	55.1	67.2
Antimony	mg/kg wwt	0.0057	0.0034	0.0072	0.0103	0.0059	0.0052	0.0061	0.0032	0.0026	0.0064	0.0047	0.0044	0.0039	0.0024
Arsenic	mg/kg wwt	0.190	0.144	0.726	0.362	0.165	0.312	0.794	0.0541	0.0761	0.216	0.139	0.146	0.324	0.145
Barium	mg/kg wwt	2.43	1.71	7.02	3.44	1.18	8.88	10.6	4.65	1.57	3.60	3.09	4.64	2.30	4.37
Beryllium	mg/kg wwt	0.0108	0.0065	0.0483	0.0107	0.0048	0.0092	0.0320	0.0174	0.0056	0.0071	0.0083	0.0127	0.0044	0.0021
Bismuth	mg/kg wwt	<0.0020	<0.0020	0.0032	0.001	<0.0020	<0.0020	0.0037	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Boron	mg/kg wwt	0.58	0.20	0.23	0.56	0.52	0.28	0.30	0.32	0.59	0.75	0.37	<0.20	0.58	0.96
Cadmium	mg/kg wwt	0.107	0.0960	0.171	0.0654	0.0848	0.0484	0.107	0.0672	0.0405	0.0533	0.0821	0.0720	0.0352	0.239
Calcium	mg/kg wwt	413	252	343	730	372	19000	7100	331	543	875	564	294	443	221
Cesium	mg/kg wwt	0.0203	0.0237	0.0551	0.0134	0.0084	0.0161	0.0455	0.0251	0.0192	0.0111	0.0186	0.0339	0.0053	0.0116
Chromium	mg/kg wwt	0.251	0.164	0.327	0.419	0.152	0.467	0.892	0.185	0.105	0.210	0.201	0.178	0.065	0.146
Cobalt	mg/kg wwt	0.138	0.0623	0.208	0.255	0.0695	0.193	0.281	0.0644	0.0541	0.250	0.0948	0.129	0.138	0.0438
Copper	mg/kg wwt	4.47	2.76	9.27	4.67	3.24	2.83	3.06	3.07	4.65	4.89	4.79	2.56	4.36	2.08
Gallium	mg/kg wwt	0.0324	0.0198	0.0952	0.0540	0.0175	0.0560	0.117	0.0572	0.0225	0.0243	0.0240	0.0278	0.0108	0.0176
Iron	mg/kg wwt	226	139	700	405	134	433	840	184	105	232	145	238	485	99.1
Lead	mg/kg wwt	0.0719	0.0881	0.916	0.0870	0.0566	0.0922	0.133	0.0662	0.0855	0.0379	0.0839	0.0517	0.0210	0.107
Lithium	mg/kg wwt	0.046	0.042	0.165	0.081	0.023	0.094	0.349	0.099	0.041	0.037	0.042	0.051	<0.020	0.031
Magnesium	mg/kg wwt	240	149	201	299	155	278	297	152	175	506	345	143	203	172
Manganese	mg/kg wwt	60.9	18.9	172	118	21.0	231	175	18.4	14.2	90.8	42.3	89.3	33.6	11.2
Mercury	mg/kg wwt	0.0176	0.0061	0.0124	0.0105	0.0101	0.0098	0.0222	0.0115	0.0066	0.0117	0.0083	0.0088	0.0081	0.0032
Methyl Mercury	mg/kg wwt	0.0100	-	-	0.0099	-	0.0068	0.0172	-	0.0035	-	-	-	0.0061	0.0021
Molybdenum	mg/kg wwt	0.160	0.138	0.161	0.131	0.104	0.175	0.168	0.0741	0.105	0.135	0.209	0.169	0.188	0.0944
Nickel (Ni)	mg/kg wwt	0.248	0.099	0.256	0.290	0.102	0.255	0.477	0.153	0.132	0.435	0.157	0.099	0.129	0.088
Phosphorus	mg/kg wwt	1230	970	985	1,218	987	1180	1130	1020	1020	1620	1280	980	1080	983
Potassium	mg/kg wwt	1330	590	690	1,232	1080	950	870	1010	960	1090	940	860	1070	890
Rhenium	mg/kg wwt	<0.0020	<0.0020	<0.0020	0.001	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Rubidium	mg/kg wwt	0.450	0.449	0.853	0.387	0.459	0.410	0.585	0.365	0.443	0.389	0.324	0.779	0.612	0.573
Selenium	mg/kg wwt	0.390	0.271	0.053	0.259	0.119	0.091	0.308	0.062	0.078	0.163	0.359	0.058	0.067	0.292
Silver	mg/kg wwt	0.0399	0.0247	0.0518	0.0386	0.0381	0.0189	0.0286	0.0194	0.0291	0.0254	0.0285	0.0337	0.0255	0.0152
Sodium	mg/kg wwt	690	<400	230	634	570	420	410	350	540	600	560	330	610	340
Strontium	mg/kg wwt	3.41	1.32	3.51	3.89	2.76	19.1	21.2	1.94	3.28	5.76	3.02	1.85	3.00	0.755
Tellurium	mg/kg wwt	<0.0040	<0.0040	<0.0040	0.002	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Thallium	mg/kg wwt	0.00326	0.00181	0.00900	0.00305	0.00187	0.00219	0.00606	0.00196	0.00147	0.00201	0.00210	0.00315	0.00199	0.00174
Thorium	mg/kg wwt	0.0410	0.0101	0.0651	0.0378	0.0127	0.0308	0.106	0.0280	0.0179	0.0140	0.0156	0.0202	0.0079	0.0060
Tin	mg/kg wwt	0.0056	<0.0040	0.0131	0.0046	<0.0040	0.0053	0.0062	0.0046	0.0042	0.155	0.260	0.276	0.0347	0.0507
Titanium	mg/kg wwt	7.26	3.43	12.4	10.00	3.38	13.9	18.9	7.06	3.65	5.44	5.09	5.92	3.13	5.66
Uranium	mg/kg wwt	0.0748	0.0511	0.0704	0.0990	0.0484	0.0444	0.129	0.0558	0.0482	0.0477	0.0806	0.0962	0.0350	0.0152
Vanadium	mg/kg wwt	0.491	0.208	0.789	0.831	0.242	0.759	1.49	0.361	0.187	0.413	0.289	0.334	0.372	0.265
Yttrium	mg/kg wwt	0.201	0.136	0.345	0.208	0.0901	0.214	0.794	0.285	0.0829	0.159	0.154	0.190	0.0853	0.0495
Zinc	mg/kg wwt	44.7	27.0	67.6	45.9	45.0	22.1	15.2	34.0	40.3	39.9	43.3	30.4	32.7	37.0
Zirconium	mg/kg wwt	0.148	0.057	0.271	0.207	0.072	0.218	0.602	0.153	0.096	0.119	0.089	0.132	0.086	0.041
Aggregate Organics															
Lipid Content	% wwt	2.3	-	1.4	2.2	1.9	1.7	1.7	2.1	3.2	2.3	1.3	1.1	2.2	1.1

Table 5.7-2: Concentrations of Metals in Benthic Macroinvertebrates from Three Lakes, 2012

Lake		01428UEUT	01538UEUT	01682LNRS
Site Map ID		14-05	15-01	16-05
Date Sampled	Unit	9-Sep-12	10-Sep-12	20-Sep-12
Physical Tests				
% Moisture	%	86.30	83.70	89.10
Metals				
Aluminum	mg/kg wwt	9.94	8.37	4.58
Antimony	mg/kg wwt	0.0025	0.0063	0.0034
Arsenic	mg/kg wwt	0.2150	0.6128	0.1610
Barium	mg/kg wwt	31.200	8.416	4.950
Beryllium	mg/kg wwt	<0.0020	0.0060	<0.0020
Bismuth	mg/kg wwt	<0.0020	0.0010	<0.0020
Boron	mg/kg wwt	<0.20	0.10	<0.20
Cadmium	mg/kg wwt	0.0189	0.0360	0.0110
Calcium	mg/kg wwt	25,100	21,900	13,200
Cesium	mg/kg wwt	0.0207	0.0673	0.0494
Chromium	mg/kg wwt	0.431	0.136	0.109
Cobalt	mg/kg wwt	0.0147	0.0179	0.0056
Copper	mg/kg wwt	6.45	4.25	4.69
Gallium	mg/kg wwt	<0.0040	0.0020	<0.0040
Iron	mg/kg wwt	34.50	246.54	14.50
Lead	mg/kg wwt	0.0439	0.0658	0.0227
Lithium	mg/kg wwt	<0.020	0.010	<0.020
Magnesium	mg/kg wwt	324	354	234
Manganese	mg/kg wwt	13.8000	36.5160	3.4400
Mercury	mg/kg wwt	<0.015	0.010	<0.0050
Methyl Mercury	mg/kg wwt	0.0036	0.0024	0.0052
Molybdenum	mg/kg wwt	0.1580	0.1663	0.0457
Nickel	mg/kg wwt	0.238	0.029	0.036
Phosphorus	mg/kg wwt	2,170	1,958	1,400
Potassium	mg/kg wwt	970	1,166	570
Rhenium	mg/kg wwt	<0.0020	0.0010	<0.0020
Rubidium	mg/kg wwt	1.280	1.128	0.574
Selenium	mg/kg wwt	0.081	0.050	0.054
Silver	mg/kg wwt	0.1560	0.0497	0.0752
Sodium	mg/kg wwt	780	1,002	450
Strontium	mg/kg wwt	138.000	51.980	33.600
Tellurium	mg/kg wwt	<0.0040	0.0020	<0.0040
Thallium	mg/kg wwt	0.00660	0.00323	0.00284
Thorium	mg/kg wwt	<0.0020	0.0036	<0.0020
Tin	mg/kg wwt	2.1400	0.3132	0.7280
Titanium	mg/kg wwt	0.330	0.265	0.144
Uranium	mg/kg wwt	0.02920	0.07152	0.01850
Vanadium	mg/kg wwt	0.0342	0.0607	0.0176
Yttrium	mg/kg wwt	0.0301	0.0645	0.0176
Zinc	mg/kg wwt	8.67	5.83	4.21
Zirconium	mg/kg wwt	<0.040	0.026	<0.040
Aggregate Organics				
Lipid Content	% wwt	1.0	1.0	1.0

Notes: Total mercury detection limit adjusted for some samples (1,528-1, 1,538-2, 1,538-3, 1,682)
< = less than; mg/kg wwt = milligram per kilogram wet weight; MDL = minimum detection limit;
% = percent; % wwt = % wet weight

The purpose of collecting and analyzing the replicate BMI samples from Lake 0158UEUT was to estimate the within-site variability of metal concentrations. The CV of percent moisture was 0.8%, similar to that of stream benthos. CVs for seven metals (i.e., bismuth, boron, gallium, lithium, methyl-mercury, rhenium, and tellurium) could not be calculated because all values were below detection levels or, in the case of methyl-mercury, there were only one replicate value available. For the remaining 35 metals, the CVs of mean concentrations ranged from 2.9% for phosphorus to 162% for thorium with a mean of 51% (SE = 6.3). That range and mean were substantially higher than for stream benthos, which may be due to the smaller sample size for lake benthos. The CV for lipid content was 14.1%, which was almost one-third lower than the CV for stream benthos lipid content. That result cannot be due to a lower sample size, but may be due to the less diverse species composition of lake benthos that was analyzed, compared to the stream benthos that was analyzed.

5.7.3 Principal Component Analysis (PCA)

The stream and lake BMI tissue metal data were pooled to provide a sample size of 25 records, of which four were stream replicate samples and four were lake replicate samples. Four of the 41 metals were removed from the data matrix because of the high number of concentrations below the MDL or empty cells: rhenium (100% non-detects), tellurium (100% non-detects), bismuth (92% non-detects), and methyl-mercury (10 empty cells). The remaining 37 variables had between 0 and 8 non-detects each. The non-detects were replaced by one-half the detection limit. All metal concentrations were ln-transformed to normalize their distributions.

PCA extracted three principal components that explained a total of 75% of the total variance. Bartlett tests showed that those three components were the only ones that explained a statistically significant ($P<0.001$) amount of variance. Hence, PCA reduced the dataset from 39 variables to three – a tenfold reduction in the size of the dataset.

A loading table was used to assign meaning to each of the components. “Loading” in this case means the correlation between a component and each of the ln-transformed metal concentrations. **Table 5.7-3** showed that the first component, PC1, explained 47% of the variance in the data and that it was significantly ($P<0.05$) positively correlated with 22 metals, significantly negatively correlated with nine metals, and not significantly ($P>0.05$) correlated with six metals. The positive correlations included many heavy metals such as vanadium, cobalt, thallium, zinc, nickel, iron, cadmium, selenium, chromium, uranium, antimony, lead, and mercury. The negative correlations included three of the most important structural metals in biology: phosphorus, calcium, and sodium. The first principal component in most biological studies is a “size” component; it is typically a measure of magnitude. Therefore, the simplest interpretation of PC1 is that it is a measure of the concentration of heavy metals in BMI tissue.

Table 5.7-3: Loading Table for PCA of Stream and Lake BMI Tissue Metal Concentrations

Variation Explained	47.2%	19.1%	9.2%
Variable	**PC1**	**PC2**	**PC3**
ln(Al)	**0.98**	0.01	0.08
ln(V)	**0.98**	0.14	-0.03
ln(Ti)	**0.97**	-0.10	0.02
ln(Ga)	**0.97**	-0.05	0.05
ln(Co)	**0.95**	0.17	-0.11
ln(Zr)	**0.92**	0.11	-0.02
ln(Th)	**0.92**	0.01	-0.04
ln(Y)	**0.89**	0.33	0.16
ln(Zn)	**0.89**	-0.21	-0.15
ln(Li)	**0.88**	0.09	0.24
ln(Ni)	**0.83**	0.18	-0.13
ln(Be)	**0.79**	**0.41**	0.25
ln(Sn)	**-0.77**	0.23	0.13
ln(Fe)	**0.75**	**0.48**	0.06
ln(P)	**-0.75**	**0.54**	-0.26
ln(Mn)	**0.74**	**0.59**	-0.01
ln(B)	**0.73**	-0.28	**-0.48**
ln(Ca)	**-0.73**	**0.52**	0.01
ln(Sr)	**-0.73**	**0.60**	-0.01
ln(Rb)	**-0.71**	**0.43**	0.33
ln(Cd)	**0.70**	-0.13	0.23
ln(Se)	**0.67**	-0.08	-0.24
ln(Cr)	**0.57**	**0.53**	0.07
ln(Ag)	**-0.56**	**0.49**	0.04
ln(U)	**0.54**	**0.64**	0.01
ln(Cs)	**-0.54**	**0.43**	**0.51**
ln(Sb)	**0.53**	**0.52**	0.01
ln(Na)	**-0.53**	**0.41**	**-0.68**
ln(Pb)	**0.47**	0.25	**0.46**
ln(Hg)	**0.46**	**0.55**	-0.23
ln(Ba)	**-0.44**	**0.64**	0.31
ln(Mg)	-0.28	**0.66**	**-0.44**
ln(Mo)	0.27	**0.61**	0.02
ln(Cu)	-0.10	**0.50**	-0.16
ln(As)	0.03	**0.84**	0.13
ln(Tl)	0.03	**0.79**	**0.42**
ln(K)	0.02	0.28	**-0.79**

Note: Bolded correlations are significant (P<0.05).

The second component, PC2, explained 19% of the variance and was significantly positively correlated with 20 metals, of which arsenic had the highest correlation (r = 0.84). All the other positive correlations ranged from 0.41 to 0.79. PC2 was not significantly correlated with the other 17 metals. The simplest interpretation is that PC2 is a measure of arsenic concentration.

The third component, PC3, explained 9% of the variance and was significantly positively correlated with three metals (i.e., cesium, lead, and tellurium), but at loadings (r = 0.42 to 0.51) that were close to non-significance. PC3 was also significantly negatively correlated with four metals (i.e., potassium, sodium, barium, and manganese), but only potassium had a relatively high correlation (r = -0.79). The other metals had correlations ranging from -0.44 to -0.68. PC3 was not significantly correlated with the remaining 30 metals. The simplest interpretation is that PC3 measured the absence of potassium.

Plots of PC1, PC2, and PC3 scores on stream and lake sampling sites, aggregated by watershed, showed that stream PC1 scores were similar across watersheds (**Figure 5.7-1**), indicating that their tissue metal concentrations were similar across watersheds. Since BMI are fixed to the substrate, this indicates that the concentrations of metals in water and sediment to which BMI communities are exposed may not be substantially different among the watersheds of the LSA. PC1 scores of the two reference stream sites, neither of which is in the LSA, are slightly lower than those in the LSA, but the differences are too small and the number of reference sites too few to make definitive conclusions.

A similar conclusion was reached by plotting PC1 scores on stream and lake sampling sites, but aggregated by the five BMI taxonomic groups (A through E) identified through cluster analysis of Bray-Curtis indices (**Figure 5.7-2**). (The groups are defined in **Table 5.3-1**). The lack of difference in PC1 scores among the five groups suggests that concentrations of metals in BMI tissue are not influenced by differences in the taxonomic composition of the communities or, by extension, the physical characteristics of habitat that drives taxonomic composition.

The single greatest difference in PC1 scores was between stream and lake sites (**Figure 5.7-1** and **Figure 5.7-2**). PC1 scores at lake sites are all lower than those at stream sites. This was undoubtedly due to the difference in type of organisms sampled in lakes compared to streams. The lake samples were “scuds” (i.e., crustaceans of the families Gammaridae and Hyallela), but stream BMI samples contained a wider diversity of crustaceans and aquatic insects.

PC2 scores were more highly variable than PC1 scores within watersheds, within taxonomic groups, and within lakes (**Figure 5.7-1** and **Figure 5.7-2**). Partly as a result of this higher variability, mean PC2 scores did not differ substantially among watersheds or among taxonomic groups or between streams and lakes. These results suggest there was little variation in exposure of BMI to arsenic on a watershed scale or between streams and lakes.

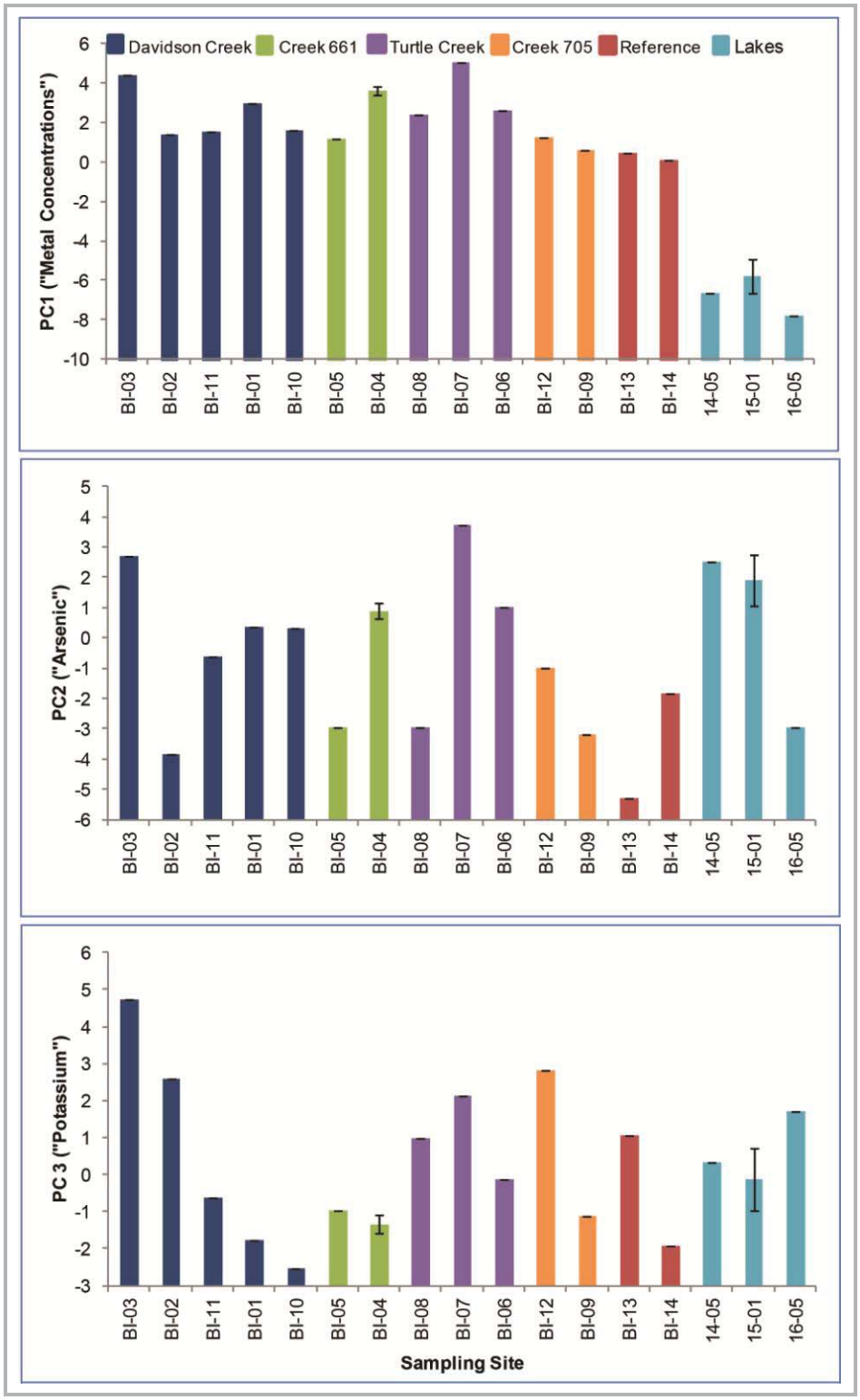


Figure 5.7-1: Plots of PC1, PC2, and PC3 Scores on Stream and Lake Sampling Sites for BMI Tissue Metal Samples, Aggregated by Watershed

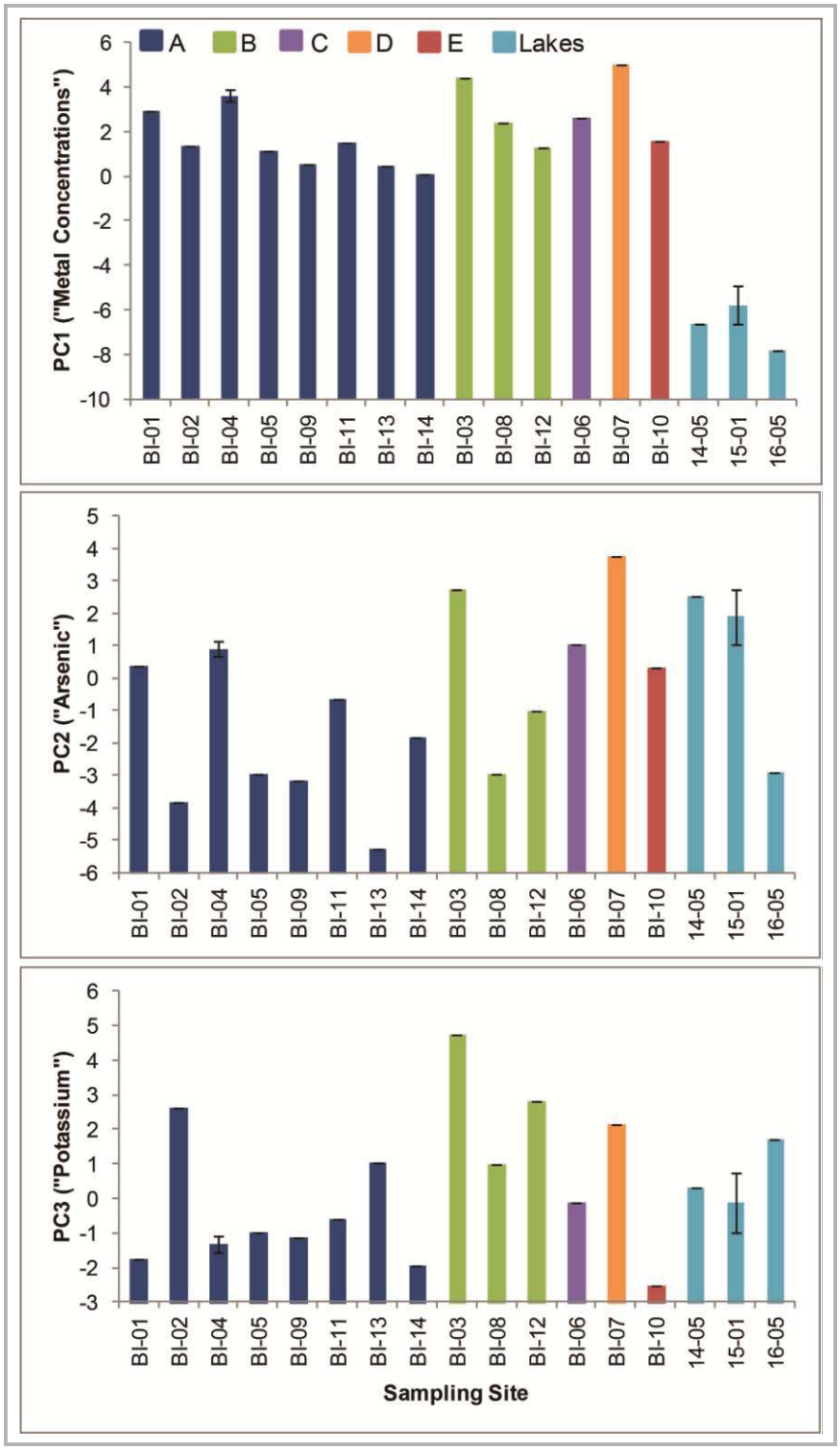


Figure 5.7-2: Plots of PC1, PC2, and PC3 Scores on Stream and Lake Sampling Sites for BMI Tissue Metal Samples, Aggregated by BMI Group

A plot of PC3 scores on sampling sites aggregated by watershed showed a clear reduction in PC3 with increasing downstream distance in Davidson Creek (i.e., from site BI-03 at the head of the watershed to site BI-10 at the confluence with Chedakuz Creek) (**Figure 5.7-1**). Similar downstream trends were observed in Turtle Creek and Creek 705 and, to a lesser extent, in Creek 661. Since PC3 was interpreted as the absence of potassium, these trends indicate trends of increasing potassium with downstream distance.

No differences in mean PC3 were observed in plots of sampling stations aggregated by taxonomic group (**Figure 5.7-2**).

In summary, stream BMI tissue samples had higher metal concentrations than lake BMI tissue samples, and there was a trend of increasing potassium concentration with downstream distance in BMI tissue samples.

5.8 Stream Fish Habitat

This section describes the results of the stream fish habitat surveys in the LSA and at stream crossings along the transmission and access road corridors. **Annex 5.8-1** shows photographs of the stream fish habitat assessment sites, **Annex 5.8-2** shows the FHAP data collected from stream sites in 2011 and 2012 (the reconnaissance 1:20,000 data are also summarized in this section), and **Annex 5.8-3** shows data on overwintering habitat collected in 2012. **Annex 5.10-5** provides a detailed description of the fish habitat in streams crossed by the transmission line and access road corridors – this section only summarizes the contents of that appendix.

Stream fish habitat is described at this place in the report because spatial variation in the quantity and quality of fish habitat drives spatial variation in fish distribution and abundance. **Section 5.9** describes fish habitat in lakes and **Section 5.10** describes fish distribution, abundance, and biological characteristics.

This section is organized by watershed. A general description of habitat is followed by a reach break analysis, a stream habitat classification, and a description of overwintering habitat (if available). The objective was to identify the quantity and quality of fish habitat on a reach-specific basis.

5.8.1 Davidson Creek Watershed

Davidson Creek Watershed has a watershed area of approximately 86 km^2. Elevations range from 1,700 masl at the summit of Mount Davidson to 950 masl at the confluence with Chedakuz Creek. Davidson Creek is the main stream in the watershed.

5.8.1.1 General Description

Davidson Creek is a fourth-order stream that flows northeast from its headwaters on Mt. Davidson to its confluence with lower Chedakuz Creek, approximately 800 m downstream of Tatelkuz Lake (**Figure 2.1-2**). Davidson Creek originates from a small headwater lake (Lake 01682LNRS) that is located near the drainage divide between the Chedakuz and Fawnie Creek watersheds (**Plate 2.1-1**).

Davidson Creek is fed by two main tributaries in the upper watershed: Creek 688328 and Creek 704454. They are both small third-order streams that flow from the flanks of Mt. Davidson, and merge with upper Davidson Creek on the west and east sides of the creek, respectively. Another small second-order stream, Creek 636713, flows into the mainstem in the upper watershed. Downstream of these three confluences, Davidson Creek flows through a small incised valley with a meandering riffle-pool morphology that is laterally stable. The middle to lower portions of the watershed contain a few small tributaries.

5.8.1.2 Reach Break Analysis

Reach 1 of Davidson Creek consists of low-gradient (<1%), riffle-pool habitat that flows unconfined through a broad floodplain (**Table 5.8-1** and **Figure 5.8-1**). Most of this reach is adjacent to the ranch located at the confluence of Davidson and Chedakuz creeks.

Reach 2 has a slightly steeper gradient (1.4%) than Reach 1 and is frequently confined within a shallow incised valley.

Reach 3 consists of a low-gradient wetland with a wide floodplain and erodible banks. The creek follows an irregular channel through this unconfined reach.

Reaches 4, 5, and 6 extend approximately 3, 5, and 4 km upstream, respectively, through low-gradient riffle-pool habitat. These three reaches are distinguished by changes in channel pattern and confinement.

Reach 7 is a 0.2 km-long straight channel section with a mean gradient of 1.3% and extended riffle sections.

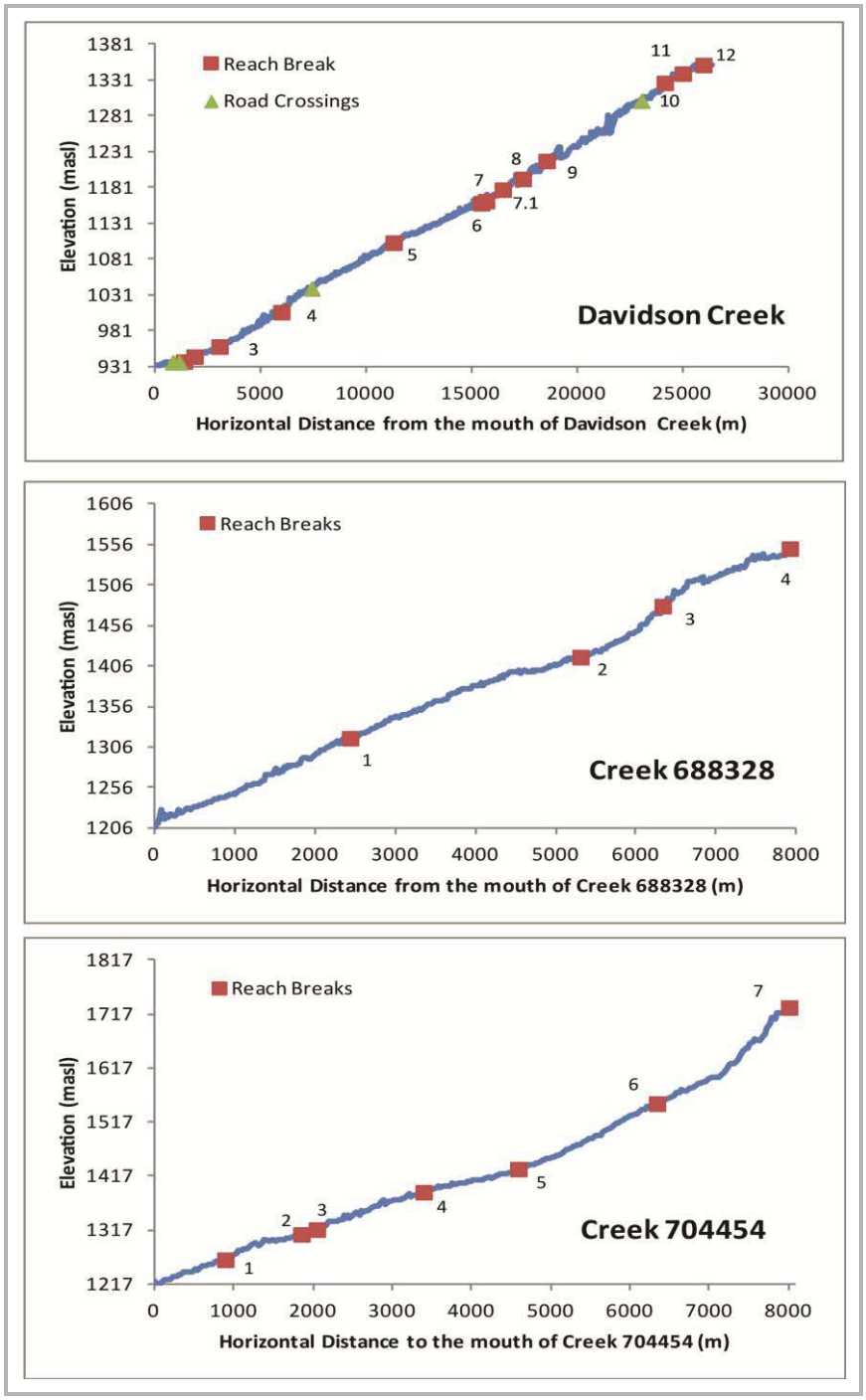
Gradients increase slightly in Reach 7.1, and stream bed materials change. Cascades ranging in length from 9 to 30 m, and containing large boulder and cobble substrates, are distributed throughout this reach.

Mean gradient drops to approximately 1.6% in Reach 8, which stretches a distance of 0.9 km and contains riffle-pool habitats with cobble and gravel substrates.

Table 5.8-1: Reach Characteristics for Davidson Creek, Creek 688328, and Creek 704454

Stream	Reach No.	Stream Order	Reach Length (km)	Reach Gradient (%)
Davidson Creek	1	4	1.38	0.5
	2	4	0.50	1.4
	3	4	1.18	1.2
	4	4	2.93	1.6
	5	4	5.31	1.8
	6	4	4.15	1.3
	7	4	0.23	1.3
	7.1	4	0.79	2.0
	8	4	0.95	1.8
	9	4	1.12	2.2
	10	4/3/2	5.60	1.9
	11	2	0.85	1.5
	12	2	0.98	1.2
Creek 688328	1	2	2.43	4.6
	2	2	2.86	3.5
	3	2	1.02	6.1
	4	2	1.58	4.5
Creek 704454	1	3	0.89	4.5
	2	3	0.96	4.9
	3	3	0.20	4.6
	4	3	1.35	5.1
	5	3	1.16	3.6
	6	2	1.79	6.9
	7	2	1.67	10.7

Notes: km = kilometre; % = percent



Notes: m = metre; masl = metres above sea level.

Figure 5.8-1: Stream Gradient Profiles, Davidson Creek Watershed

Reaches 9 (1.1 km) and 10 (5.6 km) have minimal cascade habitat and are both low-gradient stream sections. Creeks 688328 and 704454 enter Davidson Creek in upper Reach 9.

Reach 11 is approximately 0.9 km-long and consists of a riffle-pool section and some longer cascade sections. Deep glides and seasonally flooded wetlands typify Reach 12, which extends approximately 1.0 km downstream of the Lake 01682LNRS outlet.

Reach 1 of Creek 688328 contains cascade-pool habitat and has a steeper mean gradient (4.56%) than reaches in Davidson Creek (**Table 5.8-1** and **Figure 5.8-1**). Reach 2 is slightly less steep than Reach 1 with a mean gradient of 3.5% over 2.9 km. It is confined within an incised valley. Some small wetland complexes are present in the upper sections of Reach 2. Reach 3 is approximately 1 km in length, and contains cascade-pool habitats, a mean gradient of 6.1%, and flows confined by steeper valley slopes. Mean gradient is 4.5% in Reach 4, a 1.6 km section dominated by riffle-pool habitat.

Mean gradient in Creek 704454 ranges from approximately 4.5% to 5.0% in Reaches 1 through 4 and contains predominantly riffle-pool habitat (**Table 5.8-1** and **Figure 5.8-1**). The creek is confined to a deeply incised valley with steep walls through Reaches 2 to 4. Reach 5 contains riffle-pool habitat with a mean gradient of 3.6%. The creek transitions into cascade-pool habitat in Reach 6 (1.7 km) and step-pool habitat in Reach 7 (1.7 km), with mean gradients of 6.9% and 10.7%, respectively.

5.8.1.3 Stream Habitat and Classification

Habitat in Reach 1 of Davidson Creek is dominated by pools (45%), with smaller amounts of riffle (31%) and glide habitat (24%) (**Table 5.8-2**, **Table 5.8-3** and **Figure 5.8-2**). Abundant high-quality spawning gravel for salmonids is present in riffles and glides in this reach, and lower quality gravel in pool sections. A mixture of riparian vegetation types is present in Reach 1, including shrubs, deciduous, coniferous, and mixed forest. Habitat quality for all four salmonid life stages (overwintering, rearing, spawning, and migration) is rated as good in Reach 1 of Davidson Creek.

Riffle (36%), glide (33%), and pool habitat (31%) are evenly distributed in Reach 2 of Davidson Creek. The dominant type of cover is LWD in riffles and glides, and deep pools in pool habitats. Side channels provide off-channel habitat. Riparian vegetation is predominately mature, coniferous forest, and it provides more than 20% of stream cover. Habitat quality for all four salmonid life stages (overwintering, rearing, spawning, and migration) is rated as good in Reach 2 of Davidson Creek.

Habitat types are also evenly distributed In Reach 3 of Davidson Creek. Stream cover is dominated by overhanging vegetation, deep pools, and small woody debris, while riparian vegetation is dominated by shrubs. This reach also has the deepest mean residual pool depth observed in all reaches of Davidson Creek. Habitat quality for all four salmonid life

stages (overwintering, rearing, spawning, and migration) is rated as good in Reach 3 of Davidson Creek.

Reach 4 of Davidson Creek has an evenly distributed mixture of glide (38%), pool (32%), and riffle (30%) habitats. The dominant and sub-dominant substrate types are cobbles and gravels, respectively. Riffle and glide habitats have low to high amounts of spawning gravels. Undercut banks, large woody debris (LWD), and deep pools are the dominant cover type. Sub-dominant cover types consist of overhanging vegetation and small woody debris. Total stream cover is between 5 and 20%. Infrequent ponds provide the only off-channel habitat within the reach. Riparian vegetation is predominately mature conifers. Habitat quality for all four salmonid life stages (overwintering, rearing, spawning, and migration) is rated as good in Reach 4 of Davidson Creek.

Riffle habitat (79%) dominates Reach 5 of Davidson Creek, with smaller amounts of pool (13%) and glide (7%) habitat. Dominant and sub-dominant substrate types are cobbles and gravels, respectively. All habitat units contain sections with low to high amounts of spawning gravels. The highest values for mean total LWD tally (40) and mean functional LWD tally (14) in Davidson Creek exist in riffle habitats within this reach. LWD and undercut banks are the dominant and sub-dominant cover types (total stream cover was greater than 20%), respectively, while infrequent side channels provide the only off-channel habitat. Riparian vegetation generally consists of mature conifers, with some mature mixed species forest. Habitat quality for salmonids is rated as fair for overwintering and migration and good for spawning and rearing in Reach 5 of Davidson Creek.

Reach 6 contains predominantly riffle (55%) and glide (41%) habitats, while pool (4%) habitat distribution is limited. Substrate composition is similar to that observed in Reaches 4 and 5 (mostly cobble with some gravel, low to high amounts of spawning gravels). Dominant cover types are undercut banks, deep pools, and overhanging vegetation. Total stream cover is between 5 and 20%. Mature conifers comprise the majority of riparian vegetation, with smaller amounts of shrubs. Habitat quality for salmonids is rated as fair for overwintering and rearing and good for migration and spawning in Reach 6 of Davidson Creek.

Habitat in Reach 7 consists mostly of riffles (59%) and glides (36%) with a limited amount of pool habitat (4%). The dominant and sub-dominant substrate types are cobbles and boulders, respectively. Low amounts of spawning gravels are present in riffle and pool habitats, and no spawning gravels are present in glide habitats. Overhanging vegetation and LWD are the dominant and sub-dominant cover types, and total stream cover is 5 to 20%. Riparian vegetation consists of shrubs and mature conifers. Habitat quality for salmonids is rated as fair for overwintering and rearing and good for migration and spawning in Reach 7 of Davidson Creek.

Table 5.8-2: Summary of Davidson Creek Fish Habitat Data, 2011 and 2012

Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
1		100	265	1,711.0															
	Riffle	31	91	537.2	1.0	5.9	5.4	0.30		G	S	H,L	6	2	LWD,OV	C	-	M,SH	MF,SHR
	Pool	45	96	766.8	0.0	8.0	5.9	0.69	0.56	G,S	S,G	L,H	8	5	DP,SWD	LWD,OV	-	SH,M,D	SHR,MF
	Glide	24	78	407.0	0.5	5.2	5.0	0.27		G	S	H	6	3	C,OV	OV,LWD,SWD	-	SH.M,C	MF,SHR
2		100	272	1,736.4															
	Riffle	36	96	628.2	1.3	6.5	5.4	0.24		G,C	C,G	L,H	11	11	LWD	OV,SWD	SC	C	MF
	Pool	31	79	542.7	0.0	6.9	5.3	0.61	0.58	S,G,C	C,S,G	N,L,H	6	6	DP	LWD,C	SC	C	MF
	Glide	33	97	565.5	0.6	5.8	4.9	0.36		G,C,S	F,G	L,H	5	5	LWD,C,OV	LWD,SWD,OV	-	C	MF
3		100	271	1,611.2															
	Riffle	33	88	530.6	0.8	6.0	5.1	0.16		G,C	S,G	L,H	0	0	OV,SWD	SWD,OV	WL	SH	SHR
	Pool	37	110	595.7	0.0	5.4	4.2	0.63	0.69	S,G	G,S	H,N,L	2	2	DP	SWD,OV,C	WL	SH	SHR
	Glide	30	73	484.9	0.4	6.6	5.0	0.26		G	C,S	H,L	0	1	SWD,OV	OV,C	WL	SH	SHR
4		100	251	1,742.0															
	Riffle	30	76	527.4	2.8	6.9	6.2	0.22	-	C	G	L,H	5	3	LWD, C	OV	-	C	MF
	Pool	32	80	549.6	0.0	6.9	4.4	0.59	0.565	C	G	L	8	5	C, DP	LWD	PD	C	MF
	Glide	38	95	665.0	1.5	7.0	5.0	0.35	-	C	G	L,H	6	4	C, DP	SWD	-	C	MF
5		100	1,310	7,648.9															
	Riffle	79	1,063	6,080.4	0.8	5.7	5.3	0.27	-	C	G	L,H	40	14	LWD	C, OV	SC	C	MF
	Pool	13	125	1,000.0	0.0	8.0	7.5	0.65	0.55	C	G	L,H	4	1	LWD, DP	C	-	C	MF
	Glide	7	122	568.5	1.1	4.7	5.0	0.35	-	C	G	L,H	7	2	LWD	OV	-	C, M	MF
6		100	253	1,315.8															
	Riffle	55	135	729.0	1.3	5.4	4.4	0.20	-	C	G	L,H	3	4	C,OV	LWD	-	C	MF
	Pool	4	9	47.3	0.0	5.3	4.9	0.50	0.45	C,S	G,B	L	2	-	DP	OV,B	-	C,S	SHR,MF
	Glide	41	109	539.6	0.8	5.0	4.7	0.30	-	C	G,B	L,H	4	2	OV	C	-	C,S	MF,SHR
7		100	253	1,260.8															
	Riffle	59	148	749.9	1.0	5.1	4.3	0.23	-	C	B	L	3	2	OV	LWD	-	S,C	SHR,MF
	Pool	4	9	54.9	0.0	6.1	5.5	0.40	0.33	C,S	G	L	14	5	OV,LWD	DP,C	-	C,S	MF,SHR
	Glide	36	96	456.0	0.8	4.8	4.3	0.25	-	C	B	N	3	1	OV	LWD	-	S,C	SHR, MF
7.1		100	252	1,411.2															
	Riffle	30	77	427.4	3.3	5.6	4.2	0.28	-	B	C	L	0	1	B	C	-	M	MF,SHR
	Pool	8	15	119.3	0.0	8.0	6.5	0.47	0.30	B	C	L,H	0	0	B	DP,C	-	M,S	MF, SHR
	Glide	30	78	429.0	2.0	7.5	4.8	0.30	-	G	C	L	1	0	C,B	OV	SC	M,S	MF,SHR
	Cascade	31	82	435.6	4.4	5.3	4.7	0.33	-	B	C	N	0	1	B	C	-	M,S	MF,SHR
8		100	826	5,773.6															
	Riffle	52	394	2,974.7	3.4	7.6	6.1	0.26	-	C	G	L	2	2	OV,C	LWD	-	C	MF
	Pool	16	134	904.5	0.0	6.8	4.8	0.67	0.49	G	C	N	3	2	LWD,DP	OV	-	C,M	MF
	Glide	33	298	1,894.4	2.9	6.4	5.2	0.35	-	C	G	L,H	3	2	OV	C	-	C,M	MF
9		100	1,174	6,411.2															
	Riffle	55	594	3,521.6	3.9	5.9	5.5	0.21	-	C	G	L	10	6	LWD	C	SC	C	MF
	Pool	16	129	1,044.9	0.2	8.1	7.0	0.45	0.44	C	G	L	5	3	LWD,C	DP	-	C	MF
	Glide	28	445	1,819.6	3.5	4.1	3.8	0.26	-	C	G	L	10	4	LWD	C,OV	SC	C	MF
	Cascade	0	6	25.2	6.0	4.2	3.2	0.05	-	B	C	L	0	0	-	-	-	C	MF

Table continues…

Table 5.8-2 (cont'd)

Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
10		100	2,375	6,595.4															
	Riffle	14	397	936.3	1.8	2.4	2.4	0.26	-	C,G	S	L,H	1	2	DP,C	LWD,IV	SC	C,S	MF,SHR
	Pool	13	306	874.7	0.1	2.9	3.7	0.64	0.54	G	S	L,H	2	2	DP,LWD	C,OV	SC	C,S	MF,SHR
	Glide	72	1,654	4,752.1	1.4	2.9	3.0	0.34	-	G,C	S	L,H	3	3	LWD,C	IV	SC	C,S	MF,SHR
	Cascade	0	18	32.4	4.0	1.8	2.2	0.25	-	C	G	L	0	0	B	-	-	C	MF
11		100	709	1,455.8															
	Riffle	47	335	686.8	2.0	2.1	2.0	0.15	-	G	C	N	2	1	IV	B,OV	-	C	MF
	Pool	5	27	72.9	0.0	2.7	2.7	0.65	0.40	B,G	C,S	N	2	2	DP	IV	-	C	MF
	Glide	36	247	522.8	0.8	2.1	2.1	0.27	-	B	C,S	N	6	3	IV	OV	-	C	MF
	Cascade	12	100	173.3	3.8	1.7	1.6	0.27	-	B	C,R	L	4	5	IV	LWD	-	C	MF
12		100	1,113	4,244.1															
	Riffle	10	305	407.9	0.9	1.3	1.1	0.23	-	B	C,S	N	5	3	IV	OV	-	C	MF
	Pool	63	263	2,682.6	0.0	10.2	7.6	0.42	0.29	S	C	N	3	0	DP	IV	-	C	MF
	Glide	27	545	1,153.6	0.8	2.1	2.1	0.33	-	C	S	N	4	2	IV	C	WL	C	MF

Notes: Substrate: R = bedrock; B = boulder (>256 mm); C = cobbles (64 - 256 mm); G = gravels (2 - 64 mm); S = fines (< 2 mm)
Spawning Gravels: H = extensive amounts; L = isolated pockets; N = none
Cover Type: B = boulders; C = undercut banks; DP = deep pools; IV = instream vegetation; LWD = large woody debris; SWD = small woody debris; OV = overhanging vegetation
Off-Channel Habitat: SC = side channel; SL = sloughs; PD = ponds; WL = seasonally flooded wetlands
Riparian Vegetation Type: C = coniferous forest; D = deciduous forest; M = mixed coniferous-deciduous forest; S = shrub; N = unvegetated
Riparian Vegetation Structure: MF = mature forest; YF = young forest; PS = pole-sapling stage; SHR = shrub/herb stage; INIT = non-vegetated or initial stage
m = metre; m^2 = metres squared; % = percent

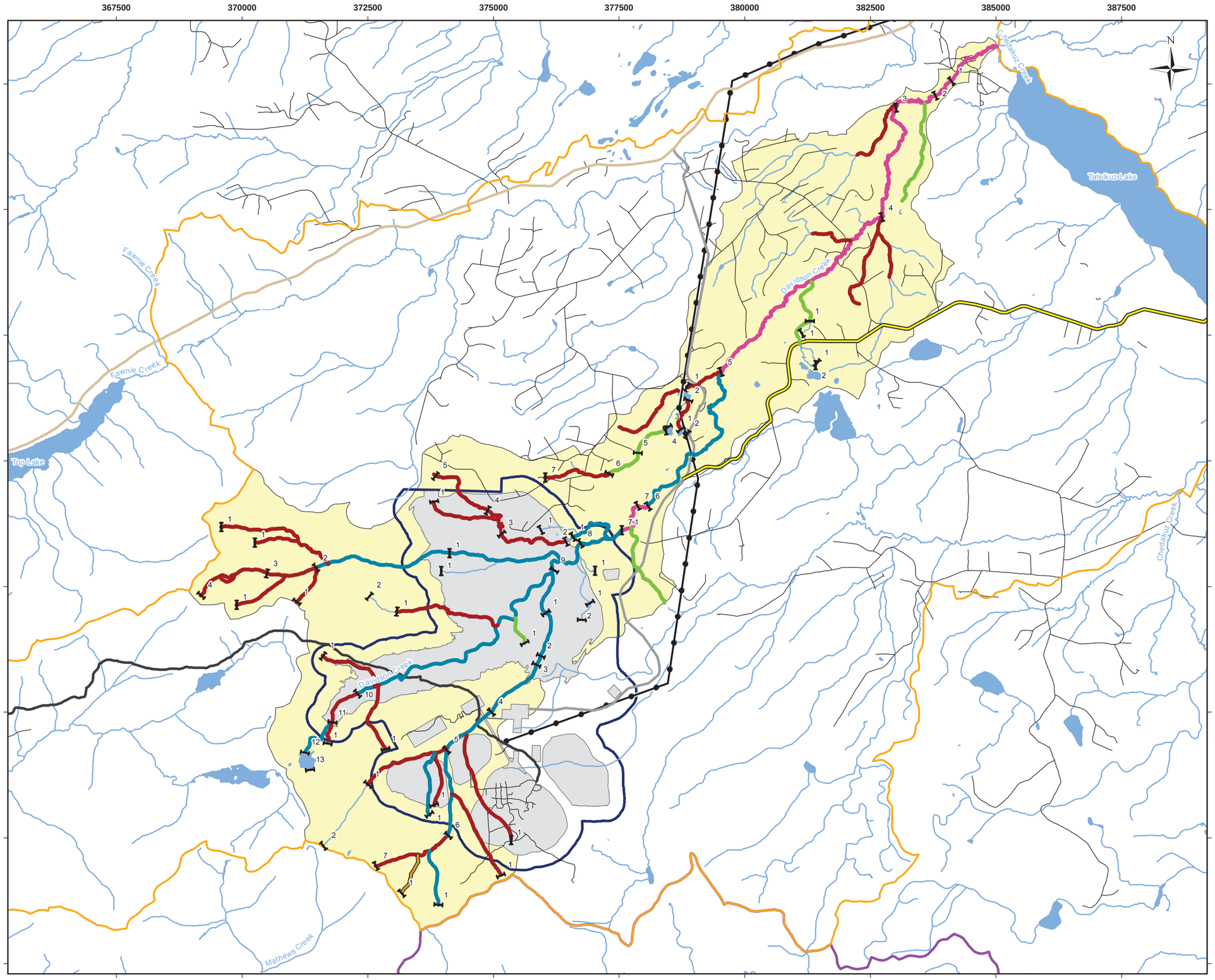
Table 5.8-3: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Davidson Creek Watershed, 2011 and 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology / Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692-522527	-	Davidson Creek	1	-	FI-66	4-Aug-12	4	S2	Riffle-pool with cobble	1.00	5.94	5.3	0.42	0.53	Gravel	<5	G	G	G	G
100-567134-610692-522527	-	Davidson Creek	2	-	FI-67	4-Aug-12	4	S2	Riffle-pool with cobble	0.88	7.29	5.02	0.36	0.33	Gravel	>20	G	G	G	G
100-567134-610692-522527	-	Davidson Creek	3	-	FI-68	6-Aug-12	4	S2	Riffle-pool with cobble	0.63	5.00	4.33	0.53	0.97	Gravel	<5	G	G	G	G
100-567134-610692-522527	-	Davidson Creek	4	-	FI-01	8-Aug-11	4	S2	Riffle-pool with cobble	1.75	5.38	5.67	0.58	0.57	Cobble	5-20	G	G	G	G
100-567134-610692-522527	-	Davidson Creek	5	-	FI-02	6-Aug-11	4	S2	Riffle-pool with cobble	3.17	5.14	4.55	0.3	0.43	Cobble	>20	F	G	G	F
100-567134-610692-522527	-	Davidson Creek	6	-	FI-03	17-Aug-11	4	S3	Riffle-pool with cobble	0.63	4.72	4.75	0.21	0.40	Cobble	5-20	F	F	G	G
100-567134-610692-522527	-	Davidson Creek	7	-	FI-04	17-Aug-11	4	S2	Riffle-pool with cobble	0.75	5.53	4.74	0.23	0.47	Cobble	5-20	F	F	G	G
100-567134-610692-522527	-	Davidson Creek	7.1	-	FI-05	19-Aug-11	4	S2	Cascade-pool with boulder	3.5	6.26	4.86	0.25	0.47	Boulder	>20	P	G	P	G
100-567134-610692-522527	-	Davidson Creek	8	-	FI-06	11-Aug-11	4	S3	Riffle-pool	2	1.90	2.02	0	0.97	Cobble	>20	G	G	G	NS
100-567134-610692-522527	-	Davidson Creek	9	-	FI-07	18-Aug-11	4	S3	Riffle-pool with cobble	0.63	5.27	5.01	0.38	0.47	Cobble	>20	G	G	F	G
100-567134-610692-522527	-	Davidson Creek	10	-	FI-08	7-Aug-11	2	S3	Riffle-pool	0.67	2.17	2.27	0.41	0.83	Boulder	>20	F	G	F	G
100-567134-610692-522527	-	Davidson Creek	11	-	FI-09	8-Aug-11	2	S4	Riffle-pool	2	1.42	1.42	0.18	0.47	Boulder	>20	P	G	P	G
100-567134-610692-522527	-	Davidson Creek	12	-	FI-10	10-Aug-11	1	S3	Riffle-pool	0.38	3.27	2.62	0.27	0.40	Fines	>20	P	P	P	F
100-567134-610692-522527-083617	-	Creek 083617	1	-	FI-69	6-Aug-12	1	NVC	NS	0.00	NS	NS	NS	NS	NS	<5	N	N	N	N
100-567134-610692-522527-114028	-	Creek 114028	1	-	FI-55	22-Jun-12	3	S4	Riffle-pool	3.13	1.05	1.09	0.17	0.30	Fines	>20	N	F	N	P
100-567134-610692-522527-114028	-	Creek 114028	2	-	FI-54	22-Jun-12	2	S4	Riffle-pool	1.25	1.12	1.27	0.28	0.33	Fines	<5	N	F	N	F
100-567134-610692-522527-226858	-	Creek 226858	1	-	FI-58	24-Jun-12	2	S4	Riffle-pool	1.67	0.57	1.18	0.15	0.43	Fines	<5	N	G	F	F
100-567134-610692-522527-262989	-	Creek 262989	1	-	FI-56	22-Jun-12	2	S4	Riffle-pool	0.88	0.88	1.00	0.12	0.23	Fines	>20	N	F	N	P
100-567134-610692-522527-226858-062193	-	Creek 062193	1	-	FI-57	24-Jun-12	1	S4	Riffle-pool with cobble	3.75	1.05	0.84	0.22	0.13	Fines	>20	P	F	N	P
100-567134-610692-522527-314089	-	Creek 314089	1	-	FI-111	18-Sep-12	2	NVC	NS	0.00	NS	NS	NS	NS	NS	<5	N	N	N	N
100-567134-610692-522527-428073	-	Creek 428073	1	-	FI-43	18-Jun-12	2	S4	Riffle-pool with gravel	0.63	0.77	0.99	0.15	0.17	Gravel	>20	P	F	G	F
100-567134-610692-522527-428073	-	Creek 428073	1	-	FI-70	5-Aug-12	2	S4	Riffle-pool with gravel	3.13	0.86	1.38	0.09	0.23	Fines	>20	P	G	F	F
100-567134-610692-522527-428073-184112	-	Creek 184112	1	-	FI-42	18-Jun-12	1	S4	Riffle-pool	0.88	0.93	0.92	0.17	0.23	Fines	>20	P	P	P	P
100-567134-610692-522527-428073	-	Creek 428073	5	-	FI-41	18-Jun-12	2	NVC	NS	0.00	NS	NS	NS	NS	NS	NS	N	F	N	N
100-567134-610692-522527-428073	-	Creek 428073	6	-	FI-40	18-Jun-12	2	NVC	NS	0.00	NS	NS	NS	NS	NS	NS	N	N	N	N
100-567134-610692-522527-428073	-	Creek 428073	7	-	FI-39	18-Jun-12	2	S6	Riffle-pool	1.38	0.98	1.10	0.16	0.30	Boulder	>20	P	F	P	N
100-567134-610692-522527-616152	-	Creek 616152	1	-	FI-71	6-Aug-12	1	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	NS0	N	N	N	N
100-567134-610692-522527-636713	-	Creek 636713	1	MP004	FI-26	11-Aug-11	1	S4	Riffle-Pool	4.5	1.48	1.19	0.15	0.45	Cobble	>20	N	P	P	P
100-567134-610692-522527-636713	-	Creek 636713	1	-	FI-60	24-Jun-12	3	S3	Riffle-pool with Cobble	2.00	1.53	1.27	0.19	0.20	Cobble	>20	F	G	P	F
100-567134-610692-522527-636713	-	Creek 636713	3	-	FI-72	1-Aug-12	2	S4	Riffle-pool with Gravel	1.00	1.33	1.23	0.27	0.43	Gravel	>20	G	G	G	G
100-567134-610692-522527-636713	-	Creek 636713	4	-	FI-73	1-Aug-12	1	S4	Riffle-pool	0.67	0.45	0.45	0.20	0.30	Fines	<5	N	F	N	G
100-567134-610692-522527-688328	-	Creek 688328	1	-	FI-94	7-Aug-12	3	S3	Riffle-pool with cobble	2.25	2.26	2.55	0.26	0.40	Cobble	<5	F	G	F	G
100-567134-610692-522527-688328	-	Creek 688328	2	-	FI-49	20-Jun-12	3	S3	Riffle-pool with Cobble	0.50	2.14	2.05	0.27	0.30	Cobble	>20	F	G	G	G
100-567134-610692-522527-688328	-	Creek 688328	2	-	FI-49	8-Aug-12	3	S3	Riffle-pool with Cobble	2.00	2.12	1.95	0.23	0.30	Cobble	>20	P	G	F	G
100-567134-610692-522527-688328	-	Creek 688328	3	-	FI-48	20-Jun-12	2	S4	Riffle-pool with Cobble	2.13	1.37	1.63	0.30	0.33	Cobble	>20	F	G	F	G
100-567134-610692-522527-688328	-	Creek 688328	3	-	FI-48	8-Aug-12	2	S4	Riffle-pool with Cobble	1.50	1.06	1.40	0.19	0.30	Cobble	5-20	N	G	P	G
100-567134-610692-522527-688328	-	Creek 688328	4	-	FI-50	20-Jun-12	1	S4	Riffle-pool with Cobble	3.00	1.24	1.20	0.13	0.30	Cobble	>20	P	F	P	P
100-567134-610692-522527-688328	-	Creek 688328	4	-	FI-50	8-Aug-12	1	S4	Riffle-pool with Cobble	2.67	0.86	0.56	0.05	0.23	Boulder	5-20	N	P	N	P
100-567134-610692-522527-688328-667871	-	Creek 667871	1	-	FI-47	20-Jun-12	1	S4	Riffle-pool	0.75	0.99	0.90	0.22	0.20	Fines	>20	N	P	N	P
100-567134-610692-522527-688328-667871	-	Creek 667871	1	-	FI-47	8-Aug-12	1	S4	Riffle-pool	5.00	0.77	0.68	0.15	0.17	Fines	5-20	N	P	N	P
100-567134-610692-522527-688328-634527	-	Creek 634527	1	-	FI-46	20-Jun-12	1	S4	Riffle-pool with Cobble	2.00	1.08	1.35	0.21	0.27	Cobble	>20	P	F	P	F
100-567134-610692-522527-688328-634527	-	Creek 634527	1	-	FI-46	8-Aug-12	1	S4	Riffle-pool with Cobble	0.70	0.81	0.86	0.04	0.43	Fines	5-20	N	G	N	P
100-567134-610692-522527-704454	-	Creek 704454	1	-	FI-74	9-Aug-12	3	S3	Riffle-pool with cobble	3.83	3.48	2.85	0.21	0.50	Cobble	5-20	G	G	G	G
100-567134-610692-522527-704454	-	Creek 704454	2	-	FI-75	7-Aug-12	3	S3	Cascade-pool with Cobble	5.00	3.18	2.88	0.18	0.57	Cobble	>20	G	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	3	-	FI-76	7-Aug-12	3	S3	Cascade-pool with Cobble	4.17	3.25	3.35	0.20	0.60	Cobble	>20	G	G	G	G
100-567134-610692-522527-704454	-	Creek 704454	4	-	FI-77	5-Aug-12	3	S3	Riffle-pool with cobble	3.33	2.59	2.02	0.17	0.50	Cobble	>20	G	G	F	F

Table continues…

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology / Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692-522527-704454	-	Creek 704454	5	-	FI-78	5-Aug-12	3	S3	Riffle-pool with cobble	3.33	2.17	2.34	0.18	0.40	Cobble	>20	F	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	5	-	FI-27	20-Aug-11	3	S4	Riffle-pool with cobble	2.25	1.97	2.24	0.23	0.47	Cobble	>20	F	G	P	G
100-567134-610692-522527-704454	-	Creek 704454	6	-	FI-62	26-Jun-12	3	S3	Riffle-pool with cobble	2.00	1.70	2.21	0.20	0.40	Cobble	>20	P	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	6	-	FI-62	5-Aug-12	3	S3	Riffle-pool with cobble	3.00	1.69	1.61	0.20	0.40	Cobble	>20	F	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	7	-	FI-79	7-Aug-12	3	S4	Cascade-pool with Cobble	11.67	0.60	0.00	0.00	0.27	Cobble	5-20	N	P	N	N
100-567134-610692-522527-704454-686326	-	Creek 686326	6	-	FI-100	7-Aug-12	3	S4	Cascade-pool with Cobble	5.33	0.93	0.67	0.01	0.27	Cobble	>20	N	P	N	N
100-567134-610692-522527-704454-853864	-	Creek 853864	1	-	FI-99	7-Aug-12	1	S3	Cascade-pool with Cobble	7.33	2.93	0.85	0.26	0.27	Cobble	>20	N	F	N	P
100-567134-610692-522527-704454-569241-076095	-	Creek 076095	1	-	FI-63	4-Aug-12	1	S3	Riffle-pool	0.50	1.55	0.82	0.16	0.47	Cobble	>20	N	F	N	P
100-567134-610692-522527-704454-569241-076095	-	Creek 076095	1	-	FI-63	26-Jun-12	1	S3	Riffle-pool	2.25	1.81	1.89	0.16	0.53	Fines	<5	N	F	N	P
100-567134-610692-522527-758727	-	Creek 758727	1	-	FI-80	2-Aug-12	1	NVC	NS	8.00	0.00	0.00	0.00	0.00	NS	>20	N	N	N	N
100-567134-610692-522527-776798	-	Creek 776798	1	-	FI-28	7-Aug-11	1	S4	Riffle-pool with gravel	6.33	0.69	0.58	0.13	0.27	Gravel	5-20	N	F	N	F
100-567134-610692-522527-776798	-	Creek 776798	1	-	FI-81	1-Aug-12	1	S4	Riffle-pool with cobble	1.83	0.96	0.94	0.19	0.47	Cobble	>20	F	G	G	F
100-567134-610692-522527-776798	-	Creek 776798	1	-	FI-53	21-Jun-12	1	S4	Riffle-pool	2.88	0.88	1.01	0.22	0.33	Fines	>20	P	F	N	P
100-567134-610692-522527-896157	-	Creek 896157	1	DS8-1	FI-29	8-Aug-11	1	S4	Riffle-pool with cobble	6.67	1.56	1.52	0.1	0.35	Cobble	<5	N	P	P	F
100-567134-610692-522527-899664	-	Creek 899664	1	DS8-2	FI-30	8-Aug-11	1	S4	Riffle-pool with gravel	5	1.18	1.03	0.13	0.37	Gravel	>20	N	F	G	G
100-567134-610692-522527-948457	-	Creek 948457	1	MP006	FI-31	13-Aug-11	1	S4	Riffle-pool	1.33	1.16	1.13	0.08	0.13	Boulder	<5	P	F	P	P
-	145	Unnamed Creek	1	KW002	FI-37	9-Aug-11	1	NVC	NS	18	NS	NS	NS	NS	NS	NS	N	N	N	N
-	144	Unnamed Creek	1	KW003	FI-36	9-Aug-11	1	NVC	NS	18	NS	NS	NS	NS	NS	NS	N	N	N	N
-	137	Unnamed Creek	1	KW005	FI-35	10-Aug-11	1	NVC	NS	45	NS	NS	NS	NS	NS	NS	N	N	N	N
-	136	Unnamed Creek	1	KW006	FI-34	10-Aug-11	1	NVC	NS	48	NS	NS	NS	NS	NS	NS	N	N	N	N
-	134	Unnamed Creek	1	KW007	FI-33	10-Aug-11	1	NVC	NS	40	NS	NS	NS	NS	NS	NS	N	N	N	N
-	127	Unnamed Creek	1	DS7-2	FI-32	7-Aug-11	1	NVC	NS	NS	NS	NS	NS	NS	NS	NS	N	N	N	N

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width



Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:75,000

0 0.5 1 2 3 4 5

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold		
PROJECT: Blackwater Gold Project		
Stream Classification Davidson Creek Watershed		
DATE: April, 2013	ANALYST: MY	**Figure** 5.8-2
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-059_stream_class_DC_v2.pdf
GIS FILE: 10-100-059_stream_class_DC_v2.mxd		amec
PROJECTION: UTM Zone 10	DATUM: NAD83	

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-059_stream_class_DC_v2.mxd

Reach 7.1 consists of cascade (31%), riffle (30%), glide (30%), and pool habitats (8%). Substrate composition is dominated by boulders and gravels, with cobbles being less frequent. Isolated pockets of spawning gravels are present in riffle and glide habitats. The presence of LWD is limited to riffle and cascade habitat only. Dominant and sub-dominant cover types are boulders and undercut banks, respectively. Total stream cover is greater than 20%. Riparian vegetation is dominated by mature conifers. Habitat quality for salmonids is rated as fair for overwintering and rearing and good for migration and spawning in Reach 7.1 of Davidson Creek.

Habitat in Reach 8 of Davidson Creek consists of riffles (52%), glides (33%), and pools (16%). Cobbles and gravels are the dominant and sub-dominant substrate types, respectively. Extensive amounts of spawning gravels are present in glide habitats. Overhanging vegetation and LWD provide the majority of stream cover (total stream cover was >20%), and riparian vegetation is a mixture of mature conifer and mixed species forest. Habitat quality for salmonids is not rated for migration (i.e., shown as “not specified” in **Table 5.8-3**) but is rated as good for spawning, rearing, and overwintering in Reach 8 of Davidson Creek.

Riffle habitat (55%) dominates Reach 9 of Davidson Creek, with smaller amounts of glide (28%) and pool habitat (16%), and a negligible amount of steep cascade habitat (<1% with a mean gradient of 6%). Dominant and sub-dominant substrate types are cobbles and gravels, respectively, with boulder substrates dominant in cascade habitat. Isolated pockets of spawning gravels are present in all habitat units. LWD dominates stream cover with a smaller amount of cobbles. Side channels provide off-channel stream habitat in riffles, pools, and glides. Habitat quality for salmonids is rated as fair for spawning and good for migration, rearing, and overwintering in Reach 9 of Davidson Creek.

Reach 10 consists primarily of glides (72%), with smaller amounts of pool (14%) and riffle (13%) habitats, and limited cascade (<1%) habitat. Substrate composition is dominated by cobbles and gravels, with fines being sub-dominant. Low to high quantities of spawning gravels are present in riffle, pool, and glide habitats. Deep pools, LWD, and boulders are the dominant stream cover types, with a total stream cover of 20%. Mature conifers comprise the majority of riparian vegetation. Side channels provided off-channel habitat in riffle, pool, and glide habitats. Habitat quality for salmonids is rated as fair for spawning and overwintering and good for migration and rearing in Reach 10 of Davidson Creek.

Riffles (47%) and glides (36%) are the dominant habitat types in Reach 11 of Davidson Creek, with smaller amounts of cascades (12%) and pools (5%) present. (However, the cascades were steep enough to constitute a partial barrier to upstream passage; at least during low summer flows if not suring freshet flows.) Substrate in this reach is dominated by boulders and gravels. Small isolated pockets of spawning gravels are present in cascade habitat. In-stream vegetation and deep pools provide the majority of stream cover within this reach (total stream cover is greater than 20%), while the riparian vegetation consists mainly of mature conifers. Habitat quality for salmonids is rated as fair for migration and poor for

spawning, rearing, and overwintering in Reach 11 of Davidson Creek. The fair rating for migration is not an accurate reflection of the true migration potential for Reach 11 because the section of stream that was surveyed did not include the steep cascades that are believed to be a partial barrier to upstream migration.

Reach 12 of Davidson Creek, directly downstream of Lake 01682LNRS, consists predominantly of pools (63%) and deep glides (27%). Riffle habitat comprises only 10% of the habitat types surveyed. Substrates in riffles, pools, and glides are dominated by boulders, fines, and cobbles. No suitable spawning gravels are present in any of the habitat types within this reach. Stream cover is provided by in-stream vegetation and deep pools, while seasonally-flooded wetlands provide off-channel fish habitat. Habitat quality for salmonids is rated as fair for migration and poor for spawning, rearing, and overwintering in Reach 12 of Davidson Creek.

5.8.1.4 Davidson Creek Tributaries

Smaller tributaries in upper Davidson Creek Watershed were surveyed in 2011 and 2012 and previously by CanFor from 1997 to 2006 for stream classifications purposes to support their riparian management practices. This section provides an overview of stream habitat within each of those tributaries using both the 2011-2012 data and historical data. **Figure 2.1-2** shows the names and locations of those tributaries, **Table 5.8-3** shows the 2011-2012 fish habitat data and **Annex 3.1-1** shows the historical stream fish habitat data.

Creek 428073 is a small, second-order stream that drains through a series of small ponds prior to connecting to Reach 5 of Davidson Creek. Sections of this stream in Reaches 5 and 6 are classified as NVC (**Figure 5.8-2**). Abundant stream cover and riffle-pool habitat provide good rearing habitat in sections of Creek 428073 where a defined channel exists. Substrates consist predominantly of cobbles, and spawning habitat quality is rated as fair. Small tributaries within this system contain good to fair rearing habitat quality and poor to no spawning habitat. No overwintering habitat is present in the system.

Creek 636713 is a third-order stream at its confluence in Reach 8 of Davidson Creek**,** draining a series of ponds and wetlands. Reach 1 is classified as S3, and provides good rearing habitat potential (**Figure 5.8-2)**. Reach 3 provides habitat quality ratings of good for all salmonid life histories, while Reach 4 provides good migration habitat and fair rearing habitat. Both Reaches 3 and 4 are classified as S4. Rearing habitat quality in Reach 5 is rated as good and moderate stream cover is available. **Table 5.8-4** and **Table 5.8-5** show FHAP survey data and reconnaissance (1:20,000) survey data for Creek 688328 and its tributaries, respectively. **Figure 5.8-1** shows a reach break analysis for Creek 688328, and **Figure 5.8-2** shows stream classifications.

Table 5.8-4: Summary of Creek 688328 Habitat Data, 2012

Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
1		100	269	627.7															
	Riffle	57	156	355.7	3.6	2.3	2.6	0.14		C,G	B,C,G	N,L,H	4	2	LWD,B,OV	LWD,B,OV,C	-	C	MF
	Pool	16	41	100.7	0.0	2.5	2.9	0.34	0.32	C,G	G,C	N,L	3	3	DP,LWD	LWD,C,DP	-	C	MF
	Glide	27	72	171.4	0.5	2.4	2.6	0.25		C,G	G,C	L,H	2	2	OV,SWD,C	LWD,C,SWD	-	C	MF
2		100	251	441.8															
	Riffle	41	107	182.5	3.1	1.7	1.6	0.12		C,G	G,C	L,N	0	0	OV,C	C,LWD,OV	-	SH,C	SHR,MF
	Pool	14	33	62.8	0.0	1.9	1.9	0.29	0.23	C	G	N	0	0	DP,OV	LWD,C	-	SH,C	SHR,MF
	Glide	44	111	196.5	1.5	1.8	1.9	0.21		C,G	G,C	N,L	1	0	OV,C	C,OV	-	SH,C	SHR,MF
3		100	257	262.7															
	Riffle	53	135	138.7	2.4	1.0	1.3	0.16		C	B,G	N,L	3	1	OV	C,LWD	-	C	MF
	Pool	19	49	51.0	0.0	1.0	2.0	0.35	0.26	C,B	S,G	N,L	2	1	OV,DP	LWD,OV	-	C	MF
	Glide	28	73	73.0	1.0	1.0	1.2	0.22		C,G	S,C	N,L	2	2	OV	LWD,C	-	C,SH	MF,SHR

Notes: Substrate: R = bedrock; B = boulder (>256 mm); C = cobbles (64 = 256 mm); G = gravels (2 - 64 mm); S = fines (< 2 mm)
Spawning Gravels: H = extensive amounts; L = isolated pockets; N = none
Cover Type: B = boulders; C = undercut banks; DP = deep pools; IV = instream vegetation; LWD = large woody debris; SWD = small woody debris; OV = overhanging vegetation
Off-Channel Habitat: SC = side channel; SL = sloughs; PD = ponds; WL = seasonally flooded wetlands
Riparian Vegetation Type: C = coniferous forest; D = deciduous forest; M = mixed coniferous-deciduous forest; S = shrub; N = unvegetated
Riparian Vegetation Structure: MF = mature forest; YF = young forest; PS = pole-sapling stage; SHR = shrub/herb stage; INIT = non-vegetated or initial stage
m = metre; m^2 = metres squared; % = percent

Table 5.8-5: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Creek 688328 and its Tributaries, 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692-522527-688328	-	Creek 688328	1	-	FI-94	7-Aug-12	3	S3	Riffle-pool with cobble	2.25	2.26	2.55	0.26	0.40	Cobble	<5	F	G	F	G
100-567134-610692-522527-688328	-	Creek 688328	2	-	FI-49	20-Jun-12	3	S3	Riffle-pool with Cobble	0.50	2.14	2.05	0.27	0.30	Cobble	>20	F	G	G	G
100-567134-610692-522527-688328	-	Creek 688328	2	-	FI-49	8-Aug-12	3	S3	Riffle-pool with Cobble	2.00	2.12	1.95	0.23	0.30	Cobble	>20	P	G	F	G
100-567134-610692-522527-688328	-	Creek 688328	3	-	FI-48	20-Jun-12	2	S4	Riffle-pool with Cobble	2.13	1.37	1.63	0.30	0.33	Cobble	>20	F	G	F	G
100-567134-610692-522527-688328	-	Creek 688328	3	-	FI-48	8-Aug-12	2	S4	Riffle-pool with Cobble	1.50	1.06	1.40	0.19	0.30	Cobble	5-20	N	G	P	G
100-567134-610692-522527-688328	-	Creek 688328	4	-	FI-50	20-Jun-12	1	S4	Riffle-pool with Cobble	3.00	1.24	1.20	0.13	0.30	Cobble	>20	P	F	P	P
100-567134-610692-522527-688328	-	Creek 688328	4	-	FI-50	8-Aug-12	1	S4	Riffle-pool with Cobble	2.67	0.86	0.56	0.05	0.23	Boulder	5-20	N	P	N	P
100-567134-610692-522527-688328-667871	-	Creek 667871	1	-	FI-47	20-Jun-12	1	S4	Riffle-pool	0.75	0.99	0.90	0.22	0.20	Fines	>20	N	P	N	P
100-567134-610692-522527-688328-667871	-	Creek 667871	1	-	FI-47	8-Aug-12	1	S4	Riffle-pool	5.00	0.77	0.68	0.15	0.17	Fines	5-20	N	P	N	P
100-567134-610692-522527-688328-634527	-	Creek 634527	1	-	FI-46	20-Jun-12	1	S4	Riffle-pool with Cobble	2.00	1.08	1.35	0.21	0.27	Cobble	>20	P	F	P	F
100-567134-610692-522527-688328-634527	-	Creek 634527	1	-	FI-46	8-Aug-12	1	S4	Riffle-pool with Cobble	0.70	0.81	0.86	0.04	0.43	Fines	5-20	N	G	N	P
-	95	Unnamed Creek	1	-	FI-95	7-Aug-12	1	S4	Cascade-pool with Cobble	3.00	0.73	0.61	0.10	0.33	Cobble	>20	N	F	P	N
-	96	Unnamed Creek	1	-	FI-96	4-Aug-12	1	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	>20	N	N	N	N

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width

Table 5.8-6: Summary of Creek 704454 Habitat Data, 2012

Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
1		100	253	910.2															
	Riffle	82	208	748.8	4.2	3.6	4.0	0.12		C	G	N,L	8	8	B,OV,LWD	C	-	C	MF
	Pool	8	21	71.4	0.0	3.4	2.8	0.25	0.28	C,G	G,C	N,L	2	2	DP,C	LWD	-	C	MF
	Glide	7	16	60.4	1.0	3.8	3.3	0.16		C	G	L,N	5	5	B,OV,LWD	C,B,LWD	-	C	MF
	Cascade	3	8	29.6	8.0	3.7	3.0	0.15		C	G	N	3	2	C	OV	-	C	MF
2		100	255	806.3															
	Riffle	47	124	378.2	4.2	3.1	2.9	0.11		C	B,G	N,L	8	6	C,B,LWD	C,B,LWD	-	C	MF
	Pool	11	29	85.1	0.0	2.9	3.2	0.35	0.34	C	B	L,N	2	2	DP	C,B,LWD	-	C	MF
	Glide	7	22	55.0	1.0	2.5	2.6	0.20		C	G	L	3	3	C,LWD	LWD,C	-	C	MF
	Cascade	36	80	288.0	7.7	3.6	3.9	0.08		C	B	N,L	12	9	B,C	LWD,DP	-	C	MF
3		100	263	901.7															
	Riffle	67	181	608.2	4.3	3.4	3.2	0.08		C,G	G,B,C	L,N	4	3	C,B,OV	LWD,B,C	-	C	MF
	Pool	11	28	98.5	0.0	3.5	3.1	0.33	0.41	C	G,B	L,N	6	6	DP	LWD,C	-	C	MF
	Glide	13	36	115.9	1.3	3.2	2.7	0.15		C	G,B	L,H	1	1	C,DP,B	LWD,B,DP,C	-	C	MF
	Cascade	9	18	79.2	9.2	4.4	3.7	0.10		C	B	N	2	1	LWD	B	-	C	MF
4		100	257	690.6															
	Riffle	64	159	445.2	4.2	2.8	2.5	0.16		C,B	B,C	N	2	2	OV,B	B,OV	-	C	MF
	Pool	19	51	131.3	0.0	2.6	2.8	0.35	0.35	C	B	N	1	1	DP,OV	OV,B,LWD	-	C	MF
	Glide	11	30	75.0	1.4	2.5	2.4	0.22		C,B	B,G,C	N,L	0	0	OV,C	B,OV	-	C	MF
	Cascade	6	17	39.1	11.0	2.3	1.4	0.35		B	C	L	1	1	B	OV	-	C	MF
5		100	246	578.0															
	Riffle	64	156	369.3	3.7	2.4	2.3	0.17		C,G	B,C,G	L,N	2	2	OV	B,C	-	C	MF
	Pool	17	37	98.1	0.0	2.7	2.7	0.31	0.25	C,G	G,C	N,L	1	1	DP	OV,B	-	C	MF
	Glide	19	53	110.6	1.0	2.1	2.7	0.21		C,G	G,C	L,N	0	0	OV,C	C,OV	-	C	MF
6		100	252	547.8															
	Riffle	68	157	373.7	3.8	2.4	2.2	0.17		C,G	G,C	L	6	4	C,LWD,OV	OV,C,B	-	C	MF
	Pool	18	53	100.7	0.0	1.9	2.1	0.27	0.36	C	G	L	2	1	DP,C	C,OV	-	C	MF
	Glide	10	34	56.7	1.6	1.7	2.2	0.14		C,G	G,C	L,H	1	1	C	LWD,OV	-	C	MF
	Cascade	3	8	16.8	9.0	2.1	2.3	0.12		C	G	L	4	3	C	LWD	-	C	MF

Notes: Substrate: R = bedrock; B = boulder (>256 mm); C = cobbles (64 - 256 mm); G = gravels (2 - 64 mm); S = fines (< 2 mm)
Spawning Gravels: H = extensive amounts; L = isolated pockets; N = none
Cover Type: B = boulders; C = undercut banks; DP = deep pools; IV = instream vegetation; LWD=- large woody debris; SWD = small woody debris; OV = overhanging vegetation
Off-Channel Habitat: SC = side channel; SL = sloughs; PD = ponds; WL = seasonally flooded wetlands
Riparian Vegetation Type: C = coniferous forest; D = deciduous forest; M = mixed coniferous-deciduous forest; S = shrub; N = unvegetated
Riparian Vegetation Structure: MF = mature forest; YF = young forest; PS = pole-sapling stage; SHR = shrub/herb stage; INIT = non-vegetated or initial stage
m = metre; m^2 = metres squared; % = percent

Table 5.8-7: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Creek 704454 and its Tributaries, 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692-522527-704454	-	Creek 704454	1	-	FI-74	9-Aug-12	3	S3	Riffle-pool with cobble	3.83	3.48	2.85	0.21	0.50	Cobble	5-20	G	G	G	G
100-567134-610692-522527-704454	-	Creek 704454	2	-	FI-75	7-Aug-12	3	S3	Cascade-pool with Cobble	5.00	3.18	2.88	0.18	0.57	Cobble	>20	G	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	3	-	FI-76	7-Aug-12	3	S3	Cascade-pool with Cobble	4.17	3.25	3.35	0.20	0.60	Cobble	>20	G	G	G	G
100-567134-610692-522527-704454	-	Creek 704454	4	-	FI-77	5-Aug-12	3	S3	Riffle-pool with cobble	3.33	2.59	2.02	0.17	0.50	Cobble	>20	G	G	F	F
100-567134-610692-522527-704454	-	Creek 704454	5	-	FI-78	5-Aug-12	3	S3	Riffle-pool with cobble	3.33	2.17	2.34	0.18	0.40	Cobble	>20	F	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	5	-	FI-27	20-Aug-11	3	S4	Riffle-pool with cobble	2.25	1.97	2.24	0.23	0.47	Cobble	>20	F	G	P	G
100-567134-610692-522527-704454	-	Creek 704454	6	-	FI-62	26-Jun-12	3	S3	Riffle-pool with cobble	2.00	1.70	2.21	0.20	0.40	Cobble	>20	P	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	6	-	FI-62	5-Aug-12	3	S3	Riffle-pool with cobble	3.00	1.69	1.61	0.20	0.40	Cobble	>20	F	G	F	G
100-567134-610692-522527-704454	-	Creek 704454	7	-	FI-79	7-Aug-12	3	S4	Cascade-pool with Cobble	11.67	0.60	0.00	0.00	0.27	Cobble	5-20	N	P	N	N
100-567134-610692-522527-704454-686326	-	Creek 686326	1	-	FI-100	7-Aug-12	3	S4	Cascade-pool with Cobble	5.33	0.93	0.67	0.01	0.27	Cobble	>20	N	P	N	N
100-567134-610692-522527-704454-853864	-	Creek 853864	1	-	FI-99	7-Aug-12	1	S3	Cascade-pool with Cobble	7.33	2.93	0.85	0.26	0.27	Cobble	>20	N	F	N	P
100-567134-610692-522527-704454-569241-076095	-	Creek 076095	1	-	FI-63	4-Aug-12	1	S3	Riffle-pool	0.50	1.55	0.82	0.16	0.47	Cobble	>20	N	F	N	P
100-567134-610692-522527-704454-569241-076095	-	Creek 076095	1	-	FI-63	26-Jun-12	1	S3	Riffle-pool	2.25	1.81	1.89	0.16	0.53	Fines	<5	N	F	N	P
-	98A	Unnamed Creek	1	-	FI-98	7-Aug-12	1	S4	Cascade-pool with Cobble	7.67	1.02	0.83	0.14	0.30	Cobble	>20	N	F	N	P

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width

Creek 688328 is a small headwater tributary that channels flow from several first-order streams (and one second-order stream) into Reach 9 of Davidson Creek. The mainstem of Creek 688328 is dominated by riffle habitat in all reaches, with a slightly higher percentage of glide habitat in Reach 2. Low quality salmonid spawning gravels are found throughout, and cobble is the dominant substrate type. Habitat quality for salmonid rearing and migration is rated high in Reaches 1, 2, and 3 of Creek 688328, and poor in Reach 4.

All other first-order tributaries to Creek 688328 generally lack residual pool depth and quality spawning substrates; and therefore provide mostly poor overwintering and spawning habitat. Stream cover varies in these tributaries, and rearing habitat quality ranges from poor to good.

Creek 704454 drains several first order tributaries from the ridge adjacent to Mount Davidson north to northeast, meeting the mainstem of Davidson Creek in lower Reach 10. **Table 5.8-6** and **Table 5.8-7** show FHAP survey data and reconnaissance (1:20,000) survey data for Creek 704454 and its tributaries, respectively. **Figure 5.8-1** shows a reach break analysis for Creek 704454, and **Figure 5.8-2** shows stream classifications.

The mainstem of Creek 704454 is dominated by riffle habitat in all reaches observed. Mean gradients vary from low to moderate, and cobble is the dominant substrate type in all reaches. Isolated patches of low quality spawning gravels are present throughout. Cover type varies from reach to reach, while riparian vegetation consists entirely of mature coniferous forest. Creek 704454 is generally low- to moderate-gradient, but the mean gradient increased significantly in Reach 7. Habitat quality for all salmonid life histories is rated either good or fair in Reaches 1 through 5 of Creek 704454. Overwintering and spawning habitat quality dropped due to minimal residual pool depths and poor spawning gravels in Reaches 5 and 6, and the stream was dry in Reach 7 at the time of assessment.

Several other cascade-dominant, first-order tributaries contribute flow to Creek 704454. These tributaries provide poor to fair rearing habitat and poor migration habitat. No spawning or overwintering habitat was observed.

5.8.1.5 Overwintering Habitat

Overflights of the LSA conducted in March 2012 and March 2013 (unpublished data) showed that the lower section (Reach 1) and the upper section (Reaches 10 to 12 plus Lake 01628LNRS) of Davidson Creek were covered with ice during both winters. Tributaries to the upper and middle sections of Davidson Creek were also covered with ice. However, in 2013, the middle section (Reaches 2 to 9) of Davidson Creek showed long areas of open water. These were probably caused by groundwater inflows.

Based on mean under-ice DO concentrations and water depths, four of the five stream sites in the Davidson Creek Watershed that were observed in March 2012 were given an overwintering habitat quality rating of good (i.e., mean DO concentrations greater than 7 mg/L) (**Table 5.8-8**). The exception is Creek 428073, with an overwintering habitat quality

rating of poor. That site is located in a pond, where minimal winter flows resulted in a thick ice cover and lower DO concentrations.

Table 5.8-8: Winter Water Quality and Dissolved Oxygen Concentrations in the Davidson Creek Watershed, March 2012

Watershed	Stream/ Lake Name	Reach	Site Number	Habitat Type	Mean Ice Depth (m)	Mean Water Depth (m)	Mean Dissolved Oxygen (mg/L)	Over-wintering Habitat Quality
Davidson Creek	Davidson Creek	1	DO-09	Pool/Glide	0.48	0.59	11.0	Good
Davidson Creek	Davidson Creek	8	DO-08	Pool	0.04	0.60	10.4	Good
Davidson Creek	Davidson Creek	10	DO-06	Pool	0.05	0.45	9.2	Good
Davidson Creek	Creek 428073	1	DO-10	Pond	1.15	0.15	4.4	Poor
Davidson Creek	Creek 688328	2	DO-04	Pool	0.05	0.28	9.9	Good

Notes: m = metres; mg/L = milligrams per litre

In summary, good overwintering habitat was present at four of five sites in Davidson Creek in 2012. However, the mean depth of water beneath the ice was low; ranging from 0.15 to 0.60 m, so the total volume of overwintering habitat available to resident fish was low, at least compared to the volume that is assumed to be available in Tatelkuz Lake and Lake 01628LNRS.

5.8.2 Turtle Creek Watershed

Turtle Creek Watershed has an area of 60 km^2, and ranges in elevation from approximately 1,270 masl at its headwaters to 940 masl at the confluence with Chedakuz Creek (**Figure 2.1-3**).

5.8.2.1 General Description

Turtle Creek is a fourth-order stream that flows northeast to its confluence with Chedakuz Creek, approximately 3 km downstream of the outlet of Tatelkuz Lake (**Figure 2.1-3**). Turtle Creek meanders approximately 21 km from its headwaters east of Top Lake to the confluence with Chedakuz Creek.

In the lower to middle reaches, the gradient of Turtle Creek is controlled by a combination of natural underlying glacial sediments and beaver ponds. As a result, multiple shallow ponds and wetlands have formed, particularly in the lower half of the watershed. While some of the ponds are created from beaver activity and thus temporary, others are more permanent and governed by natural gradient breaks and impermeable soils. Many of these ponds and wetlands are shallow and occupy the entire valley floor, and the riparian zone is dominated by sedges, shrub alder and birch, and black spruce.

Creek 700, the main tributary of Turtle Creek, flows north from the flanks of Mt. Davidson and drains several small first-order tributaries and wetlands near its headwaters (**Figure 2.1-3**). Creek 700 ranges in elevation from 1,580 masl in the upper headwaters to 1,065 masl at its confluence with Turtle Creek.

5.8.2.2 Reach Break Analysis

Reach 1 of Turtle Creek is approximately 3,400 m in length with a low mean gradient (0.5%) (**Table 5.8-9** and **Figure 5.8-3**). It flows through a large unconfined wetland complex that occupies an inactive alluvial fan near the confluence at Chedakuz Creek. Beaver activity upstream of the Ootsa FSR has resulted in the abandoment of an historical channel on the west side of the wetland complex, and the redirection of flow through the main channel along the eastern edge.

Reach 2 is characterized by increasing stream channel confinement, riffle-pool habitat, and cobble and gravel substrates. Mean gradient increases to 2.2% within this section of Turtle Creek.

Large wetland complexes and multiple channels are present throughout Reach 3, and mean gradient is less than 1%.

Reach 4 is approximately 740 m long, low-gradient, and frequently confined by valley walls along its length.

Reach 5 is low-gradient and influenced by narrow wetland complexes. It is occasional confined.

Reach 6 of Turtle Creek is a short, 260 m channel that is dominated by a flooded wetland complex. It transitions to Reach 7, a low-gradient, wetland-influenced section extending more than 4 km upstream.

Reaches 8 through 14 (all less than 500 m in length) consist of a series of flooded wetland complexes interspersed by higher gradient sections that have well-defined channels.

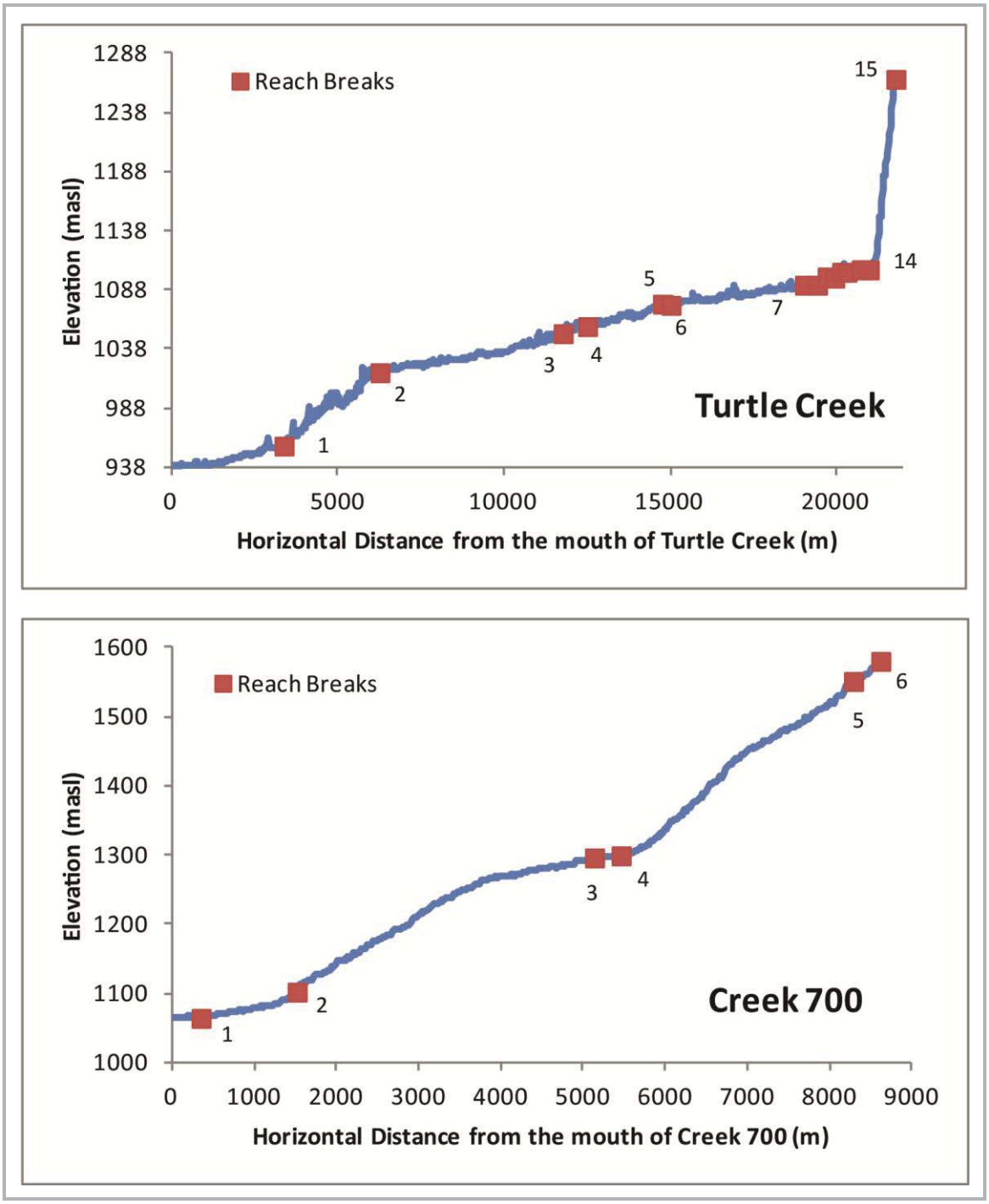
Turtle Creek terminates in Reach 15, an 800 m-long section that has a mean stream gradient of approximately 20%.

Creek 700 flows into Reach 5 of Turtle Creek (**Figure 2.1-3**). Reach 1 of Creek 700 is a short, low-gradient reach located within wetland complex in the lower valley of Turtle Creek. Mean gradient increases to 3.3% in Reach 2, and is dominated by gravel and cobble substrates. Channel confinement and mean gradient increases to 5.4% in Reach 3 for a distance of 1,200 m. Mean gradient drops to 0.9% in Reach 4 of Creek 700 and becomes influenced by drainage from a large wetland complex along the east bank margin. Reaches 5 and 6 are governed by steeper stream gradients.

Table 5.8-9: Reach Descriptions of Turtle Creek and Creek 700

Stream	Reach No.	Stream Order	Reach Length (km)	Approximate Reach Gradient (%)
Turtle Creek	1	4	3.37	0.5
	2	4	2.89	2.1
	3	3	5.51	0.6
	4	3	0.74	0.8
	5	3	2.26	0.8
	6	2	0.26	-0.4
	7	2	4.01	0.4
	8	2	0.39	0.0
	9	2	0.29	2.4
	10	2	0.23	-0.4
	11	2	0.21	2.4
	12	1	0.17	0.0
	13	1	043	0.5
	14	1	0.24	0.0
	15	1	0.80	20.1
Creek 700	1	2	0.35	-0.3
	2	2	1.17	3.2
	3	2	3.62	5.4
	4	2	0.32	0.9
	5	1	2.83	8.9

Notes: km = kilometre; % = percent



Notes: m = metre; masl = metres above sea level;

Figure 5.8-3: Stream Gradient Profiles for the Turtle Creek Watershed

5.8.2.3 Stream Habitat and Classification

Reach 1 of Turtle Creek is dominated by glides (93%) with minimal pool habitat (7%) and no riffles (**Table 5.8-10** and **Table 5.8-11** and **Figure 5.8-4**). Large channel stream morphology dominated by fine substrates characterizes this wetland reach. No spawning gravels are present. Stream cover is provided mainly by overhanging vegetation. Small woody debris (SWD) and instream vegetation are sub-dominant cover types. Total stream cover is greater than 20%. Riparian vegetation consists of shrubs. Functional LWD is absent due to lack of a mature forest canopy. Flow in the abandoned channel on the west side of wetland complex disperses with no visible channel evident in lower reach near Chedakuz Creek. Habitat quality is rated as poor for spawning and overwintering and fair for migration and rearing in Reach 1 of Turtle Creek (**Table 5.8-11**).

Riffle habitat (69%) is the dominant habitat type in Reach 2, with only minor amounts of glide (21%) and pool habitats (10%). Reach 2 contains the highest amount of riffle habitat in comparison to other reaches in Turtle Creek, which are typically dominated by glides. Cobbles are the dominant substrate type in all habitat types, and gravels and fines are sub-dominant. Spawning gravels are present in isolated pockets of pool habitat only. Overhanging vegetation, deep pools, and undercut banks are the dominate stream cover types in riffles, pools, and glides, respectively. Total stream cover is greater than 20%. Side channels are present. Riparian vegetation consists of mature coniferous forests. Habitat quality is rated as poor for spawning, fair for migration and rearing, and good for overwintering in Reach 2 of Turtle Creek (**Table 5.8-11**).

Reach 3 of Turtle Creek consists of glide (86%) and pool (14%) habitats through this wetland dominated reach. Fines and gravels are the dominant and sub-dominant substrate types, respectively. No spawning gravels are present within the surveyed area. Total stream cover is greater than 20% with dominant cover types consisting of instream vegetation and deep pools. Riparian vegetation is comprised primarily of shrubs, which accounts for little functional LWD in the stream. Habitat quality is rated as poor for spawning and good for migration, rearing, and overwintering in Reach 3 of Turtle Creek (**Table 5.8-11**).

Glide habitat (70%) dominates Reach 4, with a smaller amount of pool habitat (27%), and a trace of riffle habitat (3%). Substrate composition is consistent with other reaches in Turtle Creek, consisting mostly of fines with some gravel. Isolated pockets of spawning gravels are present only in pool habitat. Large and small woody debris and overhanging vegetation provide the majority of stream cover. Total stream cover is greater than 20%. Riparian vegetation consists of a mixture of shrubs and mature conifers. Habitat quality is rated as poor for spawning, and good for migration, rearing, and overwintering in Reach 4 of Turtle Creek (**Table 5.8-11**).

Table 5.8-10: Summary of Turtle Creek Fish Habitat Data, 2011

Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
1		100	105	178.5															
	Pool	7	7	11.9	0.0	1.7	1.5	0.30	0.25	S		N	0	0	OV	SWD	-	S	SHR
	Glide	93	98	166.6	0.5	1.7	1.5	0.20	-	S		N	4	0	OV	IV	-	S	SHR
2		100	252	844.0															
	Riffle	69	157	586.1	0.8	3.7	3.2	0.27	-	C	G	N	13	4	OV	LWD	SC	C	MF
	Pool	10	29	84.1	0.0	2.9	3.0	0.48	0.37	G,C	S	L	3	1	DP	LWD,OV	-	C	MF
	Glide	21	66	173.8	1.0	2.6	2.4	0.40	-	C	S	N	3	0	C	OV	-	C	MF
3		100	256	1,189.5															
	Pool	14	37	171.1	0.0	4.6	4.6	0.73	0.63	S	G	N	0	0	DP	OV	-	S	SHR
	Glide	86	219	1,018.4	0.7	4.7	4.8	0.30	-	S	G	N	0	0	IV	C	-	S	SHR
4		100	267	1,140.7															
	Riffle	3	8	31.6	0.8	4.0	3.9	0.28	-	S,C	G	N	6	3	SWD	OV	-	C,S	SHR,MF
	Pool	27	75	305.6	0.0	4.1	4.2	0.46	0.34	S	G	L	3	2	LWD,DP	OV	-	S,C	SHR,MF
	Glide	70	184	803.5	1.2	4.4	4.4	0.33	-	S	G	N	11	3	LWD	OV	-	S,C	SHR,MF
5		100	180	431.2															
	Pool	17	15	75.0	0.0	5.0	4.8	0.84	0.84	S	G	N	8	0	OV	DP	SL	S	SHR
	Glide	83	78	356.2	0.7	4.6	4.2	0.55	-	S	G	N	3	2	OV	IV	-	M	MF

Notes: Substrate: R = bedrock; B = boulder (>256 mm); C = cobbles (64 - 256 mm); G = gravels (2 - 64 mm); S = fines (< 2 mm)
Spawning Gravels: H = extensive amounts; L = isolated pockets; N – none
Cover Type: B = boulders; C = undercut banks; DP = deep pools; IV = instream vegetation; LWD = large woody debris; SWD = small woody debris; OV = overhanging vegetation
Off-Channel Habitat: SC = side channel; SL = sloughs; PD = ponds; WL = seasonally flooded wetlands
Riparian Vegetation Type: C = coniferous forest; D = deciduous forest; M = mixed coniferous-deciduous forest; S = shrub; N – unvegetated
Riparian Vegetation Structure: MF = mature forest; YF = young forest; PS = pole-sapling stage; SHR = shrub/herb stage; INIT–– non-vegetated or initial stage
m = metre; m^2 = metres squared; % = percent

Table 5.8-11: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments for the Turtle Creek Watershed, 2011 and 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean BfW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean BfD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692-480511	-	Turtle Creek	1	-	FI-17	16/08/2011	4	S3	Riffle-pool	0.13	2.37	2.18	0.16	0.43	Fines	>20	P	F	P	F
100-567134-610692-480511	-	Turtle Creek	2	-	FI-18	09/08/2011	4	S3	Riffle-pool	0.50	3.02	2.78	0.29	0.70	Bedrock	>20	G	F	P	F
100-567134-610692-480511	-	Turtle Creek	3	-	FI-19	16/08/2011	3	S3	Riffle-pool	0.38	4.14	4.26	0.35	0.73	Fines	>20	G	G	P	G
100-567134-610692-480511	-	Turtle Creek	4	-	FI-20	15/08/2011	3	S3	Riffle-pool	0.63	4.67	4.71	0.31	0.53	Fines	>20	G	G	P	G
100-567134-610692-480511	-	Turtle Creek	5	-	FI-21	09/08/2011	3	S3	Large Channel	0.5	5.32	4.65	0.84	0.97	Fines	>20	G	G	F	G
100-567134-610692-480511-645840	-	Creek 700	1	-	FI-22	10/08/2011	2	S2	Large Channel	0.5	9.50	8.90	1.20	1.40	Fines	5-20	G	G	P	P
100-567134-610692-480511-645840	-	Creek 700	2	-	FI-23	10/08/2011	2	S3	Riffle-pool with gravel	1.63	3.55	3.47	0.31	1.10	Gravel	5-20	G	G	G	G
100-567134-610692-480511-645840	-	Creek 700	3	-	FI-24	09/08/2011	2	S3	Riffle-pool with cobble	7.25	2.41	2.41	0.42	0.50	Bedrock	>20	N	F	P	P
100-567134-610692-480511-645840	-	Creek 700	3	-	FI-24	05/09/2012	2	S3	Cascade pool	6.67	2.62	2.25	0.24	0.17	Cobble	5-20	P	F	G	NS
100-567134-610692-480511-645840	-	Creek 700	4	-	FI-25	05/09/2011	2	S4	Large Channel	0.67	1.13	0.78	0.15	0.13	Fines	>20	N	F	N	NS
100-567134-610692-480511-645840	-	Creek 700	5	-	FI-101	15/09/2012	2	S4	Riffle-pool with gravel	2.38	1.55	1.06	0.23	0.23	Gravel	>20	P	G	F	F

Notes: [1] Habitat Quality: G- good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; m = metre; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width

370000 372500 375000 377500 380000 382500

5910000 5907500 5905000 5902500 5900000

Davidson Creek

Davidson Creek

Davidson Creek

Rawhide Creek

Rawhide Creek

N

Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:50,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold	
PROJECT: Blackwater Gold Project	
Stream Classification Turtle Creek Watershed	
DATE: April, 2013	ANALYST: MY
JOB No: VE52095	QA/QC: IM
GIS FILE: 10-100-060_stream_class_TC_v2.mxd	PDF FILE: 10-100-060_stream_class_TC_v2.pdf
PROJECTION: UTM Zone 10	DATUM: NAD83

Figure 5.8-4

amec

Y:\GIS\Projects\VE\VE52095 Richfield Blackwater\Mapping\10 fisheries-aquatics\Baseline\10-100-060_stream_class_TC_v2.mxd

Reach 5 is similar to most other lower reaches of Turtle Creek in terms of both habitat type and substrate composition. This reach contains abundant wetlands, large channel morphology, and glide (83%) and pool (17%) habitat types. Substrates are dominated by fines with limited gravels. No suitable spawning gravels are present in the reach. Overhanging vegetation is the predominant cover type and total stream cover is greater than 20%. Riparian vegetation is a mixture of shrubs and mature conifers. Sloughs associated with wetland complexes are the primary off-channel habitat type. Habitat quality is rated as fair for spawning, and good for migration, rearing, and overwintering in Reach 5 of Turtle Creek (**Table 5.8-11**).

Reach 7 of Turtle Creek was assessed during field surveys completed by Ecofor in 2004 (**Annex 3.1-1**), and poor quality rearing and spawning habitat conditions were reported for riffle-pool habitats. Residual pool depths are low and not suitable for overwintering.

No stream habitat data have been collected for Reaches 6 and 8 through 14 of Turtle Creek. Reach 15 was assessed by Ecofor in 2004, and a mean gradient of 21.25% was reported. This reach provides no suitable spawning, rearing, or overwintering habitat.

5.8.2.4 Creek 700

Reach 1 of Creek 700 is low-gradient and contains large-channel habitat with fine substrates and poor quality spawning habitat. Habitat quality is rated as poor for spawning, and good for migration, rearing, and overwintering in Reach 1 of Creek 700 (**Table 5.8-11**).

Reach 2 of Creek 700 contains riffle-pool habitats with gravel substrates and good spawning habitat. Habitat quality is rated as good for migration, spawning, rearing, and overwintering in Reach 2 of Creek 700 (**Table 5.8-11**).

Reaches 3 through 5 have total stream cover ranging from moderate (5 to 20%) to abundant (>20%). Riffle-pool habitats with cobble/bedrock substrates are present in Reaches 3 and 5, and large channel habitat exists in Reach 4. Habitat quality is rated as poor to fair for migration and spawning, fair to good for rearing, and none to poor for overwintering in Reaches 3 through 5 of Creek 700 (**Table 5.8-11**).

Three tributaries flowing into Reaches 3, 4, and 5 of Creek 700 were assessed in 2004 by Ecofor (**Annex 3.1-1**). These first-order tributaries are small, had relatively steep gradients, and contain poor habitat quality for all salmonid life stages.

5.8.2.5 Overwintering Habitat

Overflights of the LSA conducted in March 2012 and March 2013 (unpublished data) showed that the lower section (Reaches 1 and 2) of Turtle Creek was covered with ice in both winters. However, in 2013 the middle and upper sections contained sections of open water, likely caused by groundwater inflows.

Overwintering habitat quality is rated as good in a ponded section of Reach 1 of Turtle Creek (**Table 5.8-12**). Mean water depth is minimal, but DO concentration is more than sufficient for overwintering fish populations. In Reach 2 of Turtle Creek, all pool and glide sections were frozen to bottom in March 2012, and water was observed below ice in riffles only.

Table 5.8-12: Winter Water Quality and Dissolved Oxygen Concentrations in Turtle Creek Watershed, March 2012

Watershed	Stream/Lake Name	Reach	Site Number	Habitat Type	Mean Ice Depth (m)	Mean Water Depth (m)	Mean Dissolved Oxygen (mg/L)	Overwintering Habitat Quality
Turtle Creek	Turtle Creek	1	DO-01	Other	1.19	0.11	10.1	Good
Turtle Creek	Turtle Creek	3	DO-02	Pool/Glide	0.80	0.03	-	None

Notes: m = metres; mg/L = milligrams per litre

In summary, good overwintering habitat is present at one of two sites in Turtle Creek in 2012. However, the mean depth of water beneath the ice was low; ranging from 0.80 to 1.19 m, thus the total volume of overwintering habitat available to resident fish was low, at least compared to the volume that is assumed to be available in Tatelkuz Lake.

5.8.3 Creek 661 Watershed

Creek 661 Watershed has an area of 67.4 km^2, and the creek is approximately 21 km in length (**Figure 2.1-4**). Elevations range from 1,550 masl in the headwaters to 980 masl at the confluence with Chedakuz Creek.

5.8.3.1 General Description

Creek 661 is a fourth-order stream that flows along the eastern flanks of Mount Davidson (**Figure 2.1-4**). It flows in a northeast direction to its confluence with upper Chedakuz Creek between Tatelkuz and Kuyakuz lakes.

Creek 505659 is a second-order stream that flows northeast into Reach 5 of Creek 661 (**Figure 2.1-4**). The mainstem of Creek 505659, along with its associated first-order tributaries, drains several headwater wetlands located to the west of Creek 661.

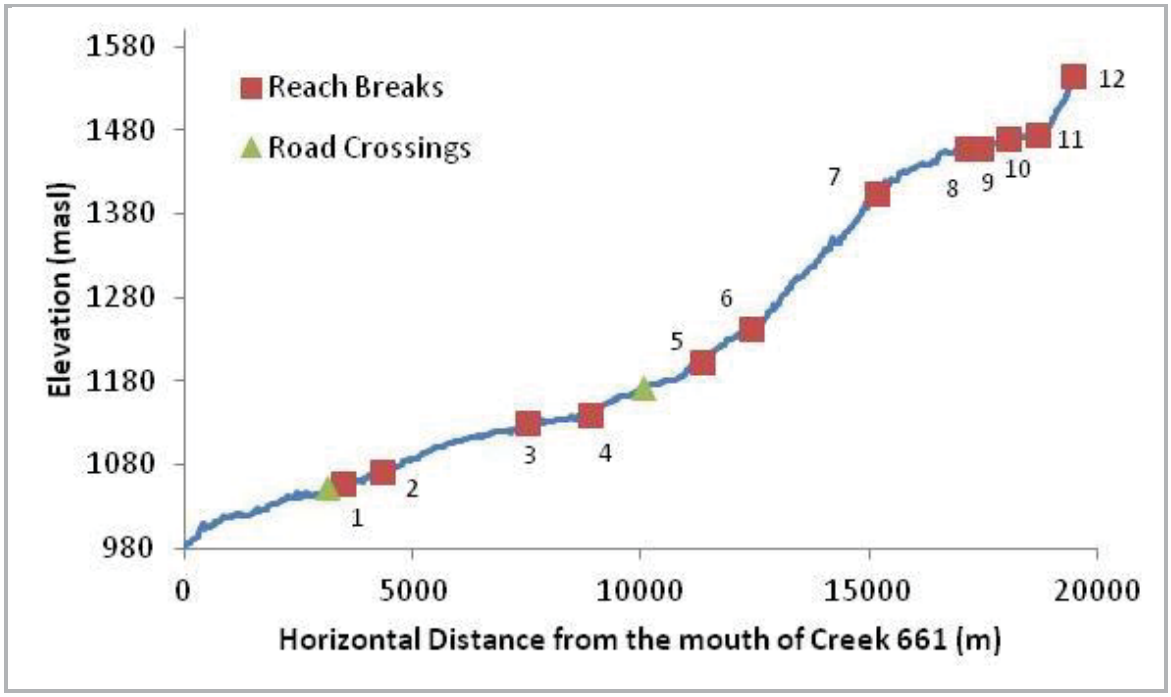
5.8.3.2 Reach Break Analysis

Reach 1 of Creek 661 is approximately 3.5 km in length, with a mean gradient of 2.2%, and is laterally stable within a small incised valley (**Table 5.8-13** and **Figure 5.8-5**).

Table 5.8-13: Reach Descriptions of Creek 661

Stream	Reach No.	Stream Order	Reach Length (km)	Approximate Reach Gradient (%)
Creek 661	1	4	3.48	2.2
	2	4	0.82	1.7
	3	4/3	3.22	1.8
	4	3	1.37	0.7
	5	3	2.46	2.6
	6	2	1.07	3.7
	7	2	2.75	5.9
	8	2	1.95	2.7
	9	2	0.30	0.7
	10	2	0.60	1.8
	11	2	0.66	0.6
	12	1	0.80	9.1

Notes: km = kilometre; % = percent



Notes: m = metre; masl = metres above sea level

Figure 5.8-5: Stream Gradient Profile of Creek 661

In Reach 2, Creek 661 flows for approximately 800 m through a series of small wetland complexes. Mean gradient (1.7%) is slightly lower than in Reach 1.

Reach 3 is 3.2 km in length with an irregular wandering stream pattern and a mean stream gradient of 1.8%. Two tributaries drain from the south into Reach 3.

In Reach 4, stream gradient drops to 0.7%. Beaver ponds and associated flooding are common through the mid-sections, while other sections of Reach 4 contain a sinuous channel pattern.

Reaches 5 through 8 of Creek 661 have moderate gradients ranging from 2.6 to 5.9%. These reaches flow relatively straight through a confined valley.

Reach 9 is a small unnamed headwater lake.

Reaches 10 and 11 are low-gradient (<1%), unconfined, and dominated by frequent wetland complexes.

Reach 12 does not have a visible channel; terrain in this area has a gradient of 9%.

Creek 505659, a small tributary that originates from the Project mine site, has two main branches that join prior to flowing into Reach 5 of Creek 661. The main branch of Creek 505659 has a length of 2.5 km and a mean stream gradient of 2.6%. Creek 505659 is confined to a shallow incised valley containing infrequent small wetland features.

5.8.3.3 Stream Habitat and Classification

Habitat in the Creek 661 Watershed is generally similar to that of the Davidson Creek Watershed, although more wetlands and beaver impoundments are present in the middle reaches of Creek 661 than in Davidson Creek.

Reach 1 of Creek 661 consists mostly of glides (44%), with smaller amounts of pools (30%) and riffles (26%) (**Table 5.8-14** and **Table 5.8-15** and **Figure 5.8-6**). Substrate is composed of gravels and cobbles, including high- and low-quality spawning gravels that are distributed throughout the reach. Cover type varies with habitat type, with overhanging vegetation and SWD providing most of the cover in rifles, depth providing most of the cover in pools, and overcut banks and LWD providing most of the cover in glides. Off-channel habitat is available in Reach 1 in the form of ponds. Riparian vegetation is dominated by mature coniferous forest. Habitat quality is rated as good for migration, spawning, rearing, and overwintering (**Table 5.8-15**).

Riffles account for 51% of the habitat observed in Reach 2 of Creek 661. Spawning gravels are present in all habitat types, and higher quality gravels are available in riffles and glides. Cover types in Reach 2 are dominated by cobbles, deep pools, and LWD. Side channels provide off-channel habitat in this reach. Riparian vegetation is dominated by mature coniferous forest. Habitat quality is rated as fair for overwintering and good for migration, spawning, and rearing (**Table 5.8-15**).

Table 5.8-14: Summary of Creek 661 Habitat Data, 2011 and 2012

Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
1		100	252	1,203.0															
	Riffle	26	77	316.2	2.0	4.1	3.5	0.16		G,C	C,G	N,H	1	1	OV,SWD	C		C	MF
	Pool	30	71	361.6	0.0	5.1	4.0	0.48	0.33	C,G	G,F	N,L,H	1	1	DP	C,SWD,OV,LWD	PD	C	MF
	Glide	44	104	525.2	0.8	5.1	3.5	0.26		G,C	F,G	H,L	1	1	C,LWD	OV,SWD		C	MF
2		100	251	1,113.5															
	Riffle	51	123	562.7	1.7	4.6	3.8	0.19		G,C	C,G	L,H	0	0	C	OV	SC	C	MF
	Pool	23	52	254.9	0.0	4.9	4.0	0.39	0.37	C,G,F	G,C,F	L,N	2	1	DP	C	SC	C	MF
	Glide	27	76	295.8	1.4	3.9	3.8	0.28		G	C,F,G	H,L	1	1	C,DP,LWD	OV,LWD	SC	C	MF
3		100	263	1,064.1															
	Riffle	2	7	19.6	3.0	2.8	2.0	0.15	-	G	C	N	0	0	OV	IV	-	C	MF
	Pool	25	60	267.0	0.0	4.5	4.5	0.51	0.48	S	G	L	1	1	DP	IV,LWD	-	C	MF
	Glide	73	196	777.5	1.7	4.0	3.8	0.30	-	G	S	L,H	8	3	LWD	OV	-	C	MF
4		100	110	337.9															
	Riffle	28	34	95.2	1.0	2.8	3.0	0.10	-	G	C	H	3	1	LWD	C	-	S	SHR
	Pool	21	26	70.2	0.0	2.7	2.6	0.33	0.23	C	G,S	L	2	1	LWD,OV	DP	-	S,C	SHR,MF
	Glide	51	50	172.5	1.3	3.5	3.3	0.18	-	C	G	L	8	4	LWD	OV	-	C	MF
5		100	101	173.9															
	Riffle	18	21	32.0	1.8	1.5	1.4	0.10	-	C	S,B	N	4	2	LWD,OV	SWD	-	C	MF
	Pool	34	32	58.7	0.0	1.8	2.1	0.40	0.43	S	C,G	L	2	2	DP	LWD	-	C	MF
	Glide	48	48	83.2	2.0	1.7	2.0	0.17	-	C	G,S	N	4	2	LWD	C	-	C,S	MF,SHR

Notes: Substrate: R = bedrock; B = boulder (>256 mm); C = cobbles (64 - 256 mm); G = gravels (2 - 64 mm); S = fines (< 2 mm)
Spawning Gravels: H = extensive amounts; L = isolated pockets; N = none
Cover Type: B = boulders; C = undercut banks; DP = deep pools; IV = instream vegetation; LWD = large woody debris; SWD = small woody debris; OV = overhanging vegetation
Off-Channel Habitat: SC = side channel; SL = sloughs; PD = ponds; WL = seasonally flooded wetlands
Riparian Vegetation Type: C = coniferous forest; D = deciduous forest; M = mixed coniferous-deciduous forest; S = shrub; N = unvegetated
Riparian Vegetation Structure: MF = mature forest; YF = young forest; PS = pole-sapling stage; SHR = shrub/herb stage; INIT = non-vegetated or initial stage
m = metre; m^2 = metres squared; % = percent

Table 5.8-15: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Creek 661 Watershed, 2011 and 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692-671007	-	Creek 661	1	-	FI-82	03/08/2012	4	S3	Riffle-pool with gravel	2.00	4.87	3.64	0.32	0.37	Gravel	5-20	G	G	G	G
100-567134-610692-671007	-	Creek 661	2	-	FI-83	02/08/2012	4	S3	Riffle-pool with cobble	1.00	4.68	3.96	0.22	0.40	Cobble	>20	F	G	G	G
100-567134-610692-671007	-	Creek 661	3	-	FI-11	13/08/2011	4	S3	Riffle-pool with cobble	0.75	4.18	3.55	0.20	0.47	Cobble	>20	G	G	F	G
100-567134-610692-671007	-	Creek 661	3	-	FI-12	11/08/2011	3	S3	Riffle-pool with gravel	1.00	3.57	3.38	0.47	0.67	Gravel	>20	G	G	F	G
100-567134-610692-671007	-	Creek 661	4	-	FI-13	12/08/2011	3	S3	Riffle-pool with gravel	0.875	3.05	2.94	0.28	0.3	Gravel	>20	F	G	F	F
100-567134-610692-671007	-	Creek 661	5	-	FI-14	12/08/2011	2	S3	Riffle-pool with cobble	2.00	1.85	2.09	0.42	0.3	Cobble	>20	P	G	P	G
100-567134-610692-671007	-	Creek 661	6	-	FI-15	15/08/2011	2	S3	Riffle-pool with cobble	2.25	1.73	1.77	0.27	0.33	Cobble	>20	N	G	N	G
100-567134-610692-671007	-	Creek 661	7	-	FI-16	15/08/2011	2	S3	Step pool	4.17	1.47	1.78	0.25	0.40	Cobble	>20	P	G	F	G
100-567134-610692-671007	-	Creek 661	11	-	FI-84	06/08/2012	2	S4	Riffle-pool	0.60	0.95	1.31	0.19	0.40	Fines	>20	N	F	N	P
100-567134-610692-671007	-	Creek 661	12	-	FI-85	06/08/2012	1	NVC	NS	15.00	0.00	0.00	0.00	0.00	NS	>20	N	N	N	N
100-567134-610692-671007-505659	-	Creek 505659	1	-	FI-86	04/08/2012	2	S3	Riffle-pool with cobble	2.33	2.19	2.02	0.20	0.63	Cobble	>20	G	G	G	G
100-567134-610692-671007-505659	-	Creek 505659	2	-	FI-87	03/08/2012	2	S3	Riffle-pool with gravel	1.17	2.00	2.02	0.31	0.90	Gravel	>20	G	G	G	P
100-567134-610692-671007-505659	-	Creek 505659	3	-	FI-88	03/08/2012	2	S3	Riffle-pool with gravel	1.67	2.22	1.75	0.18	0.57	Gravel	>20	G	G	G	G
100-567134-610692-671007-505659	-	Creek 505659	4	-	FI-89	03/08/2012	2	NVC	NS	0.00	0.00	0.00	0.00	0.00	Fines	>20	N	N	N	N
100-567134-610692-671007-505659	-	Creek 505659	6	-	FI-64	26/06/2012	2	S4	Riffle-pool	1.88	0.78	0.97	0.10	0.43	Fines	5-20	P	G	P	F
100-567134-610692-671007-505659	-	Creek 505659	7	-	FI-90	02/08/2012	1	S4	Riffle-pool	0.67	0.67	0.67	0.08	0.30	Fines	>20	N	P	N	P
100-567134-610692-671007-505659-146920	-	Creek 146920	1	-	FI-91	06/08/2012	1	S3	Riffle-pool with cobble	4.50	1.65	1.25	0.15	0.47	Gravel	>20	F	G	F	G
100-567134-610692-671007-505659-146920	-	Creek 146920	2	-	FI-65	26/06/2012	1	S3	Riffle-pool with cobble	3.88	1.58	1.62	0.13	0.37	Cobble	5-20	P	G	N	F
100-567134-610692-671007-505659-146920	-	Creek 146920	3	-	FI-38	20/08/2011	1	S4	Riffle-pool	0.50	1.21	1.42	0.12	0.30	Fines	>20	P	F	P	G
100-567134-610692-671007-543585	-	Creek 543585	1	-	FI-92	03/08/2012	1	S4	Riffle-pool	1.67	1.17	1.01	0.13	0.40	Fines	>20	P	G	P	G
100-567134-610692-671007-885275	-	Creek 885275	1	-	FI-93	06/08/2012	1	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	5-20	N	N	N	N

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; m = metre; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width

375000 377500 380000 382500 385000 387500 390000

5900000 5897500 5895000 5892500 5890000

Davidson Creek

Chedakuz Creek

Tatelkuz Lake

Kuyakuz Lake

N

Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:54,698

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification Creek 661 Watershed

DATE:	ANALYST:	
April, 2013	MY	**Figure** 5.8-6
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-062_stream_class_661_v2.pdf
GIS FILE: 10-100-062_stream_class_661_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-062_stream_class_661_v2.mxd

Reach 3 of Creek 661 consists predominantly of glides (73%) with lesser amounts of pool (25%) and riffle (2%) habitats. Gravels are the dominate substrate types in riffles and glides, and fines in pools. There are extensive amounts of spawning gravels in glide habitats, although none are present in riffle habitats. Overhanging vegetation, deep pools, LWD, and instream vegetation are the most common stream cover types. Total stream cover is greater than 20%. Habitat quality is rated as fair for spawning and good for migration, rearing, and overwintering (**Table 5.8-15**).

Habitat in Reach 4 consists of glide (51%), riffle (28%), and pool (21%) habitats. Dominant substrate types are cobbles in pools and glides, and gravels in riffles. Extensive amounts of spawning gravels are present in riffle habitats, while only isolated pockets of spawning gravels are present in pool and glide habitats. The majority of stream cover is LWD, while overhanging vegetation, deep pools, and undercut banks are less common. Total stream cover is greater than 20%. Riparian vegetation consists of a mixture of shrubs and mature conifers. Habitat quality is rated as fair for migration, spawning, and overwintering and good for rearing (**Table 5.8-15**).

Habitat in Reach 5 consists of glide (48%), pool (34%), and riffle (18%) habitats. Substrate is dominated by cobbles in riffles and glides, and fines in pool habitat. No spawning gravels are present in glide or riffle habitats within this reach. LWD, overhanging vegetation, and deep pools are the dominant stream cover types. Total stream cover is greater than 20%. Shrubs and mature conifers comprise the riparian vegetation in this reach. Habitat quality is rated as poor for overwintering and spawning, and good for migration and rearing (**Table 5.8-15**).

Reach 6 of Creek 661 has riffle-pool morphology and is dominated by cobble substrates. Abundant stream cover (>20% of total area), adequate flow, and lack of barriers provide this reach with good rearing and migration habitat. Habitat quality is rated as absent for overwintering and spawning, and good for migration and rearing (**Table 5.8-15**).

Higher stream gradient (~6%) resulted in a step-pool morphology within Reach 7. Mean residual pool depths are shallow (0.25 m) with overwintering conditions rated as poor. Habitat quality is rated as poor for overwintering, fair for spawning, and good for migration and rearing (**Table 5.8-15**).

In July 2006, large channel morphology was evident in Reach 8 of Creek 661. This is likely due to the fact that this reach was assessed just downstream of the outlet from the pond that occupies Reach 9. The dominant substrate in this reach was fines. Overwintering habitat quality was rated fair in this reach, due to the presence of adequate pool depth. Rearing and spawning habitat quality were rated good and poor, respectively. Migration habitat quality was not assessed.

In July 2006, Reach 10 of Creek 661 had a riffle-pool morphology and substrates dominated by fines. This reach had moderate stream cover (5 to 20%), and a rearing habitat rating of

fair. No overwintering or spawning habitat was observed, and migration habitat quality was not assessed.

Reach 11 of Creek 661 is low-gradient with a riffle-pool morphology. Substrates in this reach are dominated by fines. Adequate stream cover provides fair rearing habitat, and migration habitat quality is rated as poor because migration is only possible during high flows. No overwintering or spawning habitat was observed.

No visible channel was observed in Reach 12 of Creek 661 when visited in August 2012.

Creek 505659, a tributary Reach 5 of Creek 661, is dominated by riffle habitat throughout. Abundant stream cover and suitable spawning gravels are present in the lower reaches of Creek 505659. Habitat quality in Reaches 1 through 3 is rated good for all life histories, with the exception of Reach 2, which is rated poor for migration habitat (**Table 5.8-15**). No visible channel is present in Reach 4 of Creek 505659. Habitat quality decreases in the upper reaches, which provide some suitable rearing and migrating habitat, and poor to no overwintering and spawning habitat. In Reaches 6 and 7, the dominant substrate type is fines and the mean residual pool depth is less than 0.10 m.

Creek 146920, a first-order tributary to Creek 505659, provides rearing and migration habitat ranging from good to fair (**Table 5.8-15**). Spawning and overwintering habitat quality ranges from fair in Reach 1 of Creek 146920 to poor or none in Reaches 2 and 3.

Creeks 543585 and 885275 are two smaller, first-order tributaries that drain to Reach 5 of Creek 661. Habitat quality in Creek 543585 is rated as poor for overwintering and spawning, and good for migration and rearing (**Table 5.8-15**). Habitat quality in Creek 885275 is rated as completely absent for all four salmonid life stages (**Table 5.8-15**).

5.8.3.4 Overwintering Habitat

Overflights of the LSA conducted in March 2012 and March 2013 (unpublished data) showed that Reaches 1 and 2 of Creek 661 and some of its tributaries were open, but that Reaches 3 and 4 were covered with ice in both winters. The open areas were likely caused by groundwater inflows.

Mean DO concentrations in excess of 9 mg/L in a pond in Creek 661 (site DO-14) and in pool habitat in Creek 505659 (site DO-13) resulted in both sites being given an overwintering habitat quality rating of good (**Table 5.8-16**). Mean water depth under the ice was considerably higher in the pool in Creek 505659 (0.8 m) than in the pond in Creek 661 (0.08 m) during the survey. The site sampled in a glide in Creek 146920 was frozen to bottom when assessed. This site is rated as providing no overwintering habitat.

Table 5.8-16: Winter Water Quality and Dissolved Oxygen Concentrations in the Creek 661 Watershed, March 2012

Watershed	Stream/Lake Name	Reach	Site No.	Habitat Type	Mean Ice Depth (m)	Mean Water Depth (m)	Mean Dissolved Oxygen (mg/L)	Overwintering Habitat Quality
Creek 661	Creek 661	4	DO-14	Other	0.80	0.08	9.9	Good
Creek 661	Creek 505659	2	DO-13	Pool	0.06	0.85	10.8	Good
Creek 661	Creek 146920	5	DO-07	Glide	0.05	-	-	None

Notes: m = metres; mg/L = milligrams per litre

In summary, good overwintering habitat is present at two of three sites in Creek 661 in 2012. However, the mean depth of water beneath the ice was low when assessed; ranging from 0.08 to 0.85 m, thus the total volume of overwintering habitat available to resident fish was low, at least compared to the volume that is assumed to be available in Tatelkuz Lake.

5.8.4 Creek 705 Watershed

The watershed area of Creek 705 is 45 km^2 and elevations range from approximately 1,500 masl upstream of Lake 01538UEUT to 1,000 masl near the confluence of Creek 705 with Fawnie Creek (**Figure 2.1-5**).

5.8.4.1 General Description

Creek 705 is a third-order stream flowing down slopes on the west side of Mt. Davidson to Fawnie Creek, approximately 8 km downstream of Top Lake (**Figure 2.1-5**). Creek 705 receives run-off from a number of small tributaries in the middle to upper watershed. It has two headwater lakes: Lake 01538UEUT near the headwaters of the southern drainage (**Plate 2.1-5**), and Lake 01428UEUT near the headwaters of the northern drainage (**Plate 2.1-6**). Water from Lake 01428UEUT flows through Creek 606013 into the mainstem of Creek 705.

5.8.4.2 Reach Break Analysis

Reach 1 of Creek 705 is located on the floodplain of Fawnie Creek and consists of a low-gradient (<1%), unconfined stream section with multiple channels (**Table 5.8-17** and **Figure 5.8-7**).

Stream gradient (3.5%) and channel confinement increase within Reach 2, while the channel remains laterally stable with gravel and cobble bed materials.

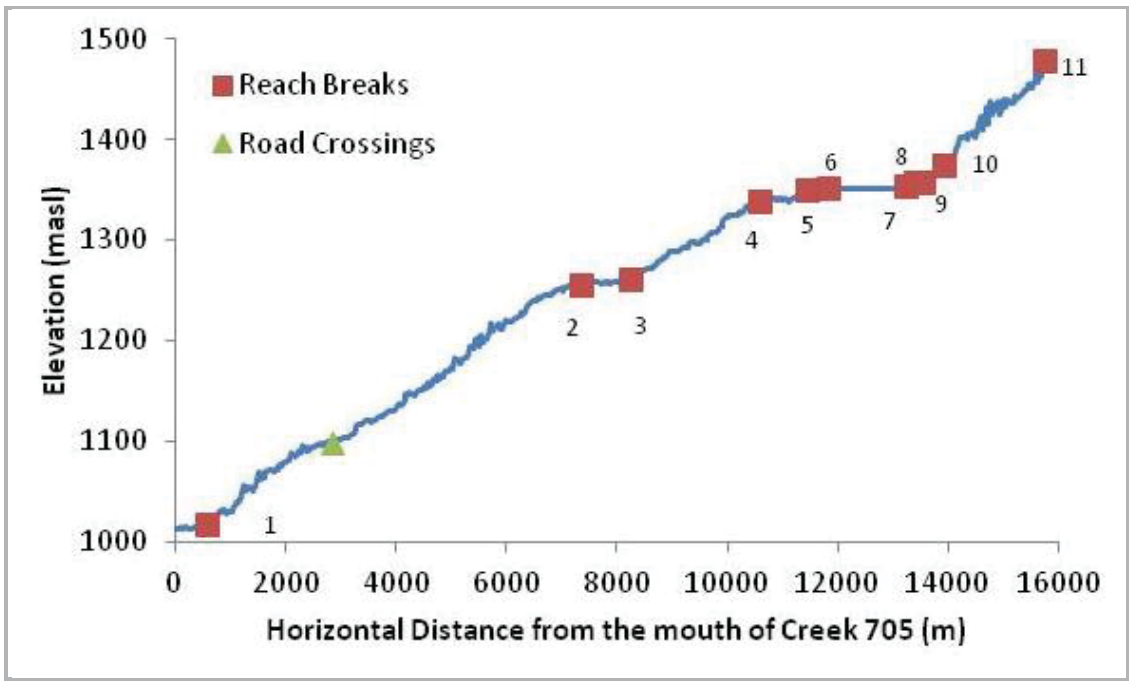
The stream channel is unconfined through Reach 3, a low-gradient (0.6%) reach dominated by a series of small wetland complexes.

Reach 4 of Creek 705 is steeper (3.3%) than Reach 3 and is frequently confined by gentle valley slopes.

Table 5.8-17: Reach Descriptions for Creek 705

Stream	Reach No.	Stream Order	Reach Length (km)	Approximate Reach Gradient (%)
Creek 705	1	3	0.59	0.9
	2	3	6.77	3.5
	3	3	0.87	0.6
	4	3	2.36	3.3
	5	2	0.86	1.3
	6	2	0.38	0.3
	7	2	1.41	0.1
	8	2	0.16	2.5
	9	2	0.13	0.0
	10	2	0.38	4.5
	11	2	1.84	5.7

Notes: km = kilometre; % = percent



Notes: m = metre; masl = metres above sea level/

Figure 5.8-7: Stream Gradient Profile of Creek 705

The confluence of Creek 606013 is located in the middle of Reach 4.

Below Lake 01538UEUT, Reaches 5 and 6 of Creek 705 are unconfined with an irregular or wandering channel pattern through a series of wetland complexes. The inlet channel in Reach 8 consists of a short, straight section that connects to a small pond immediately east of Lake 01538UEUT. Stream gradients increase through Reaches 10 and 11, and the stream transitions to being entrenched with cascade-pool habitats in Reach 11.

Creek 606013 contains a total of four reaches with the third reach delineating Lake 01428UEUT. Reach 1 is relatively straight and confined by gently sloping valley walls. Reach 2 is a low-gradient reach located near the outlet of Lake 01428UEUT. The inlet channel to the lake (Reach 4) flows through a low-gradient, wetland dominated area.

5.8.4.3 Stream Habitat and Classification

FHAP surveys were not conducted in the Creek 705 Watershed during 2011 and 2012. Rather, reconnaissance 1:20,000 stream habitat data collected by AMEC in 2012, and by others from 1997 to 2004 (**Annex 3.1-1**), were used to describe stream habitat and classifications in the Creek 705 Watershed (**Table 5.8-19**).

Reaches 2 and 3 of Creek 705 consist of riffle-pool stream morphology dominated by cobble and gravel substrates, respectively (**Figure 5.8-8**). Total stream cover is moderate to abundant, which provides good rearing habitat in both reaches. Spawning habitat quality is rated as good, but no overwintering habitat is present because of shallow residual pool depths (<0.10 m) in both reaches.

Reach 4 of Creek 705 has a riffle-pool morphology, and the streambed is dominated by cobble substrates. Abundant cover and low to moderate gradients provide good rearing habitat and fair migration habitat, respectively. Overwintering and spawning habitat quality are rated as poor.

Cascade-pool and riffle-pool habitat are present in Reach 10 of Creek 705, which is classified as S4. The dominant bed material varies from cobble to bedrock, and abundant stream cover provides good quality rearing habitat. Spawning and migration habitat quality ranges from good to fair, but overwintering habitat quality is rated as poor due to minimal residual pool depths.

Reach 11 is similar to Reach 10 in terms of habitat conditions and quality. Reach 11 is classified as S3 due to a wider bankfull width.

Reach 1 of Creek 606013, located downstream of Lake 01428UEUT, contains riffle-pool morphology that is dominated by cobble substrates. Total stream cover is abundant (>20%), providing good quality rearing habitat. Migration habitat quality is rated as fair, and spawning habitat and overwintering habitat quality is rated as poor.

No information is available on habitat in Reach 2 of Creek 606013 and Reach 3 of Lake 01428UEUT.

Riffle-pool morphology with cobble substrates, a wide floodplain, and stream cover varying from abundant (<20%) to moderate (5 to 20%) are present in Reach 4 of Creek 606013, situated upstream of Lake 01428UEUT. Good rearing and migration habitat quality, and fair spawning and overwintering habitat are present.

5.8.4.4 Overwintering Habitat

Overflights of the LSA conducted in March 2012 and March 2013 (unpublished data) showed that all reaches of Creek 705 and the two headwater lakes, Lake 01538UEUT and Lake 01428UEUT, were covered with ice, indicating less influence of groundwater inflows than in Davidson Creek, Turtle Creek, and Creek 661.

One stream site in the Creek 705 Watershed was assessed for overwintering habitat quality in March 2012 (**Table 5.8-18**). A pool site located in Reach 2 of Creek 705 is given a good quality rating due to the high DO concentration (>10 mg/L) and adequate overwintering depth (0.28 m) at this location.

Table 5.8-18: Winter Water Quality and Dissolved Oxygen Concentrations in the Creek 705 Watershed, March 2012

Watershed	Stream/Lake Name	Reach	Site No.	Habitat Type	Mean Ice Depth (m)	Mean Water Depth (m)	Mean Dissolved Oxygen (mg/L)	Overwintering Habitat Quality
Creek 705	Creek 705	2	DO-16	Pool	0.45	0.28	10.7	Good

Notes: m = metres; mg/L = milligrams per litre

In summary, good overwintering habitat was present at one site in Creek 705 in 2012. However, the mean depth of water beneath the ice was low (0.26 m) when assessed, thus the total volume of overwintering habitat available to resident fish was low, at least compared to the volume that is assumed to be available in lakes in the Fawnie Creek Watershed such as Top Lake or Laidman Lake.

5.8.5 Tatelkuz Lake Tributaries Watershed

5.8.5.1 General Description

The Tatelkuz Lake Tributaries Watershed includes tributaries flowing into the west side of Tatelkuz Lake (**Figure 2.1-6**). The watershed lies between the Davidson Creek Watershed to the northwest and Creek 661 Watershed to the south. It includes Creek 579340, a low-gradient, third-order stream draining several small to moderate sized ponds and wetlands. It also includes Creek 549629.

For the purposes of fish habitat assessment, Tatelkuz Lake Tributaries Watershed is defined to include a section of lower Chedakuz Creek directly downstream of Tatelkuz Lake as far as the Turtle Creek confluence (approximately 700 m downstream of the Davidson Creek confluence) (**Figure 2.1-6**). This section includes Reaches 14 and 15 of Chedkuz Creek. Tatelkuz Lake is Reach 16.

Table 5.8-19: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Creek 705 Watershed, 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-641477-543682-698692	-	Creek 705	4	-	FI-103	16/09/2012	2	S3	Riffle-pool with Cobble	3.25	2.17	1.45	0.19	0.43	Cobble	>20	P	G	P	F
100-567134-641477-543682-698692	-	Creek 705	10	-	FI-45	19/06/2012	2	S4	Riffle-pool with Cobble	2.00	0.83	1.10	0.13	0.30	Cobble	>20	P	G	G	F
100-567134-641477-543682-698692	-	Creek 705	10	-	FI-45	19/09/2012	2	S4	Cascade-pool with Boulder	8.33	1.00	1.60	0.10	0.33	Bedrock	>20	P	G	F	F
100-567134-641477-543682-698692	-	Creek 705	11	-	FI-44	19/06/2012	2	S3	Riffle-pool with Cobble	3.38	2.42	2.47	0.15	0.60	Cobble	>20	P	G	P	F
100-567134-641477-543682-698692-606013	-	Creek 606013	1	-	FI-102	16/09/2012	2	S3	Riffle-pool with Cobble	3.50	1.78	1.29	0.16	0.27	Cobble	5-20	P	G	P	F
100-567134-641477-543682-698692-606013	-	Creek 606013	4	-	FI-61	25/06/2012	2	S3	Riffle-pool with Cobble	1.75	1.76	1.75	0.41	0.47	Fines	>20	F	G	F	G
100-567134-641477-543682-698692-606013	-	Creek 606013	4	-	FI-61	19/09/2012	2	S3	Large channel	0.00	1.92	1.92	0.49	0.40	Fines	5-20	P	F	N	G

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; m = metre; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width

360000 362500 365000 367500 370000

5897500 5895000 5892500 5890000

Top Lake
Fawnie Creek
Fawnie Creek
Davidson Creek
Mathews Creek

N

Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:40,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification Creek 705 Watershed

DATE:	ANALYST:	
April, 2013	MY	**Figure** 5.8-8
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-061_stream_class_705_v3.pdf
GIS FILE: 10-100-061_stream_class_705_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-061_stream_class_705_v3.mxd

Tatelkuz Lake Tributaries Watershed is also defined to include a portion of middle Chedakuz Creek from the Creek 661 confluence downstream to Tatelkuz Lake (**Figure 2.1-6**). This section includes Reaches 17, 18, and 19 of Chedkuz Creek.

5.8.5.2 Stream Habitat and Classification

Reach 14 of Chedakuz Creek is dominated by glide habitat (86%) (**Table 5.8-20**, **Table 5.8-21**, and **Figure 5.8-9**). Gravels are the dominant substrate type, and high quality spawning gravels are present throughout. Abundant instream vegetation dominates the cover type in riffles and glides. Deep pools provide the majority of cover in pools and good overwintering habitat conditions. Riparian vegetation is a mixture of grasses, shrubs, and mature conifers. Migration habitat quality is rated as good due to a low stream gradient (<1%) and lack of obstructions to upstream movement. A side channel provides off-channel habitat in this section of Chedakuz Creek.

Habitat conditions in Reach 15 of Chedakuz Creek are very similar to those in Reach 14, with the exception of the presence of riffles (33%), cobbles as the dominant substrate in some glide habitat, and the presence of a small wetland, providing off-channel habitat.

The mainstem of Creek 579340 is dominated by fine substrates. Abundant stream cover provides good rearing habitat in Reaches 3, 5, and 9. Overwintering, spawning, and migration generally ranges from poor to none throughout all mainstem reaches of this tributary. Reach 7 is Snake Lake. Channel width is greatest in Reach 8, giving it an S3 stream classification. No visible channel is present in Reaches 4 and 6 in September 2012, and all other reaches are classified as S4.

Creek 549629 provides fair rearing and migration habitat, but poor to no overwintering and spawning habitat. Good migration habitat and fair rearing habitat exist in Reach 1 of Creek 737376, but there is no visible channel in Reach 2 of Creek 737376 and Reach 1 of Creek 664387.

5.8.5.3 Overwintering Habitat

Despite adequate water depth for overwintering habitat, mean DO concentration was below lethal levels for salmonids in the pond site in Reach 1 of Creek 571602 when assessed (**Table 5.8-22**). This site is given an overwintering habitat quality rating of zero. Snake Lake, located in Reach 7 of Creek 579340, has a greater water depth and a higher DO concentration, but overwintering habitat quality is rated as poor.

Table 5.8-20: Summary of Lower Chedakuz Creek Habitat, 2012

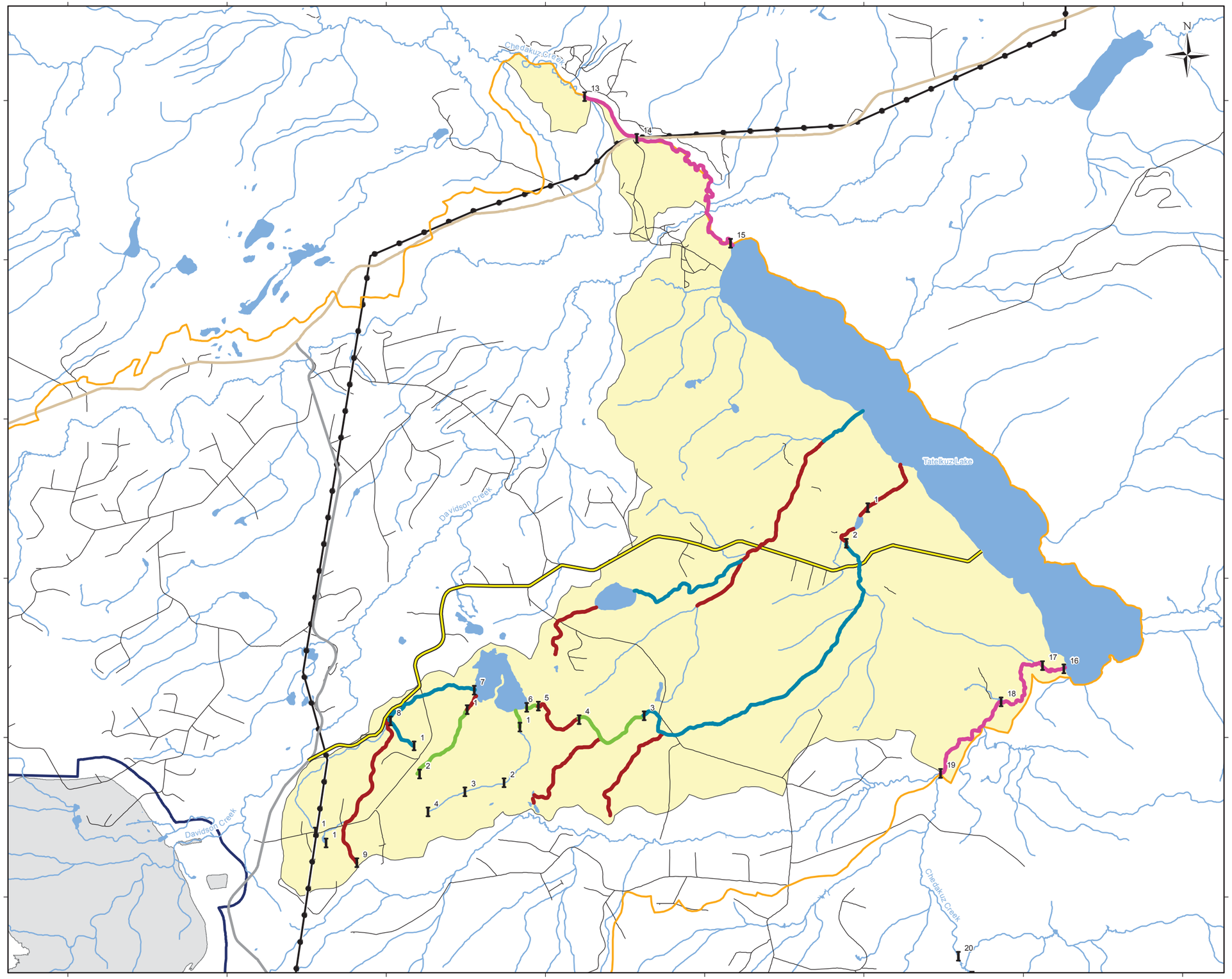
Reach No.	Habitat Unit Type	Percent Composition (%)	Total Survey Length (m)	Total Area (m^2)	Mean Gradient (%)	Mean Bankfull Width (m)	Mean Wetted Width (m)	Mean Water Depth (m)	Mean Residual Pool Depth (m)	Substrate			Mean Total LWD Tally	Mean Functioning LWD	Cover Type		Off-Channel Habitat	Riparian Vegetation	
										Dominant	Sub-Dominant	Spawning Gravels			Dominant	Sub-Dominant		Type	Structure
14		100	307	4,096.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Pool	14	44	532.4	0	12.1	11.3	0.86	1.04	G	C	H	6	6	DP	IV		SH,G	SHR
	Glide	86	263	3,563.7	0	13.6	13.0	0.56		G	C,F	H	9	9	IV	OV	SC	SH	SHR
15		100	350	4,588.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Riffle	33	114	1,827.8	0.5	16.0	16.1	0.19	-	G	F	H	2	2	IV	OV	-	SH,C	SHR,MF
	Pool	3	12	2,52.0	0	21.0	16.5	0.98	0.96	G	C	H	0	0	DP	IV	-	C,SH	MF,SHR
	Glide	64	224	2,508.8	0	11.2	10.5	0.59	-	C,G	G,C	H	9	8	IV	OV	WL	SH,G,C	INIT,SHR,MF

Notes: Substrate: R = bedrock; B = boulder (>256 mm); C = cobbles (64 - 256 mm); G = gravels (2 - 64 mm); S = fines (< 2 mm)
Spawning Gravels: H = extensive amounts; L = isolated pockets; N – none
Cover Type: B = boulders; C = undercut banks; DP = deep pools; IV = instream vegetation; LWD = large woody debris; SWD = small woody debris; OV = overhanging vegetation
Off-Channel Habitat: SC = side channel; SL = sloughs; PD = ponds; WL = seasonally flooded wetlands
Riparian Vegetation Type: C = coniferous forest; D = deciduous forest; M = mixed coniferous-deciduous forest; S = shrub; N = unvegetated
Riparian Vegetation Structure: MF = mature forest; YF = young forest; PS = pole-sapling stage; SHR = shrub/herb stage; INIT–– non-vegetated or initial stage
m = metre; m^2 = metres squared; % = percent

Table 5.8-21: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Tatelkuz Lake Tributaries Watershed, 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692	-	Chedakuz Creek	14	-	FI-113	2012/09/17	6	S2	Riffle-pool with gravel	1.00	14.18	14.58	0.95	0.50	Fines	5-20	G	G	G	G
100-567134-610692	-	Chedakuz Creek	15	-	FI-112	2012/09/18	6	S2	Riffle-pool with gravel	0.13	13.62	13.33	1.00	0.80	Fines	5-20	G	G	G	G
100-567134-610692		Chedakuz Creek			KO-30	10-Sep-12	3	S2	Riffle-pool with gravel	1.38	7.55	5.30	0.22	0.30	Gravel	<5	F	G	G	G
100-567134-610692-579340	-	Creek 579340	3	-	FI-104	2012/09/18	3	S3	Large Channel	2.33	2.77	1.00	0.13	0.37	Fines	>20	N	G	N	P
100-567134-610692-579340	-	Creek 579340	4	-	FI-105	2012/09/17	2	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	<5	N	N	N	N
100-567134-610692-579340	-	Creek 579340	5	-	FI-52	2012/09/18	2	S4	Riffle-pool	0.63	1.23	1.07	0.15	0.33	Fines	>20	P	F	N	P
100-567134-610692-579340	-	Creek 579340	5	-	FI-52	2012/09/17	2	S4	Riffle-pool	0.88	1.00	0.96	0.14	0.37	Fines	5-20	P	G	P	P
100-567134-610692-579340	-	Creek 579340	6	-	FI-106	2012/09/17	2	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	<5	N	N	N	N
100-567134-610692-579340	-	Creek 579340	8	-	FI-107	2012/09/18	2	S3	Large Channel	0.33	3.84	3.62	0.19	0.40	Fines	>20	N	P	N	F
100-567134-610692-579340	-	Creek 579340	9	-	FI-59	24/06/2012	2	S4	Riffle-pool	2.75	1.37	1.48	0.27	0.00	Fines	71-90	P	G	N	F
100-567134-610692-579340	-	Creek 579340	9	-	FI-59	18/09/2012	2	S4	Riffle-pool	1.00	0.98	1.08	0.14	0.30	Fines	5-20	N	G	N	P
100-567134-610692-579340-549629	-	Creek 549629	1	-	FI-51	2012/06/21	2	S4	Riffle-pool	0.38	0.76	0.67	0.08	0.33	Fines	<5	P	F	N	F
100-567134-610692-579340-549629	-	Creek 549629	1	-	FI-51	2012/09/17	2	S4	Large Channel	0.50	0.78	0.61	0.00	0.33	Fines	<5	N	P	N	P
100-567134-610692-579340-664387	-	Creek 664387	1	-	FI-110	2012/09/17	1	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	<5	N	N	N	N
100-567134-610692-579340-737376	-	Creek 737376	1	-	FI-108	2012/09/17	1	S4	Large Channel	0.00	0.87	1.08	0.17	0.43	Fines	5-20	N	F	N	G
100-567134-610692-579340-737376	-	Creek 737376	2	-	FI-109	2012/09/17	1	NVC	NS	0.00	0.00	0.00	0.00	0.00	NS	5-20	N	N	N	N

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; m = metre; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width



Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:60,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification
Tatelkuz Lake Tributaries Watershed

DATE:	ANALYST:	**Figure** 5.8-9
April, 2013	MY	
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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-128_stream_class_tatelkuz_L.mxd

Table 5.8-22: Winter Water Quality and Dissolved Oxygen Concentrations in the Tatelkuz Lake Tributaries Watershed, March 2012

Watershed	Stream/Lake Name	Reach	Site No.	Habitat Type	Mean Ice Depth (m)	Mean Water Depth (m)	Mean Dissolved Oxygen (mg/L)	Overwintering Habitat Quality
Tatelkuz Lake Tributaries	Creek 571602	1	DO-12	Other	0.91	0.89	1.4	None
Tatelkuz Lake Tributaries	Snake Lake	7	DO-11	Other	0.94	1.50	4.0	Poor

Notes: m = metres; mg/L = milligrams per litre

5.8.6 Chedakuz Creek Watershed

For the purposes of this fish habitat assessment, the Chedakuz Creek Watershed includes those streams that were surveyed in 2012 that were outside the five main watersheds of the LSA (i.e., Davidson Creek, Creek 661, Turtle Creek, Creek 705, and Tatelkuz Lake Tributaries). The Chedakuz Creek Watershed includes four streams (**Figure 2.1-7**):

- Upper Chedakuz Creek immediately upstream of Kuyakuz Lake;
- Creek 601947, a tributary to Tatelkuz Lake that enters from the northeast shore;
- Creek 522107, a tributary to lower Chedakuz Creek that enters from the northeast immediately opposite the confluence of Davidson Creek; and
- Creek 101550, a third-order tributary to lower Chedakuz Creek located approximately 1,500 m upstream of the Nechako Reservoir.

5.8.6.1 General Description

Low gradient riffle-pool habitat dominates Chedakuz Creek just upstream of its mouth at Kuyakuz Lake (**Table 5.8-23**). Abundant gravels provide good spawning habitat conditions for salmonids, while moderate residual pool depths provide fair overwintering habitat. Rearing and migration habitat are also rated good at this site. Upper Chedakuz Creek is classified as S2 at this location.

Creek 601947 is a third-order S3 tributary with cobble-dominated riffle-pool morphology. It provides good rearing, spawning, and migration habitat for salmonids, but overwintering conditions are limited by shallow residual pool depths.

A riffle-pool morphology typified the habitat in Creek 522107, an S3 tributary to Chedakuz Creek. Beaver impoundments obstruct upstream movement of fish at this site. Deep pools provide good rearing and overwintering habitat, while abundant patches of suitable spawning gravel provides good spawning habitat.

Creek 101550, a third-order S2 tributary to Chedakuz Creek, has riffle-pool habitat dominated by cobble substrates. Habitat quality at this site is rated as good for all salmonid life stages.

Table 5.8-23: Summary of Reconnaissance (1:20,000) Stream Habitat Assessments, Chedakuz Creek Watershed, 2012

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Site Map ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover (%)	Habitat Quality[1]			
																	Overwintering	Rearing	Spawning	Migration
100-567134-610692	-	Middle Chedakuz Creek	-	-	KO-30	10-Sep-12	3	S2	Riffle-pool with gravel	1.38	7.55	5.30	0.22	0.30	Gravel	<5	F	G	G	G
100-567134-610692-101550	-	Creek 101550	-	-	KO-02	14-Sep-12	3	S2	Riffle-pool with cobble	3.25	6.25	3.98	0.53	0.43	Cobble	<5	G	G	G	G
100-567134-610692-522107	-	Creek 522107	-	-	KO-12	11-Sep-12	5	S3	Riffle-pool with gravel	0.50	4.02	3.62	0.79	0.47	Gravel	0	G	G	G	P
100-567134-610692-601947	-	Creek 601947	-	-	KO-19	10-Sep-12	3	S3	Riffle-pool with cobble	3.50	4.77	3.16	0.30	0.33	Cobble	5-20	P	G	G	G

Notes: [1] Habitat Quality: G = good; F = fair; P = poor; N = none; NS = not specified
BfW = bankfull width; BfD = bankfull depth; ID = identification; ILP = Interim Locational Point; m = metre; NS = not specified; NVC = non-visible channel; % = percent; Res. = Residual; WW = Wetted Width

5.9 Lake Fish Habitat

Annex 5.9-1 shows the lake habitat data collected in 2011, and **Annex 5.9-2** shows the lake site cards from the FDIS database. **Annex 5.9-3** shows photographs of each lake habitat site, and **Annex 5.9-4** shows the physical limnology data collected in 2011 and 2012.

5.9.1 Lake 01682LNRS)

Lake 01682LNRS is the headwater lake of Davidson Creek. It has one circular basin with the deepest portion of the lake located in the centre (**Table 5.9-1** and **Figure 5.9-1**). The basin has shallow slopes creating a large littoral area relative to its total surface area. There are two small islands in the lake, both of which are well-vegetated. There are no inlets, and there is one outlet to Davidson Creek that exits from the north end of the lake.

Table 5.9-1: Bathymetric Parameters of Lakes 01682LNRS, 01538UEUT, and 01428UEUT Measured in 2011 and 2012

Lake	Max. Depth (m)	Mean Depth (m)	Relative Depth (Z_r, %)	Shoreline Length (m)	Total Surface Area (m^2)	Total Littoral Area (m^2)	Total Volume (m^3)	Surface Volume Ratio	Shoreline Development (D_l)
Lake 01682LNRS[1]	16.3	5.54	4.77	1,667	91,881	57,419	509,173	0.18	1.55
Lake 01538UEUT[2]	11.2	5.45	1.66	4,304	357,375	187,504	1,946,905	0.18	2.03
Lake 01428UEUT[3]	7.6	3.09	1.64	2,508	169,304	164,676	522,815	0.32	1.72

Notes: [1] BC Freshwater Atlas Code/Waterbody ID - 100-567134-610692-522527/01682LNRS
[2] BC Freshwater Atlas Code/Waterbody ID - 100-567134-641477-543682-698692/01538UEUT
[3] BC Freshwater Atlas Code/Waterbody ID - 100-567134-641477-543682-698692-606013/01428UEUT
m = metre; % = percent; m^2 = metres squared; m^3 = cubic metres; % = percent

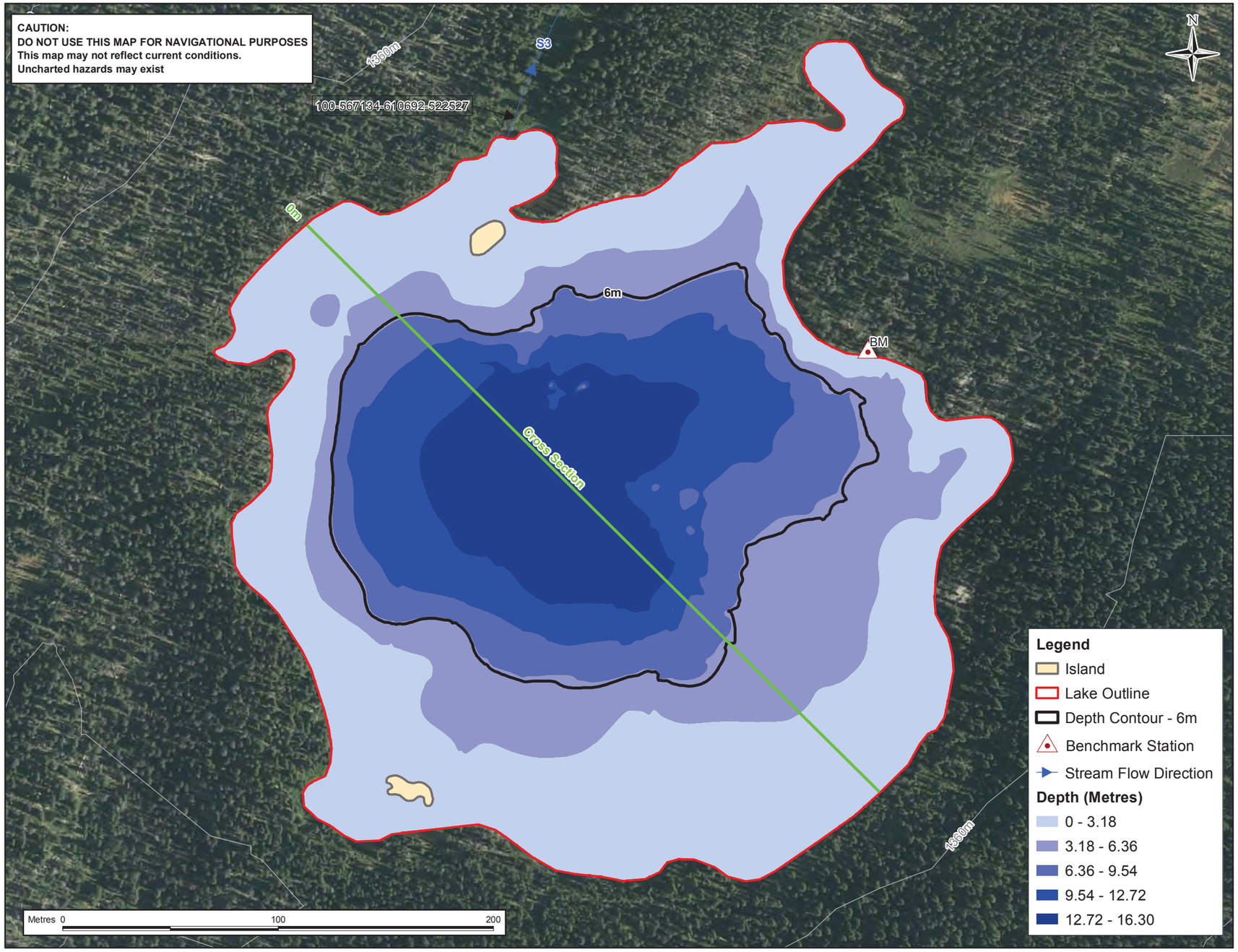
Lake 01682LNRS was thermally stratified on all sampling dates in August 2011 and September 2012. The thermocline ranged in depth from 3.0 m to 6.0 m in mid-August 2011, and from 6.0 m to 8.0 m in mid-September 2012 (**Table 5.9-2** and **Figure 5.9-2**).

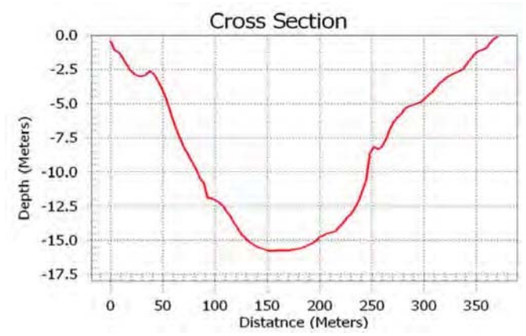
Table 5.9-2: Limnology Parameters Measured in Six Lakes, August 2011 and September 2012

Lake	Date	Temp. Range (°C)	DO Range (mg/L)	Specific Conductivity Range (µS/cm)	pH Range	Secchi Depth (m)	1% Euphotic Depth (m)	Thermo Cline Depth (m)
Lake 1682LNRS	14-Aug-11	4.5 – 14.5	0.1 - 9.5	42 – 67	6.8 – 7.7	5.5	14.9	3.0 – 6.0
	26-Jun-12	4.3 – 13.2	0.2 - 10.1	-	-	-	-	3.0 – 6.0
	11-Sep-12	5.0 – 12.1	0.1 - 10.2	-	-	-	-	5.0 – 7.0
	19-Sep-12	4.8 – 12.1	0 - 9.3	48 – 69	-	5.7	15.4	6.0 – 8.0
Lake 01538UEUT	12-Aug-11	10.7 – 15.8	3.6 - 9.0	41 – 43	7.1 – 8.0	4.0	10.8	4.0 – 6.0
	26-Jun-12	9.7 – 12.4	8.1 - 9.3	-	-	-	-	4.0 – 7.0
	10-Sep-12	13.5 – 13.7	8.2 - 8.6	34 – 35	-	5.7	15.4	-
	11-Sep-12	11.9 – 12.1	6.9 - 9.1	-	-	-	-	-
Lake 01428UEUT	16-Aug-11	12 – 12.6	0 - 9.2	32 – 44	7.2 – 8.0	4.0	10.8	-
	08-Sep-12	12.4 – 14.0	7.5 - 8.6	48	-	3.0	8.1	3.0 – 4.0
	11-Sep-12	10.3 – 10.8	3.2 - 9.5	-	-	-	-	-
Tatelkuz Lake	25-Jun-12	7.0 – 14.2	8.8 - 10.4	-	-	-	-	4.0 – 6.0
	10-Sep-12	5.8 – 14.8	1.2 - 9.2	-	-	-	-	9.0 – 12.0
Kuyakuz Lake	25-Jun-12	12.7 – 14.1	8.9 - 9.5	-	-	-	-	-
	10-Sep-12	14.8 – 15.1	0.7 - 7.9	-	-	-	-	-
Snake Lake	26-Jun-12	8.9 – 15.1	0.2 - 8.3	-	-	-	-	3.0 – 4.0
	11-Sep-12	11.8 – 12.5	0.4 - 7.7	-	-	-	-	-

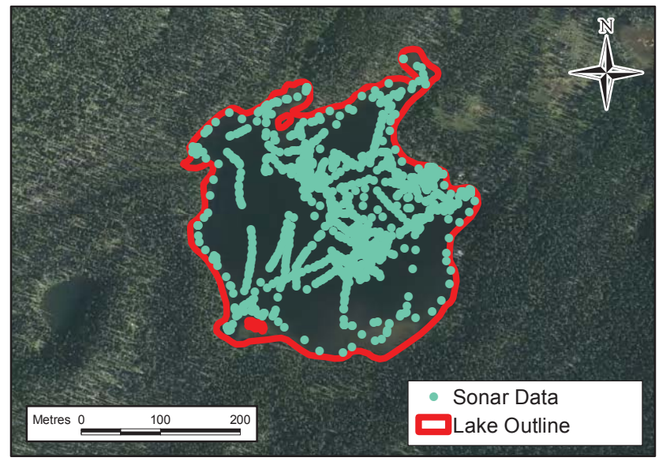
Note: °C = degrees Celsius; DO = dissolved oxygen; µS/cm = microSiemens per centimetre; m = metre; mg/L = milligram per litre; '-' = not sampled/calculated; % = percent.

CAUTION:
DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions.
Uncharted hazards may exist









REFERENCE:
Lake 01682LNRS outline is digitized from Orthophoto and is not base on TRIM base data.

NOTES:
1 - Depths are in meters
2. Not intended for navgational use
3. Uncharted rocks shoals may exist
4. Original Bathymetry map developed by Ecofor Consultants Ltd.

SURVEYED BY:	KW/GC
SURVEYED DATE:	August 14-15, 2011
FWA CODE:	100-567134-610692-522527
ORTHOPHOTO:	2011
N.T.S:	093F/2

Statistics at Time of Survey

ELEVATION:	1345 m	MEAN DEPTH:	5.54 m
SURFACE AREA:	91,881 sq.m	MAX DEPTH:	16.3 m
AREA ABOVE 6M CONTOUR:	57,419 sq. m	PERIMETER, MAIN SHORE:	1553 m
VOLUME:	509,173 cu. m	PERIMETER, ISLANDS:	113.9 m
ABOVE WATER LEVEL:	1.7 m	BENCHMARK UTM:	371414 E, 5894098 N

CLIENT
newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664
amec

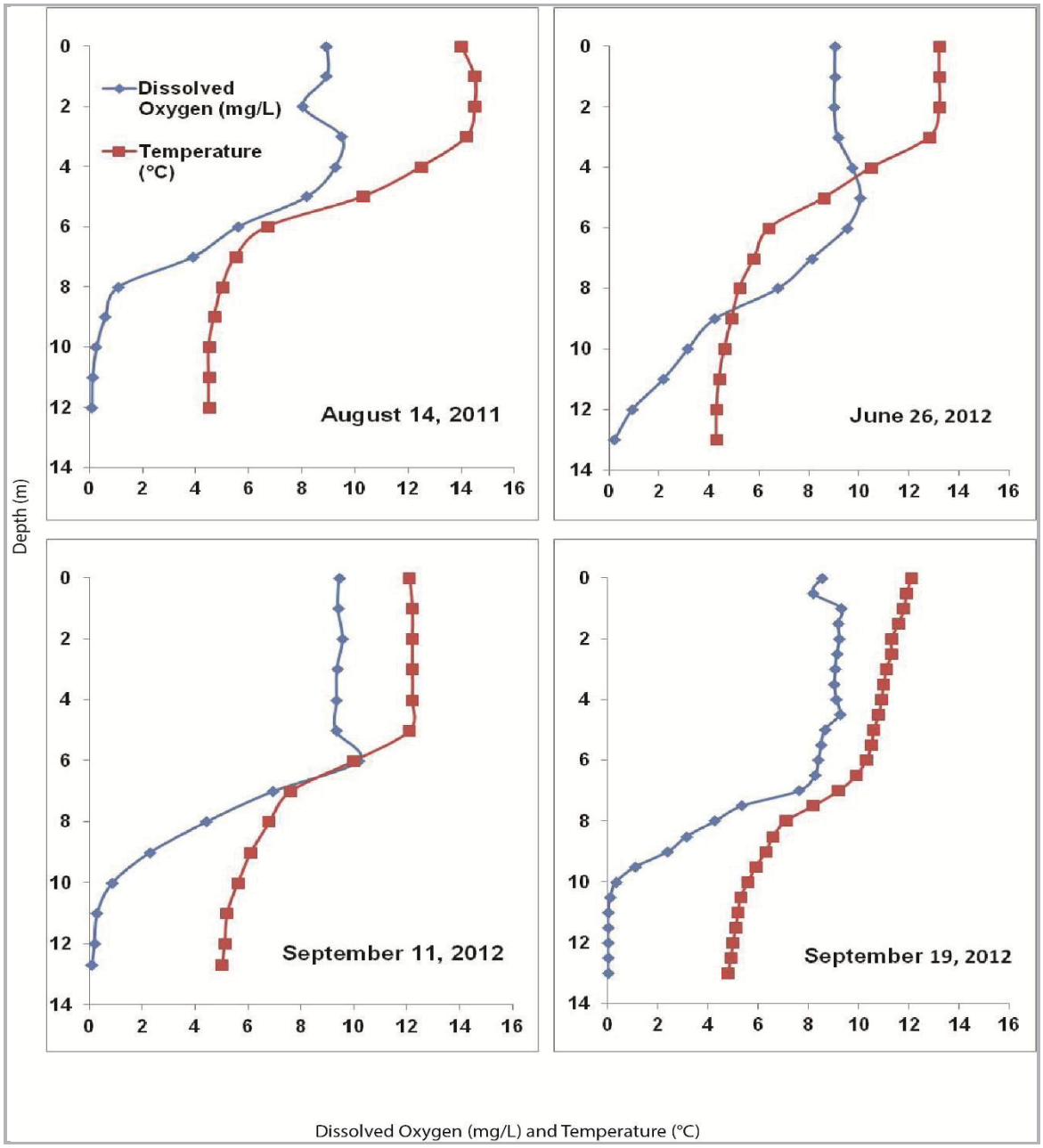
ANALYST:	BB
QA:	BO
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:2,000

PROJECT
Blackwater Gold Project

TITLE
Lake 01682LNRS – Bathymetry Map

REV. NO:	A
DATE:	June, 2012
PROJECT NO:	VE52095
FIGURE NO:	5.9-1

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Notes: °C = degrees Celsius; m = metre; mg/L = milligrams per litre.

Figure 5.9-2: Dissolved Oxygen/Temperature Profile for Lake 01682LNRS, August 2011 and June and September 2012

The littoral area of Lake 01682LNRS comprises 62% of the total lake surface area because most of the shoreline around the lake was shallow, resulting in a wide littoral area between the shore and the 6 m depth contour around most of the lake (**Table 5.9-3** and **Figure 5.9-3**).

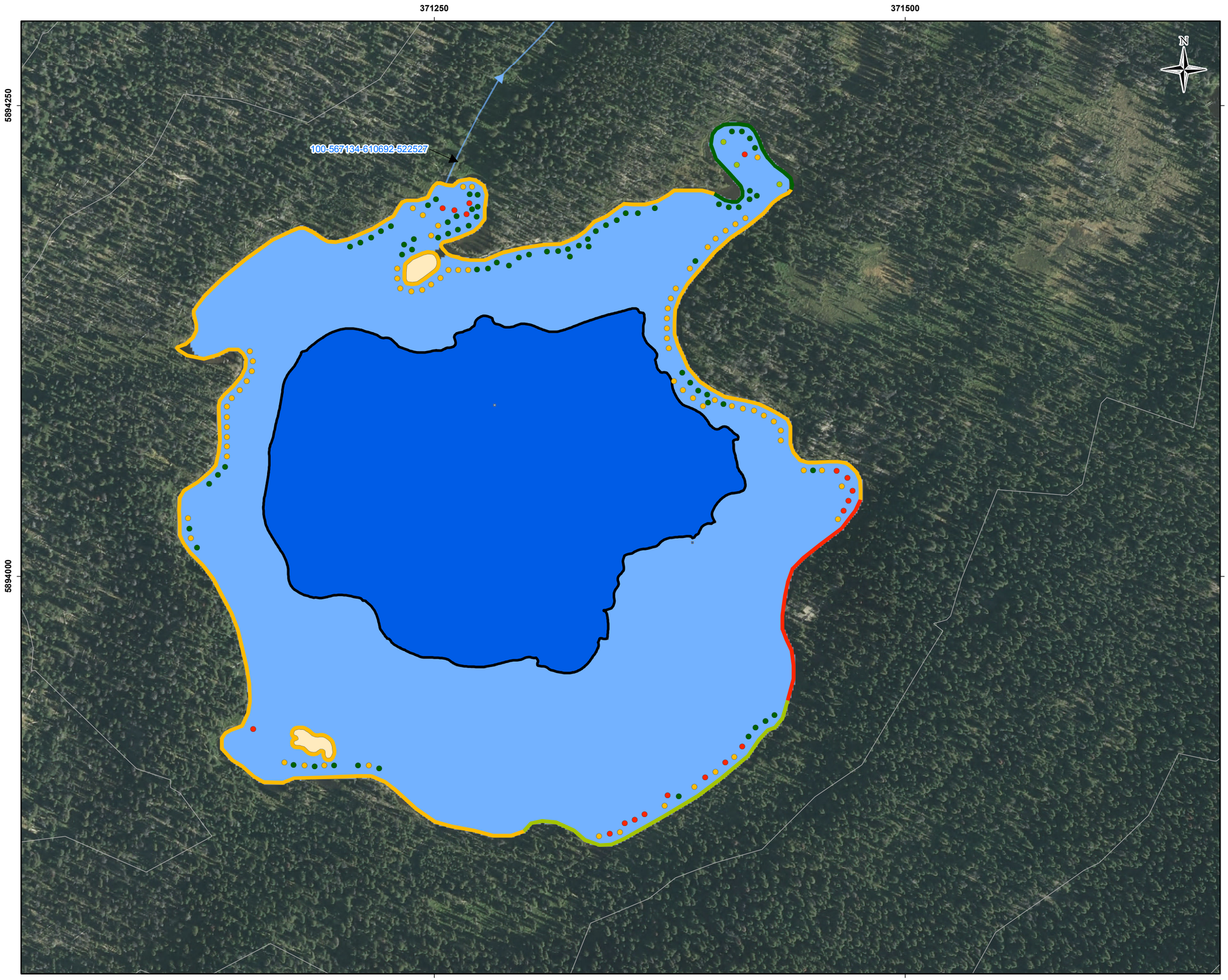
The 1% euphotic zone depth of 15 mm in mid-August was within 2 m of the lake bottom. Combined with a high surface to volume ratio, this suggests that Lake 01682LNRS has a high potential for littoral production.

Most (75%) of the littoral habitat in Lake 01682LNRS is comprised of the dominant cobble, subdominant boulder/gravel (Cbg) substrate type, which is present around the lake perimeter except along the southeast shoreline. Approximately 11% of the substrate is the dominant cobble, subdominant boulder/fines (Cbf) substrate type, which is found on the southeast shore of the lake. Approximately 7% of the substrate consists of the dominant gravel, subdominant boulder/fines (Gbf) substrate type which is located on the east shore of Lake 01682LNRS. Approximately 7% of the substrate is the dominant fines, subdominant gravel (Fg) substrate type, which is present in a well-protected bay at the north end of the lake only. This small bay also contains all the *Potamogeton spp.* in the lake.

Table 5.9-3: Surface Areas of Littoral Habitat Classes and Pelagic Habitat in Lakes 01682LNRS, 01538UEUT, and 01428UEUT

	Lake 01682LNRS		Lake 01538UEUT		Lake 01428UEUT	
	Area (m^2)	Area (%)	Area (m^2)	Area (%)	Area (m^2)	Area (%)
Littoral Habitat Classes[1]						
Gf (gravel/fines)	0	0	20,438	10.9	0	0
Gbf (gravel/boulder-fines)	4,249	7.4	132,003	70.4	0	0
Cbf (cobble/boulder-fines)	6,029	10.5	19,125	10.2	76,410	46.4
Cbg (cobble/boulder-gravel)	43,007	74.9	15,938	8.5	76,739	46.6
Fg (fines/gravels)	4,134	7.2	0	0	11,527	7.0
Littoral/Pelagic Classes						
Littoral Habitat[2]	57,419	62	187,504	52	164,676	97
Pelagic Habitat[3]	34,462	38	169,871	48	4,628	3
Total Lake	**91,881**	**100**	**357,375**	**100**	**169,304**	**100**

Notes: [1] (dominant habitat type/subdominant habitat type)
[2] Littoral habitat areas include all habitats to the 6 m depth contour
[3] Pelagic habitat areas includes all off-shore habitat below the 6 m depth contour
m^2 = metres squared; % = percent.



Legend

Vegetation Sample Location
- Carex sp
- Elodea sp
- Equisetum sp
- Potamogeton sp

Depth Contour - 6m

Island

Pelagic Habitat

Littoral Habitat

Littoral Habitat Classification Type

Dominant Cobbles; Subdominant Boulders and Fines (Cbf)

Dominant Cobbles; Subdominant Boulders and Gravels (Cbg)

Dominant Fines; Subdominant Gravels (Fg)

Dominant Gravels; Subdominant Boulders and Fines (Gbf)

Watercourse and flow direction

Scale:1:2,000

50 25 0 50 100

Meters

Reference

Freshwater Atlas scale 1:20,000;
Original littoral habitat map was developed by EcoFor Consultants Ltd.

CLIENT: newgold

PROJECT: Blackwater Gold Project

Lake 01682LNRS – Littoral Habitat Classification Map

DATE: June, 2012	ANALYST: EO	**Figure** 5.9-3
JOB No: VE52095	QA/QC: BO	PDF FILE: 10-100-051_v2_bathy_01682LNRS.pdf
GIS FILE: 10-100-051_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Aquatic plants are found scattered around the entire perimeter of the lake. The two dominant aquatic plant species are *Elodea spp.* and *Equisetum spp*. Small numbers of *Carex spp.* and *Potamogeton spp.* are also present in localized areas. The riparian vegetation surrounding Lake 01682LNRS consists of mature conifers, shrubs, herbs, and mosses. Overwintering habitat quality in Lake 01682LNRS in March 2012 was given an overall rating of poor due to the presence of low DO concentrations from a depth of 4.0 m to the lake bottom (**Table 5.9-4**). However, overwintering habitat quality is rated as fair to good above a depth of 4.0 m.

Table 5.9-4: Winter Dissolved Oxygen Observations in Headwater Lakes, March 2012

Waterbody Name	Watershed	Baseline Site ID	Mean Ice Depth (m)	Mean Water Depth (m)	Depth (m)	Mean Dissolved Oxygen (mg/L)	Overwintering Habitat Quality
Lake 01682LNRS	Davidson Creek	DO-05	1.19	8.89	1	7.9	Good
					2	6.7	Fair
					3	6.2	Fair
					4	5.8	Poor
					5	5.5	Poor
					6	4.9	Poor
					7	4.6	Poor
					8	4.3	Poor
					9	3.9	Poor
Lake 01538UEUT	Creek 705	DO-17	1.09	2.61	1	8.9	Good
					2	8.1	Good
					3	7.7	Good

Notes: m = metre; mg/L = milligrams per litre.

5.9.2 Lake 01538UEUT

Lake 01538UEUT is the southernmost headwater lake in the Creek 705 Watershed. It has two distinct basins, both orientated in an east-west direction (**Figure 5.9-4**). The smaller, western basin is less than 9 m deep and has a large littoral area at the western end near the lake outlet. One inlet tributary, classified as a NCD, enters the western basin. The eastern basin of Lake 01538UEUT is deeper and larger than the western basin. There are two inlet tributaries flowing into the lake at its eastern end; one was classified as S4 and the other classified as NCD. The steepest shoreline gradients in Lake 01538UEUT are located in the eastern basin on the north and south shorelines.

The two basins are separated by two islands located just west of the middle of the lake, a peninsula, and shallow littoral areas. The larger island is located in the middle of the lake directly across from the peninsula that extends out from the northern lake shoreline. The other smaller island is located east of the peninsula and near to the north lake shoreline.

Lake 01538UEUT has a smaller relative depth than Lake 01682LNRS, and one that is almost identical to Lake 01428UEUT (**Table 5.9-1**). Lake 01538UEUT has the same surface area to volume ratio as Lake 01682LNRS, and a smaller ratio than Lake 01428UEUT.

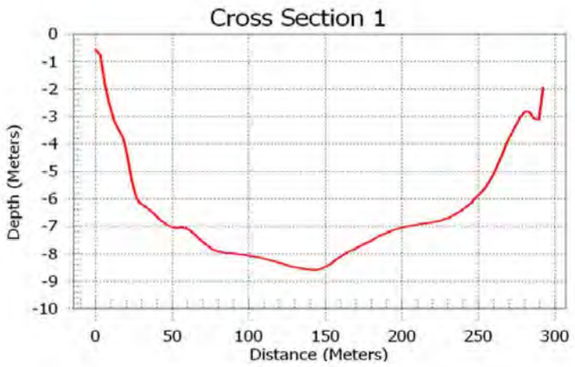
In August 2011, Lake 01538UEUT had a weak thermocline between 4 and 6 m (**Table 5.9-2** and **Figure 5.9-5**). It is unclear whether the lake stratified in summer 2012, but it was completely mixed by September 2012.

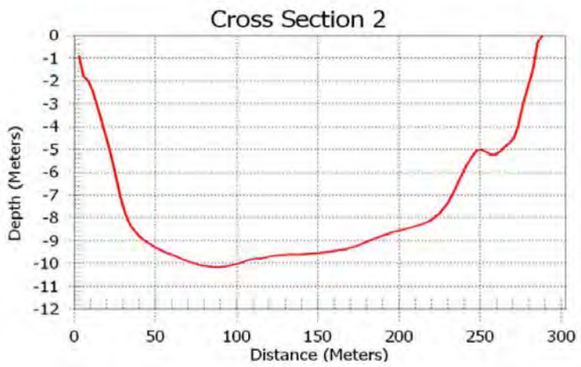
The 1% euphotic zone depth of 10.8 m in August 2011 placed it within 40 cm of the lake bottom (**Table 5.9-2**). This result, combined with the high surface–area-to-volume ratio and the high index of shoreline development number, suggests that Lake 01538UEUT has a high potential for littoral community biological production.

Most (71%) of the littoral habitat in Lake 01538UEUT is of the Gbf (i.e., gravel/boulder-fine) substrate type (**Table 5.9-3** and **Figure 5.9-6**). This habitat is distributed around the entire lake. Dominant gravel/subdominant fines (Gf) substrate type (11%) is located along the south shore and near the lake outlet. Cbf (cobble/boulder-fines) substrate type (10%) is located in the southwest corner of the lake. The remaining littoral area along the north shore is Cbg (cobble/boulder-gravel) substrate type (8.5%).

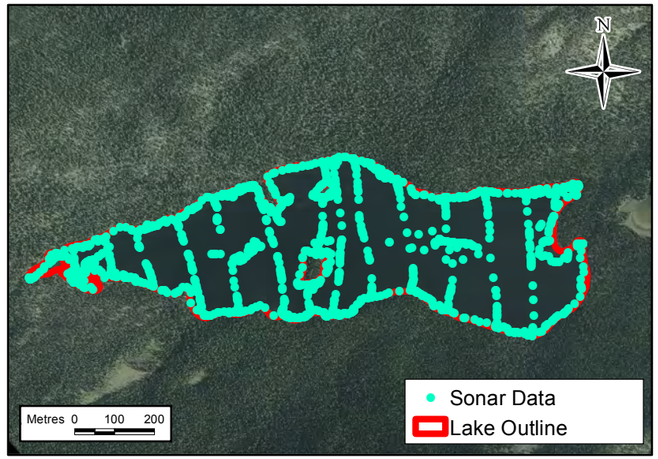
The two dominant aquatic plant species are *Carex spp.* and *Equisetum spp*. *Elodea spp.* and *Potamogeton spp.* are present, but are less abundant than other aquatic plant species. These aquatic plant species were scattered around the lake except for a notable absence along the north shore of the east basin. The riparian vegetation surrounding Lake 01538UEUT consists of mature conifers, shrubs, herbs, and mosses.

In March 2012, overwintering habitat was rated as good at depths less than 3 m (**Table 5.9-4**), due to DO concentrations greater than 7 mg/L observed under the ice.

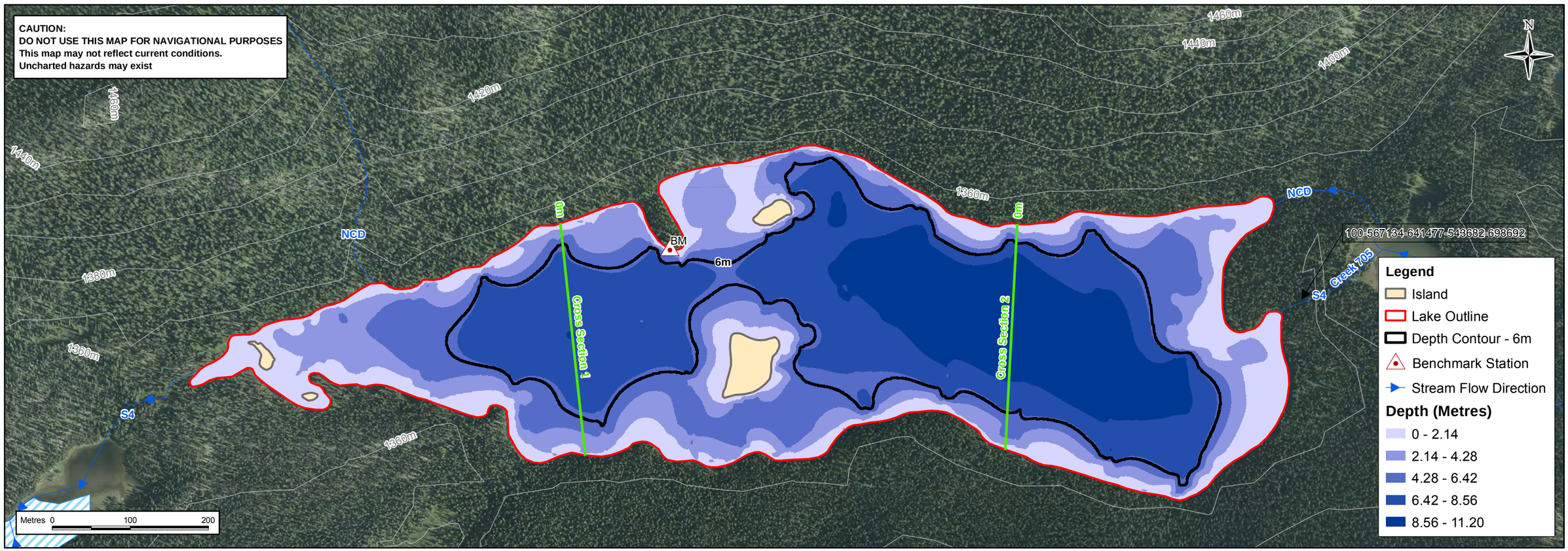








CAUTION:
DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions.
Uncharted hazards may exist



REFERENCE:
Lake 01538UEUT outline is digitized from Orthophoto and is not based on TRIM base data.

NOTES:
1 - Depths are in meters
2. Not intended for navigational use
3. Uncharted rocks shoals may exist
4. Original Bathymetry map developed by Ecofor Consultants Ltd.

SURVEYED BY:	KW/GC
SURVEYED DATE:	August 12-13, 2011
FWA CODE:	100-567134-641477-543682-698692
ORTHOPHOTO:	2011
N.T.S.:	093F/2

Statistics at Time of Survey

ELEVATION:	1346 m	MEAN DEPTH:	5.45 m
SURFACE AREA:	357,375 sq.m	MAX DEPTH:	11.2 m
AREA ABOVE 6M CONTOUR:	187,504 sq. m	PERIMETER, MAIN SHORE:	3757 m
VOLUME:	1,946,905 cu. m	PERIMETER, ISLANDS:	546.8 m
ABOVE WATER LEVEL:	1.9 m	BENCHMARK UTM:	369778 E, 5893850 N

CLIENT
newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

amec

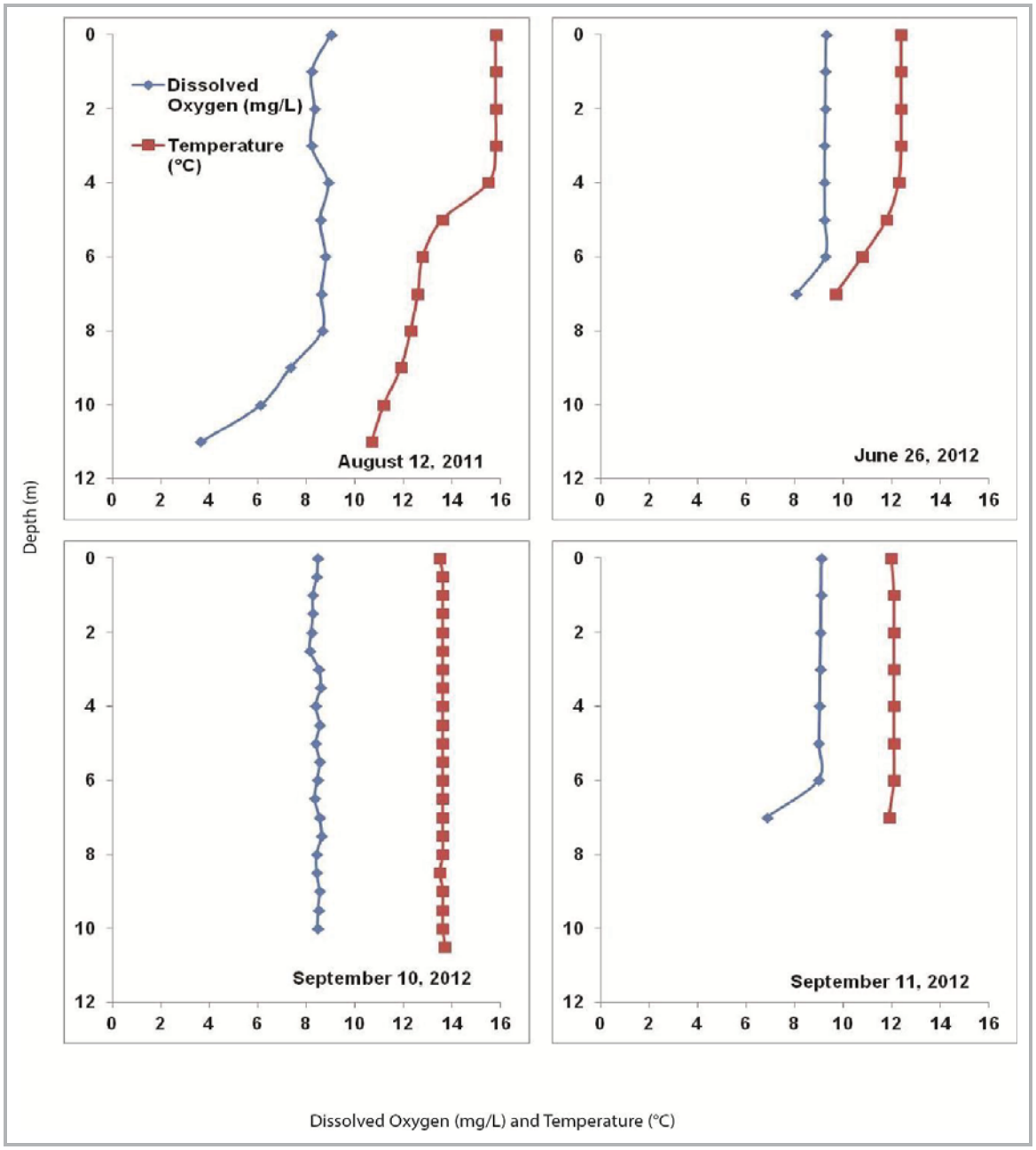
ANALYST:	BB
QA:	BO
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:5,000

PROJECT
Blackwater Gold Project

TITLE
Lake 01538UEUT – Bathymetry Map

REV. NO:	A
DATE:	June, 2012
PROJECT NO:	VE52095
FIGURE NO:	5.9-4

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-053_v3.mxd



Notes: °C = degrees Celsius; m = metre; mg/L = milligrams per litre; % = percent.

Figure 5.9-5: Dissolved Oxygen and Temperature Profiles for Lake 01538UEUT, 2011-2012

5.9.3 Lake 01428UEUT

Lake 01428UEUT is the northernmost headwater lake in the Creek 705 Watershed. It has one large main basin with a small, shallow bay at the northeast end of the lake (**Figure 5.9-7**). The lake is longer than it is wide, and is oriented along a northeast/southwest axis. The main basin is deepest near the middle with steep gradients along the north shore. The southeast end of the lake is shallow with depths less than 4 m. The small, shallow bay has a depth of less than 2 m and extends into a large wetland area. The lake has no islands and has a single inlet tributary and a single outlet. The inlet tributary flows in from the northeast and the outlet discharges to Creek 705 via Creek 606013.

Lake 01428UEUT has a maximum depth of 7.6 m, a mean depth of 3.09 m, and a relative depth of 1.64 m (**Table 5.9-1**). The lake has a surface-area-to-volume ratio of 0.31:1.

In August 2011, Lake 01428UEUT had a Secchi depth of 4.0 m (**Table 5.9-1**). Water temperatures were uniform from the surface to the bottom of the lake on all sampling dates (**Table 5.9-2** and **Figure 5.9-8**). The absence of a well defined thermocline in this lake is likely due to its shallow depth resulting in the lake being more easily mixed by wind action.

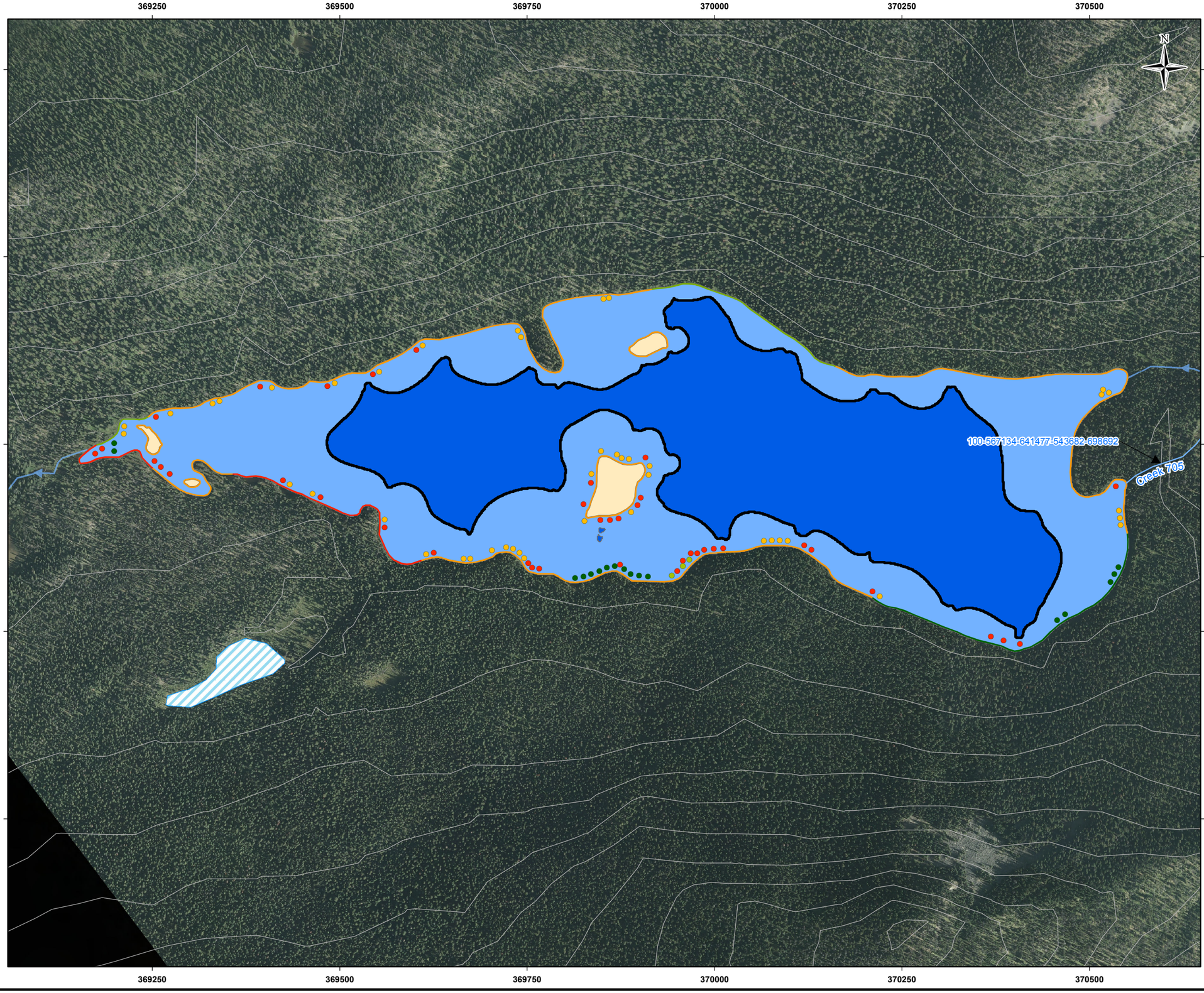
DO concentrations were constant with depth, with the exception of readings taken from the lake bottom in August 2011 and September 2012. This is a common phenomenon at the bottom of lakes because DO demand is highest at the water/sediment interface where microbial life is at its maximum density.

The 1% euphotic zone depth for Lake 01428UEUT was 10.8 m in August 2011 and 8.1 m in September 2012, which are both below the maximum depth of the lake (7.6 m). This indicates that light penetrates the whole water column, and photosynthesis is possible down to the deepest point in the lake.

Ninety-seven percent of this lake is classified as littoral habitat (<6 m deep), while only 3% is classified as pelagic habitat (**Table 5.9-3** and **Figure 5.9-9**). Approximately half of the littoral habitat is classified as the Cbf substrate type (46%), while the other half is classified as the Cbg substrate type (47%). There is also a small amount of Fg substrate type (7%).

The littoral habitat includes areas with emergent aquatic vegetation. The north shore of the lake has *Equisetum spp.* as the dominant aquatic species, while the dominant aquatic species along the southern shore was *Elodea spp*. There is a low distribution and abundance of *Carex spp.* and *Potamogeton spp.* throughout the lake.

The riparian vegetation surrounding Lake 01428UEUT consists of mature conifers, shrubs, herbs, and mosses.



Legend

Vegetation Sample Location
- Carex sp
- Elodea sp
- Equisetum sp
- Potamogeton sp

Depth Contour - 6m

Island

Pelagic Habitat

Littoral Habitat

Littoral Habitat Classification Type
- Dominant Cobbles; Subdominant Boulders and Fines (Cbf)
- Dominant Cobbles; Subdominant Boulders and Gravels (Cbg)
- Dominant Gravels; Subdominant Boulders and Fines (Gnf)
- Dominant Gravels; Subdominant Fines (Gbf)

Watercourse and flow direction

Scale:1:5,000

100 50 0 100 200

Meters

Reference

Freshwater Atlas scale 1:20,000.
Original littoral habitat map was developed by Ecofor Consultants Ltd.

CLIENT: newgold

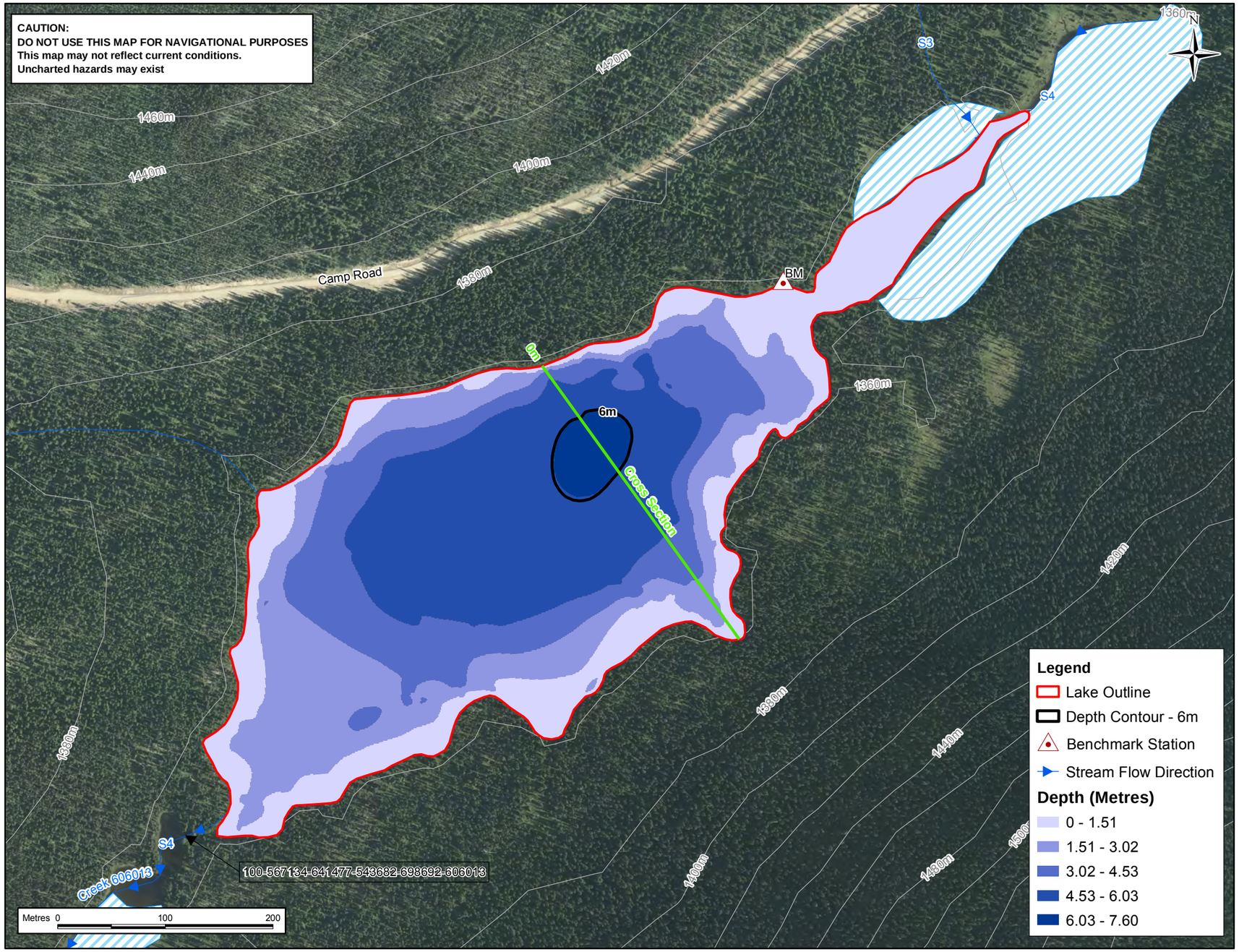
PROJECT: Blackwater Gold Project

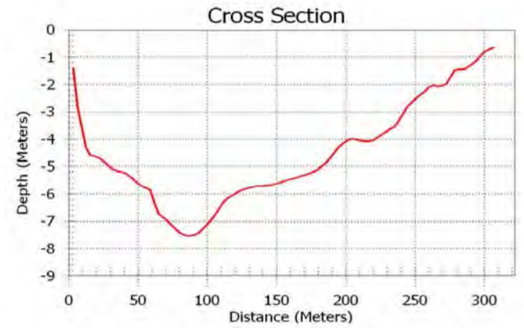
Lake 01538UEUT – Littoral Habitat Classification Map

DATE: June, 2012	ANALYST: MY	**Figure** 5.9-6
JOB No: VE52095	QA/QC: BO	PDF FILE: 10-100-052_v2_littoral_01538UEUT.pdf
GIS FILE: 10-100-052_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

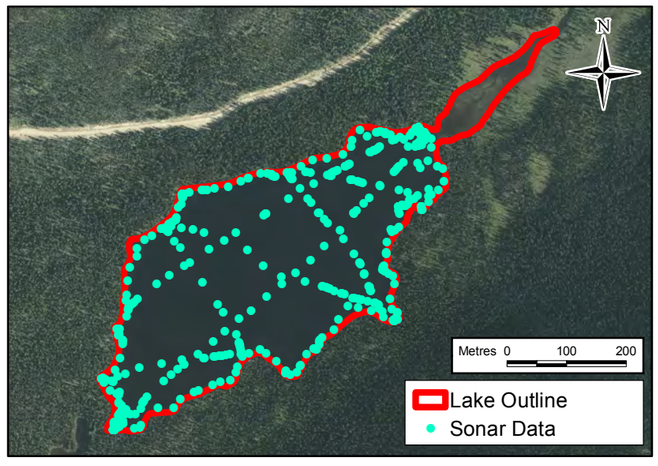
Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-052_v2.mxd

CAUTION:
DO NOT USE THIS MAP FOR NAVIGATIONAL PURPOSES
This map may not reflect current conditions.
Uncharted hazards may exist









REFERENCE:
Lake 01428UEUT outline is digitized from Orthophoto and is not based on TRIM base data.

NOTES:
1 - Depths are in meters
2. Not intended for navigational use
3. Uncharted rocks shoals may exist
4. Original Bathymetry map developed by Ecofor Consultants Ltd.

SURVEYED BY:	KW/GC
SURVEYED DATE:	August 16-17, 2011
FWA CODE:	100-567134-641477-543682-698692-606013
ORTHOPHOTO:	2011
N.T.S.:	093F/2

Statistics at Time of Survey

ELEVATION:	1354 m	MEAN DEPTH:	3.09 m
SURFACE AREA:	169,304 sq.m	MAX DEPTH:	7.6 m
AREA ABOVE 6M CONTOUR:	164,676 sq. m	PERIMETER, MAIN SHORE:	2508 m
VOLUME:	522,815 cu. m	PERIMETER, ISLANDS:	N/A
ABOVE WATER LEVEL:	1.8 m	BENCHMARK UTM:	369637 E, 5895845 N

CLIENT
newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

amec

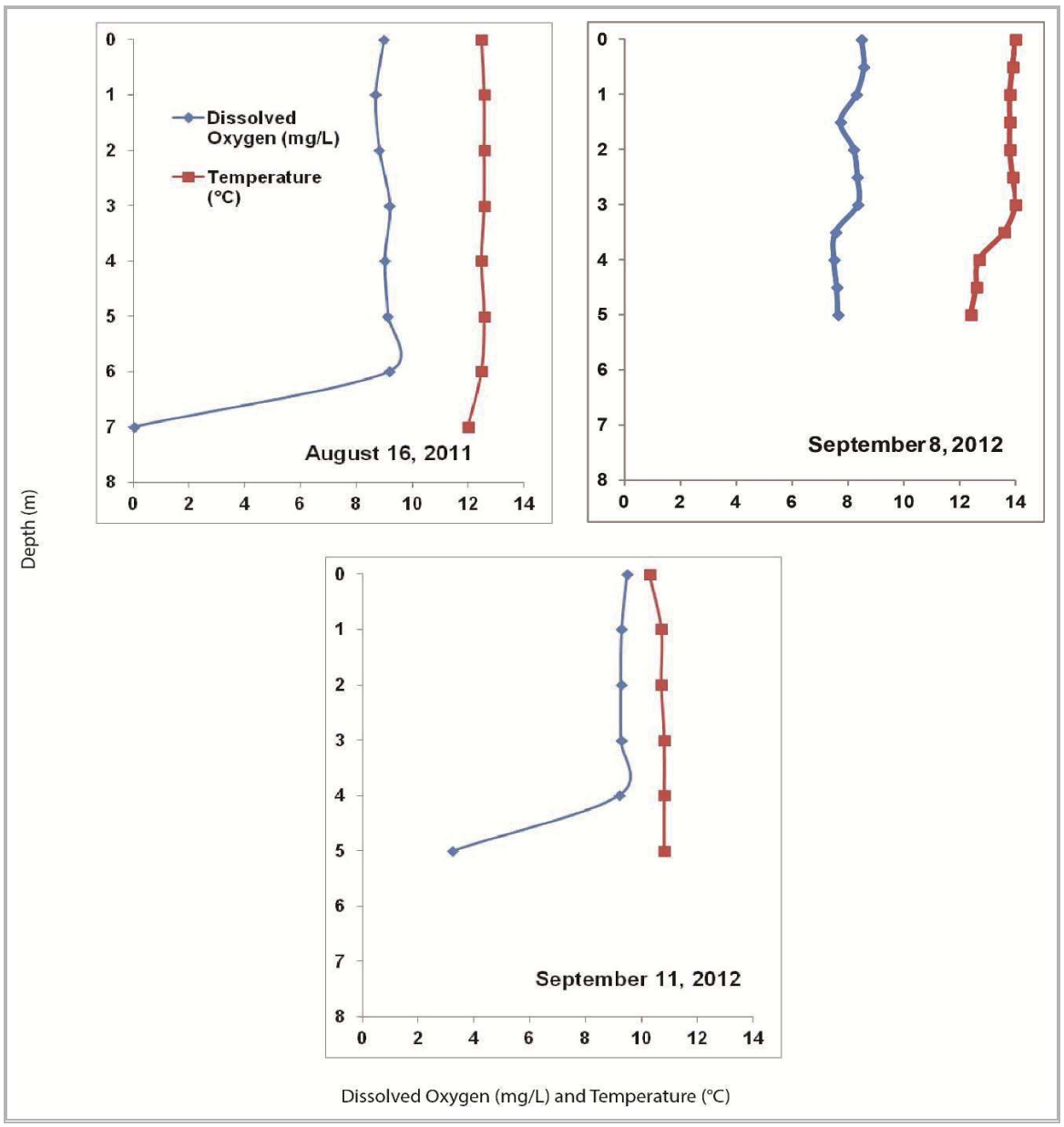
ANALYST:	BB
QA:	BO
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:4,000

PROJECT
Blackwater Gold Project

TITLE
Lake 01428UEUT – Bathymetry Map

REV. NO:	A
DATE:	June, 2012
PROJECT NO:	VE52095
FIGURE NO:	5.9-7

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-054_v3.mxd



Notes: °C = degrees Celsius; m = metre; mg/L = milligrams per litre.

Figure 5.9-8: Dissolved Oxygen and Temperature Profiles for Lake 01428UEUT, 2011-2012

368750 369000 369250 369500 369750 370000

5896250 5896000 5895750 5895500 5895250

N

Creek 696013

Legend

- Carex sp
- Elodea sp
- Equisetum sp
- Potamogeton sp
- Depth Contour - 6m
- Pelagic Habitat
- Littoral Habitat

Littoral Habitat Classification Type

- Dominant Cobbles; Subdominant Boulders and Fines (Cbf)
- Dominant Cobbles; Subdominant Boulders and Gravels (Cbg)
- Dominant Fines; Subdominant Gravels (Fg)
- Watercourse and flow direction

Scale:1:4,500

100 50 0 100 200

Meters

Reference

Freshwater Atlas scale 1:20,000;
Original littoral habitat map was developed by EcoFor Consultants Ltd.

CLIENT: newgold

PROJECT: Blackwater Gold Project

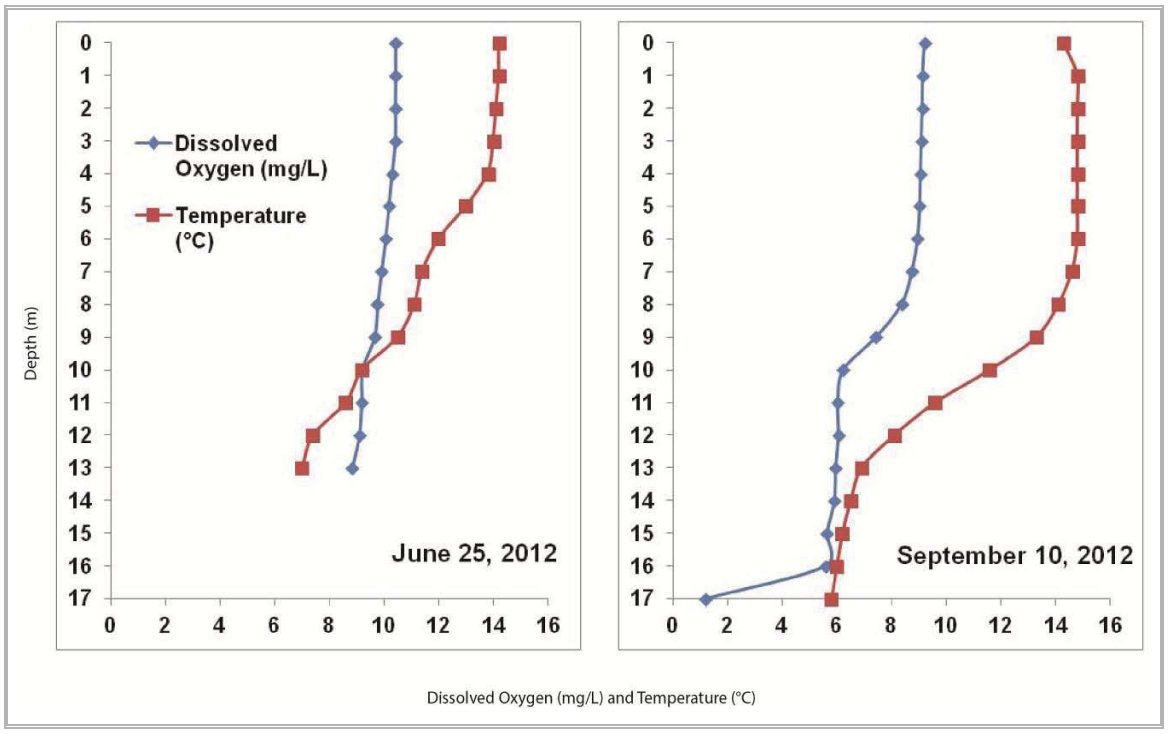
Lake 01428UEUT – Littoral Habitat Classification Map

DATE: June, 2012	ANALYST: MY	**Figure** 5.9-9
JOB No: VE52095	QA/QC: BO	PDF FILE: 10-100-055_v2_littoral_01428UEUT.pdf
GIS FILE: 10-100-055_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-055_v2.mxd

5.9.4 Tatelkuz Lake

A weak thermocline was present in Tatelkuz Lake in late June 2012 at depths between 4 and 6 m (**Table 5.9-2** and **Figure 5.9-10**). This thermocline strengthened and deepened by 10 September 10 2012, with a well-defined thermocline between 7 and 12 m.

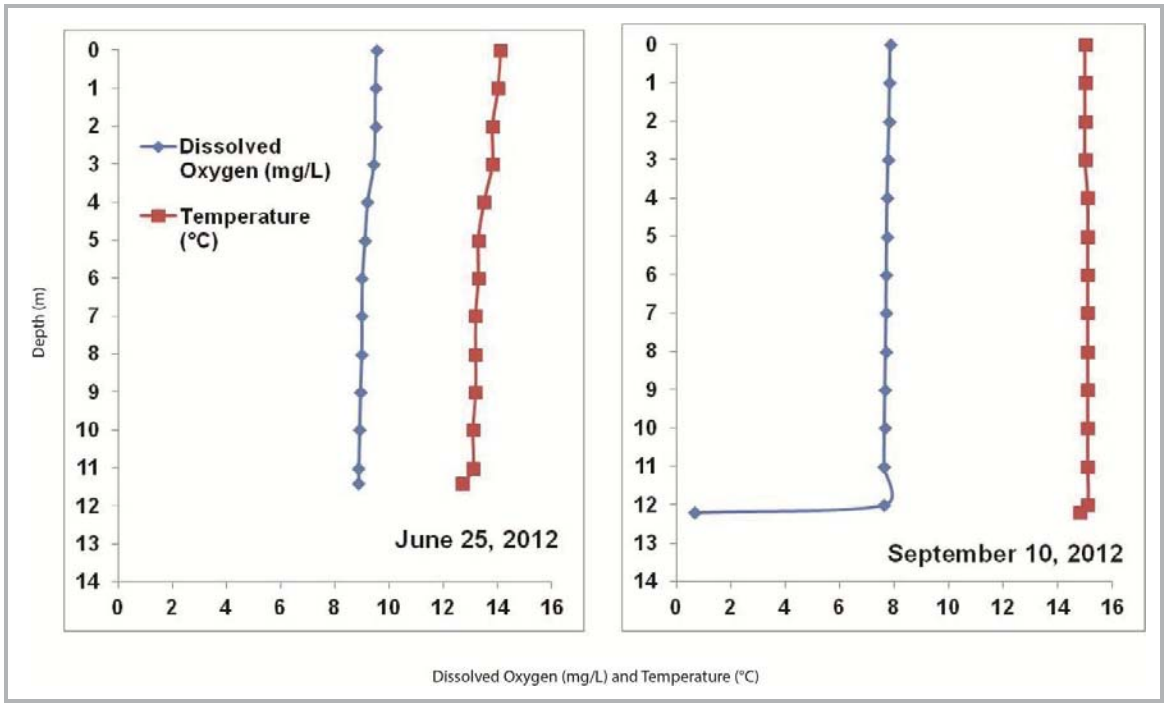


Notes: °C = degrees Celsius; m = metre; mg/L = milligrams per litre

Figure 5.9-10: Dissolved Oxygen and Temperature Profiles for Tatelkuz Lake, 2012

5.9.5 Kuyakuz Lake

A thermocline was not present in Kuyakuz Lake in June or September of 2012 (**Table 5.9-2** and **Figure 5.9-11**). Water temperature and DO concentration were uniform throughout the water column in both months. DO concentrations near the bottom showed a sharp drop to near-anoxic levels.



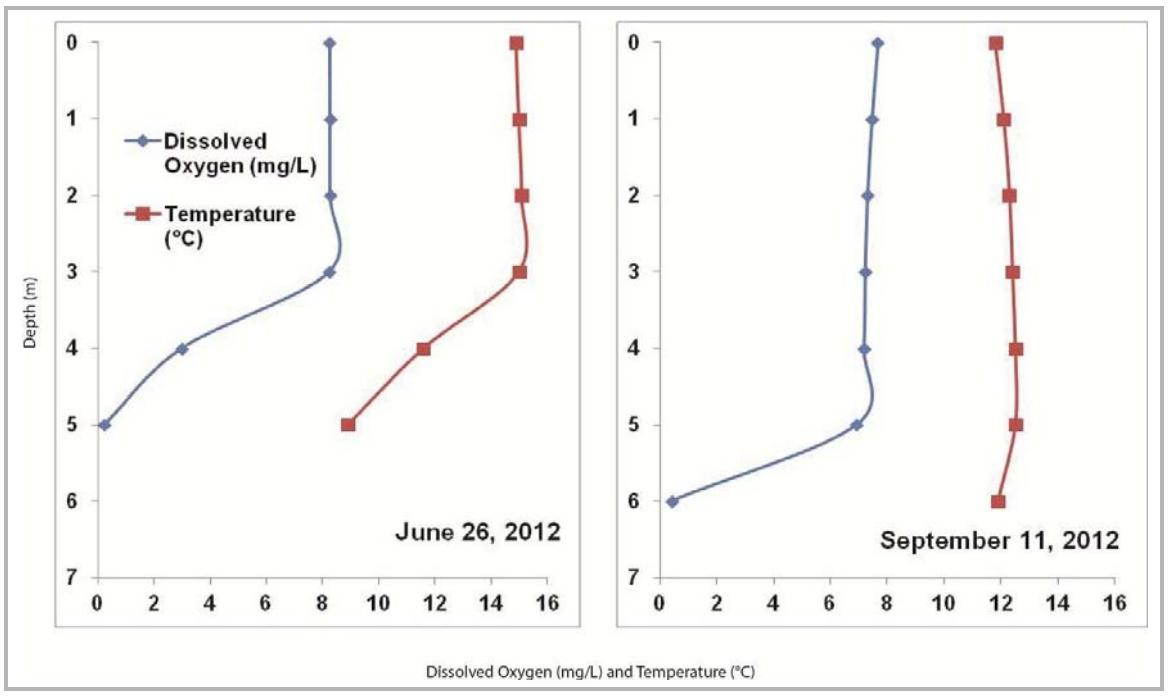
Notes: °C = degrees Celsius; m = metre; mg/L = milligrams per litre.

Figure 5.9-11: Dissolved Oxygen and Temperature Profiles for Kuyakuz Lake, 2012

5.9.6 Snake Lake

A thermocline was present in Snake Lake in June 2012 at a depth between 3 and 4 m (**Table 5.9-2** and **Figure 5.9-12**). However, the lake had apparently turned over by 11 September 2012. In September 2012, DO concentrations remained relatively constant until 5 m, where it dropped to a near-anoxic concentration at the bottom.

In March 2012, winter DO concentrations were measured from Snake Lake at a depth of 1 m (**Table 5.9-4**). Mean depth during winter sampling was 1.5 m. Since depths of 6 m were measured in September 2012, it is clear that the deepest locations were not sampled in March 2012. Overwintering rating is therefore not certain.



Notes: °C = degrees Celsius; m = metre; mg/L = milligrams per litre.

Figure 5.9-12: Dissolved Oxygen and Temperature Profiles for Snake Lake, 2012

5.10 Fish Communities

This section describes the species composition, population structure, relative abundance, spatial distribution, migration timing, and biological characteristics of fish communities in the LSA and RSA and the proposed transmission line and access road corridors, based on the following five survey programs conducted in 2011 and 2012:

- Spring rainbow trout spawning survey in 2011;
- Summer stream inventories in July and August 2011 and August to October 2012;
- Summer lake inventories in four headwater lakes in August 2011 and September 2012;
- Summer survey of fish and fish habitat in streams crossed by the proposed transmission line and road access corridors in August and September 2012; and
- Fall mountain whitefish spawning survey in 2012.

Annex 5.10-1 shows the fish sampling permits for 2011 and 2012. **Annex 5.10-2** shows stream and lake fish effort and catch data, and **Annex 5.10-3** shows the kokanee spawning habitat data. **Annex 5.10-4** shows fish photographs. **Annex 5.10-5** shows the report of the surveys of the proposed transmission line and road access corridors (Avison, 2013). **Annex 5.10-6** shows the biological characteristics of all fish sampled in 2011 and 2012, and **Annex 5.10-7** shows the taxonomic composition of fish stomach contents. **Annex 5.10-8** shows fish tissue metal concentrations from both stream and lake samples, and **Annex 5.10-9** shows the statistical analysis of those concentrations by watershed and tissue. **Appendices 5.10-10** and **5.10-11** show the microsatellite DNA analysis and data, respectively, for rainbow trout populations (Taylor 2012), and **Appendices 5.10-12** and **5.10-13** show the microsatellite DNA analysis and data, respectively, for kokanee populations (Taylor 2013).

5.10.1 Species Composition and Population Structure

A total of nine species of fish were observed or captured in streams and lakes of the LSA and RSA in 2011 and 2012 (**Table 5.10-1**). This list includes all of the fish species observed or captured from streams that will be crossed by the proposed transmission line and access road corridors.

None of these species are endangered, threatened, or vulnerable according to the BC Conservation Data Centre (BC CDC) (BC CDC 2013) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2013).

This is an underestimate of the total number of fish species in the LSA and RSA because it does not include large-scale sucker (*Catostomus macrocheilus*), which was reported by Walsh and Hale (1977) to be present in Tatelkuz Lake.

Table 5.10-1: Fish Species Observed or Captured in the LSA and RSA, 2010-2011

Common Name	Scientific Name	BC Fish Species Code
Kokanee	*Oncorhynchus nerka*	KO
Rainbow trout	*Oncorhynchus mykiss*	RB
Lake chub	*Couesius plumbeus*	LKC
Longnose sucker	*Catostomus catostomus*	LSU
Brassy minnow	*Hybognathus hankinsoni*	BMC
Mountain whitefish	*Prosopium williamsoni*	MW
Burbot	*Lota lota*	BB
Longnose dace	*Rhinichthyes cataractae*	LNC
White sucker	*Catostomus commersonii*	WSU

In this baseline report, catch, effort, CPUE, and biological characteristics of kokanee and rainbow trout were aggregated and presented on a population basis because modern resource management and conservation biology use breeding populations as the basic unit of management. Three populations of kokanee were identified based on the following sources of information:

- Genetic differences among kokanee from different watersheds of the LSA and RSA, based on microsatellite DNA analyses;
- Observed differences in seasonal timing of kokanee spawning among streams of the LSA and RSA;
- Measured differences among streams in the LSA in mean water temperature during the August and September kokanee spawning period; and
- Measured differences in body length of kokanee spawners among streams of the RSA.

Seven populations of rainbow trout were identified based on the following sources of information:

- Genetic differences among rainbow trout from different watersheds of the LSA and RSA, based on microsatellite DNA analyses;
- Capture of upstream migrating spawning rainbow trout from Chedakuz Creek into Davidson Creek, Turtle Creek, and Creek 661 in spring 2011 using hoop nets;
- Capture of upstream migrating spawning rainbow trout from Fawnie Creek into Creek 705 in spring 2011 using hoop nets;
- Presence of a partial barrier to fish passage in Reach 11 of upper Davidson Creek;
- Presence of a headwater lake in Davidson Creek, and of two headwater lakes in the Creek 705 Watershed, and their absence in Turtle Creek and Creek 661 Watersheds;
- Presumed larger volumes of good overwintering habitat in Tatelkuz Lake and headwater lakes than in streams of the LSA;

- Relatively high densities of rainbow trout YOY in Reach 12 of upper Davidson Creek (above the potential barrier to passage) that indicate the presence of nearby spawning areas;
- Predominance of small, juvenile rainbow trout in streams during summer, and the absence of large, adult stream-residents; and
- Slower growth of rainbow trout in all three headwater lakes than in streams.

These sources of information will be discussed in greater detail below.

These ten populations and their proposed seasonal migration routes are working hypotheses based on surveys conducted in 2011 and 2012. The hypotheses will continue to be tested using the results of future baseline and monitoring studies.

Species of fish other than rainbow trout and kokanee could not be assigned to populations with confidence because of insufficient data – those species made up less than 1% of the total number of fish captured and counted in 2011 and 2012.

5.10.1.1 Kokanee

Relative Abundance and Life History

Kokanee, the landlocked form of sockeye salmon (**Plate 5.10-1**), was the most common species encountered, comprising 86% of total fish counts (**Table 5.10-2**). This was due mainly to 23,964 kokanee spawners that were counted during kokanee spawning surveys conducted in August and September 2011 and 2012.

Kokanee live in lakes where they feed mostly on zooplankton and small fish (McPhail 2007). In late summer and fall, when water temperatures drop below 12°C (Ford et al., 1995; McPhail 2007), adult kokanee in BC typically migrate from their residence lakes to tributary streams to spawn (Scott and Crossman, 1973). In the LSA and RSA, kokanee spawners were observed in spawning creeks from early August to mid-September (**Table 5.9-2**). In lakes, kokanee may also spawn in inshore areas where upwelling or subsurface flows exist (McPhail 2007). It is not known whether kokanee lake spawning occurs in Tatelkuz and Kuyakuz lakes.

On the spawning grounds, females establish territories and dig nests (referred to as “redds”) into which they deposit their eggs. After fertilization of eggs by a male, the female covers the nest with gravel. Adults die within several weeks of spawning, and embryos incubate in gravel over winter. Fry emerge after ice break-up, which occurs in late May (**Table 5.10-3**), and quickly migrate downstream to their residence lake.



Plate 5.10-1: Kokanee Caught in Upper Chedakuz Creek, 10 September 2012

Juveniles rear in their residence lakes over summer and early fall. Overwintering begins once an ice cover forms over residence lakes. Ice begins to forms on lakes in the LSA and RSA in October and begins to break up in April and May.

Kokanee are a popular sport fish in BC, and have probably been harvested in Aboriginal fisheries in the LSA and RSA.

Tatelkuz and Kuyakuz lakes are the main kokanee lakes in the LSA and RSA, respectively. Kokanee are not present in the four headwater lakes of the LSA.

Table 5.10-2: Total Number of Fish Observed or Captured, LSA, RSA, and Transmission Line and Access Road Corridors, 2011-2012

Gear Type	Species										
Hoop Net											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	**Total**
Biological characteristics, released	1,679	4	4	1	0	0	0	0	0	0	1,688
Biological characteristics, mortality	89	0	0	0	0	0	0	0	0	0	89
Biological characteristics, aging structure, released	76	17	0	0	0	0	0	0	0	0	93
Biological characteristics, aging structure, mortality	19	0	0	0	0	0	0	0	0	0	19
Biological characteristics, aging structure, DNA, released	101	0	0	0	0	0	0	0	0	0	101
Biological characteristics, aging structure, DNA, mortality	28	0	0	0	0	0	0	0	0	0	28
Escaped during sampling	5	0	0	0	0	0	0	0	0	0	5
Hoop net Totals	**1,997**	**21**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2,023**
Backpack Electrofishing											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	
Biological characteristics, released	816	1	0	0	23	5	1	0	0	0	846
Biological characteristics, mortality	5	0	0	0	0	0	0	0	0	0	5
Biological characteristics, aging structure, released	146	0	0	0	0	0	0	0	0	0	146
Biological characteristics, aging structure, mortality	1	0	0	0	0	0	0	0	0	0	1
Biological characteristics, aging structure, DNA, released	3	0	0	0	0	0	0	0	0	0	3
Biological characteristics, aging structure, DNA, mortality	1	0	0	0	0	0	0	0	0	0	1
Biological characteristics, aging structure, DNA, tissue metals, mortality	6	0	0	0	0	0	0	0	0	0	6
Biological characteristics, aging structure, DNA, tissue metals, stomach contents, mortality	9	0	0	0	0	0	0	0	0	0	9
Biological characteristics, aging structure, tissue metals, stomach contents, mortality	17	0	0	0	0	0	0	0	0	0	17
Tallied, released	133	0	0	0	0	0	0	0	0	0	133
Escaped during sampling	183	0	0	0	0	3	0	0	0	233	419
Visual observation	3	0	0	0	0	0	0	0	0	0	3
Backpack Electrofishing Totals	**1,323**	**1**	**0**	**0**	**23**	**8**	**1**	**0**	**0**	**233**	**1,589**
Gillnetting											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	
Biological characteristics, released	13	0	0	2	0	0	0	86	0	0	101
Biological characteristics, mortality	28	0	0	0	0	0	0	0	0	0	28
Biological characteristics, aging structure, released	8	0	0	0	0	0	0	0	0	0	8
Biological characteristics, aging structure, mortality	0	0	0	1	0	0	0	0	0	0	1
Biological characteristics, aging structure, DNA, released	0	0	0	0	0	0	0	0	0	0	0
Biological characteristics, aging structure, DNA, mortality	0	0	0	0	0	0	0	0	0	0	0

Table continues...

Table 5.10-2 (cont'd)

Gear Type	Species										Total
Biological characteristics, aging structure, DNA, tissue metals, mortality	53	0	0	0	0	0	0	0	0	0	53
Biological characteristics, aging structure, DNA, tissue metals, stomach contents, mortality	22	0	0	0	0	0	0	0	0	0	22
Biological characteristics, aging structure, tissue metals, stomach contents, mortality	0	0	0	0	0	0	0	0	0	0	0
Tallied, released	0	0	0	0	0	0	0	0	0	0	0
Escaped during sampling	0	0	0	0	0	0	0	0	0	0	0
Visual observation	0	0	0	0	0	0	0	0	0	0	0
Gillnetting Totals	**124**	**0**	**0**	**3**	**0**	**0**	**0**	**86**	**0**	**0**	**213**
Minnow Trapping											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	
Biological characteristics, released	54	0	0	51	0	24	0	16	1	0	146
Biological characteristics, aging structure, released	17	0	0	0	0	0	0	0	0	0	17
Biological characteristics, aging structure, mortality	0	0	0	1	0	0	0	0	0	0	1
Biological characteristics, aging structure, DNA, tissue metals, mortality	18	0	0	0	0	0	0	0	0	0	18
Tallied, released	3	0	0	0	0	0	0	0	0	0	3
Escaped during sampling	3	0	0	0	0	0	0	0	0	0	3
Minnow Trapping Totals	**95**	**0**	**0**	**52**	**0**	**24**	**0**	**16**	**1**	**0**	**188**
Beach Seining											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	
Biological characteristics, released	40	1	0	0	0	0	0	0	0	0	41
Biological characteristics, mortality	1	0	0	0	0	0	0	0	0	0	1
Biological characteristics, aging structure, released	0	6	0	0	0	0	0	0	0	0	6
Biological characteristics, aging structure, mortality	0	1	0	0	0	0	0	0	0	0	1
Beach Seining Totals	**41**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**49**
Angling											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	
Biological characteristics, aging structure, DNA, tissue metals, mortality	1	0	0	0	0	0	0	0	0	0	1
Biological characteristics, aging structure, DNA, tissue metals, stomach contents, mortality	7	0	0	0	0	0	0	0	0	0	7
Angling Totals	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**
Stream Counts											
	RB	**MW**	**BB**	**LSU**	**KO**	**BMC**	**LNC**	**LKC**	**WSU**	**SPP**	
Visual counts	0	0	0	0	23,964	0	0	0	0	0	0
Stream Counts Totals	**0**	**0**	**0**	**0**	**23,964**	**0**	**0**	**0**	**0**	**0**	**23,964**
GRAND TOTAL	**3,588**	**30**	**4**	**56**	**23,987**	**32**	**1**	**102**	**1**	**233**	**28,034**

Notes: BB = burbot; BMC = brassy minnow; KO = kokanee; LKC = lake chub; LNC = longnose dace; LSU = longnose sucker; MW = mountain whitefish; RB = rainbow trout; SPP = unidentified species; WSU = white sucker

Table 5.10-3: Life History Periodicity Chart for the Nine Fish Species of the LSA and RSA

Species	Life Stage - Activity	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Kokanee	Adult migration/spawning																								
	Embryo incubation																								
	Juvenile migration																								
	Juvenile rearing																								
	Juvenile overwintering																								
	Adult rearing																								
	Adult overwintering																								
Rainbow trout	Adult migration/spawning																								
	Embryo incubation																								
	Juvenile migration (lake dwelling)																								
	Juvenile rearing																								
	Juvenile overwintering																								
	Adult rearing																								
	Adult overwintering																								
Lake chub	Adult spawning																								
	Embryo incubation																								
	Juvenile rearing																								
	Juvenile/adult migration																								
	Juvenile/adult overwintering																								
Longnose sucker	Adult spawning																								
	Embryo incubation																								
	Juvenile migration																								
	Juvenile rearing																								
	Adult rearing																								
	Adult overwintering																								
	Adult migration																								
Brassy minnow	Adult spawning																								
	Embryo incubation																								
	Juvenile rearing																								
	Juvenile overwintering																								
	Adult rearing																								
	Adult overwintering																								

Table continues...

Table 5.10-3 (cont'd)

Species	Life Stage - Activity	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Mountain whitefish	Adult spawning																								
	Embryo incubation																								
	Juvenile migration																								
	Juvenile rearing																								
	Juvenile overwintering																								
	Adult rearing																								
	Adult migration																								
	Adult overwintering																								
Burbot	Adult migration/spawning																								
	Embryo incubation																								
	Juvenile rearing																								
	Adult rearing																								
Longnose dace	Adult spawning																								
	Embryo incubation																								
	Juvenile rearing																								
	Adult rearing/overwintering																								
White sucker	Adult migration/spawning																								
	Embryo incubation																								
	Juvenile migration																								
	Juvenile rearing																								
	Juvenile overwintering																								
	Adult rearing																								
	Adult overwintering																								

Population Structure

Microsatellite DNA analysis of kokanee tissue samples collected in 2012, and discussed in **Section 5.10.3.7**, showed three broad groupings of kokanee, one of which is present in Kuyakuz Lake and its tributaries, and two of which are present in Tatelkuz Lake and its tributaries (Taylor 2013; **Appendices 5.10-12** and **5.10-13** and **Figure 5.10-1**).

Kokanee of the Kuyakuz Lake population spend the majority of their life in Kuyakuz Lake. In fall, spawners emerge from the lake to spawn in tributaries to Kuyakuz Lake such as upper Chedakuz Creek. They also spawn in the mainstem of middle Chedakuz Creek downstream of Kuyakuz Lake. Eggs incubate in the gravel over winter and fry emerge in spring and migrate to Kuyakuz Lake.

There are assumed to be two kokanee populations in Tatelkuz Lake: one that spawns in early to mid-August in Davidson Creek, Creek 661, Creek 522107, Creek 601947, and middle Chedakuz Creek (labelled “Tatelkuz Lake Early” in **Figure 5.10-1**), and a second population that spawns in early September in lower Chedakuz Creek just downstream of the outlet of Tatelkuz Lake (called “Tatelkuz Lake Late”).

Temperature differences between the spawning grounds maintain the separation of the two populations. Water temperatures are always higher in lower Chedakuz Creek than in higher-elevation tributaries such as Davidson Creek and Creek 661 (**Section 5.1**), thereby allowing later spawning of some kokanee in lower Chedakuz Creek than in other tributaries. Embryos incubate in stream gravel over winter and fry emerge in spring and migrate downstream to Tatelkuz Lake (or upstream in the case of those emerging from gravel in lower Chedakuz Creek).

Until more information becomes available on the spatial distribution of spawning kokanee in middle Chedakuz Creek, the divide between the populations that reside in Tatelkuz and Kuyakuz lakes is arbitrarily drawn at the mid-point of Chedakuz Creek between Kuyakuz Lake and Tatelkuz Lake (**Figure 5.10-1**).

5.10.1.2 Rainbow Trout

Relative Abundance and Life History

Rainbow trout is the second most common fish species of the LSA and RSA, comprising 13% of all fish observed or captured (**Table 5.10-2**). It is the predominant species in streams of the LSA because juvenile rainbow trout rear in stream habitat for at least one summer and sometimes two or three summers before migrating into their lake of residence (**Plate 5.10-2**).



Plate 5.10-2: Rainbow Trout Caught in a Hoop Net in Lower Davidson Creek (HN-01), 18 June 2011

Rainbow trout belong to the salmonid family (Family Salmonidae), but have a trout life cycle. That is, it can spawn multiple times in its life instead of spawning once and dying, as do all Pacific salmon. While a sea-run form of rainbow trout (i.e., steelhead) is present in coastal streams of BC, all rainbow trout in the LSA and RSA and the proposed transmission line and access road corridors spend their entire lives in fresh water.

Rainbow trout are spring spawners (**Table 5.10-3**). Once water temperature rises above 4°C (McPhail 2007), adults migrate from overwintering lakes or rivers to tributary streams, spawn, and then quickly return to their lakes or rivers of residence (Scott and Crossman 1973). In the LSA and RSA, rainbow trout begin migrating to spawning grounds in May and finish spawning by the end of June.

370000 375000 380000 385000 390000 395000 400000

5915000 5910000 5905000 5900000 5895000 5890000

N

Chutanli Lake

Chedakuz Creek

Creek 505659

Kluskus-Blue FSR

Creek 522107

Turtle Creek

Proposed Transmission Line

Kluskus-Ootsa FSR

Fawnie Creek

Davidson Creek

Tatelkuz Lake

Water Pipeline Route

Creek 601947

Creek 700

Top Lake

Snake lake

Suscha Lake

Creek 688328

Creek 661

Proposed Mine Access Road

Creek 705

Creek 146920

Creek 505659

Creek 543585

Creek 661

Lake 01428UEUT

Exploration Road

Lake 01682LNRS

Creek 704454

Creek 885275

Lake 01538UEUT

Chedakuz Creek

Kuyakuz Lake

Mathews Creek

370000 375000 380000 385000 390000 395000 400000

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-127_kokanee_pop_structure.mxd

Legend

- Proposed Mine Access Road
- Proposed Transmission Line (April 11,2013)
- Proposed Transmission Line
- Exploration Road
- Kluskus FSR
- Kluskus Blue FSR
- Kluskus Ootsa FSR
- Water Pipeline Route
- Stream (>4th Order)
- Waterbody
- Proposed Mine Site

Aquatic Environment & Wetland

- Aquatic Regional Study Area
- Aquatic Local Study Area

Kokanee Populations

- Kuyakuz Lake
- Tatelkuz Lake Early
- Tatelkuz Lake Late

0 0.5 1 2 3 4 5

Kilometres

Scale:1:110,000

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Population Structure of Kokanee in the RSA

DATE: June, 2013	ANALYST: AA	**Figure** 5.10-1
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-127_kokanee_pop_structure.pdf
GIS FILE: 10-100-127_kokanee_pop_structure.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Embryos incubate in gravel for several weeks and fry emerge to rear in stream habitat. Juveniles spend their first summer in streams, and sometimes stay as long as 1 or 2 years if there is available habitat, and then migrate to their overwintering lake or river. There, they rear and forage until becoming sexually mature adults, typically within 3 to 5 years.

Rainbow trout in streams feed primarily on benthic invertebrates, drifting aquatic insects and terrestrial insects that fall on the water surface. Once in lakes, they will also feed on zooplankton and other fish, if those sources are available.

Rainbow trout are the most popular freshwater sport fish in BC, and have likely been harvested by Aboriginals in the LSA and RSA.

Population Structure

Lake versus Stream Life History

Rainbow trout have both lake-resident and river-resident life history types. As a first step toward identifying population structure of rainbow trout in the LSA, all rainbow trout populations in the LSA are assumed to be predominantly lake-resident. The main reason for this assumption is that lakes provide the large volume of under-ice habitat that is required to support large adult rainbow trout during the winter. Good overwintering habitat exists in sites within the streams of the LSA (**Section 5.8**), particularly lower Chedakuz Creek which is open all year, but stream habitat is assumed to be lower in volume than the available lake habitat. This does not mean that some stream overwintering does not exist; only that lake-residence is more common than stream-residence.

Overflights in March of 2012 and 2013 have shown that all lakes in the LSA and RSA are covered with ice during winter. Streams are generally ice-covered as well, except for sections of Davidson Creek, Turtle Creek, and Creek 661 that are probably influenced by groundwater inflow. Lower Chedakuz Creek is also open all winter throughout most of its length due to warmer water flowing from Tatelkuz Lake.

Based on overwintering surveys of stream habitat conducted in March 2012 in the Davidson Creek, Turtle Creek, Creek 661, Creek 705, and Chedakuz Creek watersheds, the depth of ice cover on streams ranged from 0.04 to 1.19 m with a mean of 0.52 m (n = 12, SE = 0.13) (**Tables 5.8-8**, **5.8-12**, **5.8-16**, **5.8-19**, and **5.8-22**). The depth of water under that ice ranged from 0.00 to 0.89 m with a mean of 0.36 m (n = 12, SE = 0.09). Two of the 10 measurements of DO concentration (or 20%) that were measured under ice in streams in March 2012 were below the concentration that defines good overwintering habitat (<5 mg/L).

The depth of ice cover on three lakes in March 2012 was greater than that on streams, ranging from 0.94 to 1.19 m with a mean of 1.07 m (n = 2, SE = 0.07) (**Table 5.9-4**). However, the depth of water under the ice ranged from 1.50 to 8.89 m with a mean of 4.00 m (n = 2, SE = 2.95). In other words, the under-ice depth of water in lakes during the winter of 2012 was 11 times greater than the under-ice depth in streams.

DO concentrations ranged from 3.9 to 7.9 mg/L in Lake 01628LNRS, from 7.7 to 8.9 mg/L in Lake 01538UEUT, and 4.0 mg/L in Snake Lake. Hence, the quality of lake overwintering habitat ranges from poor to good, which is about the same distribution of overwintering habitat quality observed for streams.

This evidence in support of a predominantly lake-resident life history for rainbow trout in the LSA is admittedly limited, but it is supported by other biological data that will be discussed in greater detail below for each individual population.

The assumption of lake-residency is a hypothesis to be tested. More data on the distribution of overwintering stream habitat quantity and quality and the ecology of rainbow trout in the LSA will be collected in future years, and will be used to test the assumption of lake-residency.

Number of Populations

Rainbow trout were found in almost every stream in the LSA and RSA in 2011 and 2012. They are present in Tatelkuz and Kuyakuz Lakes and in the headwater lake of Davidson Creek (Lake 01682LNRS) and the two headwater lakes of Creek 705 (Lake 01538UEUT and Lake 01428UEUT). Rainbow trout are not present in Snake Lake because of low DO concentrations during winter.

Microsatellite DNA analysis of rainbow trout tissue samples showed four broad groupings corresponding to four watersheds: Davidson Creek, Creek 705, Turtle Creek, and Creek 661 (Taylor 2012) (**Appendices 5.10-10** and **5.10-11**). Discussion of these results is provided in greater depth in **Section 5.10.3.7**.

Based on these results, one population is assumed to spawn in each watershed, except for those watersheds with headwater lakes, in which case one additional population is assumed to exist for each headwater lake. Hence, there are seven populations of rainbow trout in the LSA: two in Davidson Creek, one each in Turtle Creek and Creek 661, and three in Creek 705 (**Figure 5.10-2**). The distributions of each of the seven populations were based on the results of the summer stream inventory (**Figure 5.10-8**). The results included streams and stream sections in which rainbow trout were confirmed to reside based on capture or observation, and streams and stream sections in which rainbow trout were believed to reside though not confirmed because the streams were not surveyed.

360000 365000 370000 375000 380000 385000 390000

5910000 5905000 5900000 5895000 5890000

N

Chedakuz Creek
Turtle Creek
Tatelkuz Lake
Proposed Transmission Line
Kluskus-Ootsa FSR
Davidson Creek
Water Pipeline Route
Creek 700
Snake Lake
Top Lake
Proposed Mine Access Road
Creek 688328
Creek 661
Lake 01428UEUT
Creek 543585
Creek 505659
Davidson Creek
Exploration Road
Lake 01682LNRS
Creek 704456
Creek 146920
Creek 661
Fawnie Creek
Creek 705
Lake 01538UEUT
Chedakuz Creek
Kuyakuz Lake
Kluskus Blue FSR
Manson Creek

Legend

- Proposed Mine Access Road
- Proposed Transmission Line
- Exploration Road
- Kluskus Blue FSR
- Kluskus Ootsa FSR
- Water Pipeline Route
- Stream
- Waterbody
- Proposed Mine Site
- Aquatic Local Study Area

Rainbow Trout Populations

- Creek 661
- Creek 705
- Creek 705 Headwaters North
- Creek 705 Headwaters South
- Davidson Creek
- Davidson Creek Headwaters
- Turtle Creek

Scale:1:110,000

0 0.5 1 2 3 4 5

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Population Structure of Rainbow Trout in the LSA

DATE: June, 2013	ANALYST: AA	**Figure** 5.10-2
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-126_rainbow_trout_catchment_v2.pdf
GIS FILE: 10-100-126_rainbow_trout_catchment_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-126_rainbow_trout_catchment_v2.mxd

Davidson Creek Populations

In Davidson Creek, rainbow trout were divided into two populations, Davidson Creek and Davidson Headwater. This division was based on the following information:

- Unrestricted access to lower and middle Davidson Creek by rainbow trout that overwinter in Tatelkuz Lake (i.e., no known barriers to fish passage), allowing spring migration of spawners from the lake to the creek;
- Observation through hoop net catches of upstream migration of rainbow trout spawners from Chedakuz Creek into lower Davidson Creek in early June 2011, followed by their downstream migration back to Chedakuz Creek later in June;
- Presence of headwater Lake 01628LNRS that is known to hold adult rainbow trout (**Sections 5.10.2.5** and **5.10.3.1**);
- Presence of a partial barrier to upstream fish passage in Reach 11 of upper Davidson Creek (**Section 5.8.1.3**);
- Predominance of early downstream rainbow trout migrants observed in hoop nets in upper Davidson Creek in June 2011 (**Section 5.10.2.3**), which is a pattern not seen in any of the other seven hoop nets in the other three watersheds of the LSA, and which indicates downstream dispersal of spawners and juveniles from headwater Lake 01628LNRS to middle Davidson Creek;
- Relatively high summer densities of juveniles at the outlet of headwater Lake 01682LNRS (**Section 5.10.2.4**), indicating spawning at that location;
- Predominance of small, juvenile rainbow trout in Davidson Creek during summer, and the absence of large, adult stream residents; and
- Slower growth of rainbow trout sampled from headwater Lake 01682LNRS than from fish sampled in lower and middle Davidson Lake (**Section 5.10.3.1**), indicating separate populations.

The Davidson Creek population includes the majority of trout that use the watershed. Most juveniles and adults in this population are assumed to use overwintering habitat in Tatelkuz Lake, mainly due to availability compared to the limited available overwintering habitat in streams. This does not exclude the possibility that some trout may overwinter in larger streams such as lower Chedakuz Creek or that some may overwinter in pools in Davidson Creek.

In spring, spawners migrate out of Tatelkuz Lake into Chedakuz Creek and then swim up into the lower and middle reaches of Davidson Creek (Reaches 1 to 10 and tributaries) to spawn. This upstream migration was observed using hoop nets installed in lower Davidson Creek in June 2011.

Spawners are unlikely to migrate further upstream into Reaches 11 and 12 of Davidson Creek because of the presence of a steep cascade in lower Reach 11 that acts as a barrier to upstream passage during summer low flows and a partial barrier to upstream fish

passage during freshet flows. It does not likely prevent downstream passage of fish from above the cascade. The presence of this cascade is not noted in the FHAP habitat survey results of **Section 5.8.1** because the cascade was not included in the 100 m stretch of Reach 11 that was surveyed. However, the cascade was observed by surveyors in 2011.

After spawning, adults are assumed to return to Tatelkuz Lake. This downstream migration out of Davidson Creek was observed in hoop nets installed in lower Davidson Creek in June 2011.

Fry and 1 to 2 year-old juveniles rear in middle and lower Davidson Creek and their tributaries for at least one summer and perhaps one or two more before eventually migrating downstream into Chedakuz Creek and Tatelkuz Lake.

The Davidson Headwater population of rainbow trout occupies much less area than the Davidson Creek population because its ambit is restricted to Reaches 11 and 12 and headwater Lake 01682LNRS. Adults overwinter in the lake, and in spring they migrate through the single lake outlet and spawn in Reaches 11 and 12 of Davidson Creek and then return to the lake. The high density of juvenile rainbow trout observed in the outlet of Lake 01682LNRS in 2011 supports the existence of a separate population of rainbow trout that spawns downstream of the lake in these two reaches.

The presence of the steep cascade in Reach 11 probably deters most members of this population from descending further downstream. However, there is almost certainly some downstream dispersal of adults and juveniles over the cascades. A predominance of early downstream migrants in hoop net catches in Reach 8 of Davidson Creek in June 2011 supports this idea (**Figure 5.10-4** and **Figure 5.10-5**). This was the only hoop net site where downstream migrants were earlier than upstream migrants were. Most of the migrants probably do not return to their natal habitat, but seek overwintering habitat in Chedakuz Creek and Tatelkuz Lake.

Juveniles of the Davidson Headwater population rear in Reaches 11 and 12 for at least one summer before eventually migrating upstream into Lake 01682LNRS. The extent to which juveniles use habitat in Reaches 11 and 12 for overwintering is uncertain. These reaches were observed to be covered by ice in March of 2012 and 2013. Overwintering habitat quality in rated as fair in Reach 11 and poor in Reach 12 (**Table 5.8-3**).

Turtle Creek Population

The Turtle Creek Watershed is not lake-headed nor is it known to have barriers to fish passage. Therefore, a single population of rainbow trout that migrates to and from Tatelkuz Lake is assumed to use this watershed for spawning and rearing. The predominance of juvenile rainbow trout in this creek during the summer supports this idea. If there was a stream-resident population of significant size, then those adults would have been caught in the summer inventories.

In spring, adults migrate out of Tatelkuz Lake into Chedakuz Creek and then upstream into Turtle Creek, as well as into Creek 700, a major tributary that flows into Reach 5 of Turtle Creek. This upstream migration was observed at hoop nets installed in lower Turtle Creek and in Creek 700.

After spawning, adults return to Tatelkuz Lake, while juveniles rear in Turtle Creek and Creek 700 for at least one summer and possibly one or two additional summers before eventually descending through Chedakuz Creek into Tatelkuz Lake to overwinter. The downstream migration was observed at hoop nets installed in lower Turtle Creek and in Creek 700.

Creek 661 Population

Creek 661 is headed by a shallow pond that is unlikely to provide overwintering habitat. It also has no barriers to upstream migration. Therefore, similar to Turtle Creek, it is assumed to support a single population of rainbow trout. The predominance of juvenile rainbow trout in this creek during summer, and the absence of large rainbow trout, supports the idea that lake-residency is the predominant life history type for this population.

Similar to the Davidson Creek and Turtle Creek populations, the Creek 661 population is assumed to overwinter in Tatelkuz Lake. Spawners migrate up middle Chedakuz Creek and then into Creek 661 to spawn in spring. This upstream migration was observed at hoop nets installed in lower Creek 661 in spring 2011.

After spawning, adults return to Tatelkuz Lake, while juveniles rear in Creek 661 and its tributaries for at least one summer and possibly one or two additional summers before eventually descending through Chedakuz Creek into Tatelkuz Lake to overwinter. The downstream migration was observed at hoop nets installed in lower Creek 661 in spring 2011.

Creek 705 Populations

Creek 705 Watershed is assumed to support three separate populations of rainbow trout, 705 Headwater North, 705 Headwater South, and Creek 705. This division was made not because of genetic differences. Rather, the watershed contains two headwater lakes with resident trout, and provides spawning and rearing habitat for trout that ascend to the lower and middle reaches of Creek 705 from overwintering locations in Fawnie Creek.

The 705 Headwater North population overwinters in headwater Lake 01428UEUT. Water from that lake flows down Creek 606013 and into the middle of Reach 4 of Creek 705. In spring, adults are assumed migrate out of Lake 01428UEUT to spawn in Creek 606013 and its tributaries. Adults are also assumed to migrate out of the major inlet to the lake and spawn there because juveniles were observed in both inlet and outlet reaches of Lake 01428UEUT in 2011, indicating that spawning occurred above and below the lake. These migrations were not observed because hoop nets were not installed in upper Creek 705 in spring.

Adults then return to the lake to forage in summer and overwinter. Juveniles remain in Creek 606013 and its tributaries to rear. For mapping purposes, the downstream extent of this population is set at the confluence of Creek 606013 and Creek 705.

The 705 Headwater South population overwinters in headwater Lake 01538UEUT. In spring, adults migrate out of its outlet to spawn in Reaches 4, 5 and 6 of Creek 705 (the lake is classified as Reach 7 of Creek 705) and its tributaries and then return to the lake. This migration was not observed because hoop nets were not installed in upper Creek 705 in spring.

Juveniles remain in the upper reaches of Creek 705 and its tributaries to rear. Juveniles were observed in the outlet reaches of Lake 01538UEUT in summer 2011, confirming their presence and utilization of upper Creek 705 for rearing. The downstream extent of this population is arbitrarily set at Reach 4 of Creek 705.

The Creek 705 population is comprised of fish that overwinter in one or more undetermined locations in the Fawnie Creek Watershed downstream of Creek 705 – probably Top Lake or Laidman Lake. In spring, adults of this population migrate upstream or downstream through Fawnie Creek into Reaches 1 to 4 of Creek 705 where they spawn. These migrants were observed passing through hoop nets installed at the downstream end of Creek 705 in June 2011. These fish then return to Fawnie Creek or their residence lakes in the Fawnie Creek Watershed. Their downstream migration was also observed using through hoop nets installed at the downstream end of Creek 705 in June 2011.

Juveniles rear in the mainstem and tributaries of the lower and middle reaches of Creek 705 until they mature and migrate downstream into Fawnie Creek. The spatial extent of this population is arbitrarily set to be from the confluence of Creek 705 and Fawnie Creek upstream to the confluence of Creek 705 and Creek 606013 (**Figure 5.10-2**).

5.10.1.3 Lake Chub

Lake chub was the third most common fish species captured in 2011 and 2012, comprising 0.4% of total counts (**Table 5.10-2**). Lake chub was the only species found in Snake Lake and was caught in relatively large numbers during a gillnet and minnow trapping survey of that lake in 2012 (**Plate 5.10-3**).



Plate 5.10-3: Lake Chub Caught by Minnow Trap in Snake Lake, 17 November 2012

Lake chub are small fish (mean length is usually less than 100 mm) and belong to the minnow family (Family Cyprinidae). The live mainly in lakes and are often the only species found in lakes with shallow depths and low DO concentrations (Scott and Crossman 1973). Immediately after ice-out in spring, lake chub migrate to tributary streams to spawn (McPhail 2007). In the LSA and RSA, spawning would occur in May and June (**Figure 5.10-2**). However, lake spawning has also been reported (McPhail 2007). Embryos take only one week to complete development and emerge from their nests in June and July (McPhail 2007). Juveniles and adults feed mainly on the smaller members of the BMI community. Lake chub are too small in size to support recreational or Aboriginal fisheries.

The population structure of lake chub in the LSA and RSA is not well understood because of low catches and the absence of microsatellite DNA analyses. At least one population is known to exist in the LSA – the one in Snake Lake. Other populations are likely in the RSA. Lake chub were reported by Burns (1977) to be present in Kuyakuz Lake. Avison (2010b, 2010c, 2010d) reported lake chub present in lakes of the Chu Molybdenum Project area in a watershed that drains via an unnamed creek into the eastern side of Chedakuz Creek

downstream of Tatelkuz Lake. Ecofor (2004) reported lake chub in upper Matthews Creek, a tributary to Laidman Lake of the Fawnie Creek Watershed.

5.10.1.4 Longnose Sucker

Longnose sucker was the fourth most common species captured in 2011 and 2012 (**Table 5.10-2**). However, it comprised only 0.2% of total number of fish observed or captured in the LSA and RSA.

Longnose sucker belongs to the sucker family (Family Catostomidae) (**Plate 5.10-4**). It resides in both lakes and rivers and feeds exclusively on BMIs. Immediately after ice-out in spring, adult longnose suckers migrate to spawning sites in tributary streams and along lake beaches (Roberge et al., 2002) (**Table 5.10-3**). Embryos are sticky and are deposited on the surface of gravel (Scott and Crossman 1973). Adults quickly return to their residence area, whether lake or stream. Fry hatch several weeks later and migrate downstream to their residence lake.

This species does not support recreational or Aboriginal fisheries, mainly because of the many small bones embedded in its muscles. In historical times, however, it was a common food for dogs in northern Canada (Scott and Crossman 1973).

Tatelkuz and Kuyakuz lakes are probably the primary residence lakes for longnose sucker in the LSA and RSA. Burns (1977) reported them present in Kuyakuz Lake, and Walsh and Hale (1977) reported them present in Tatelkuz Lake. In 2012, they were captured in the two headwater lakes of Creek 705 (Lake 01538UEUT and Lake 01428UEUT), but not in Lake 01682LNRS, the headwater lake of Davidson Creek.

The population structure of longnose sucker in the LSA and RSA is not well understood because of low catches and the absence of microsatellite DNA analyses. A working hypothesis is the presence of at least four separate populations – one each for Tatelkuz Lake, Kuyakuz Lake, Lake 01538UEUT, and Lake 01428UEUT.



Plate 5.10-4: Longnose Sucker Caught by Gillnet in Lake 01428UEUT, 9 September 2012

5.10.1.5 Brassy Minnow

Brassy minnow was the fifth most common species captured in 2011 and 2012 (**Table 5.10-2**), comprising 0.1% of the total number of fish observed and captured. Similar to lake chub, brassy minnow are small in body size and belong to the Family Cyprinidae (**Plate 5.10-5**).

They are found mainly in small streams and wetlands where they feed on a wide assortment of plants and small invertebrates. Distribution in BC is disjunct, with isolated populations in the lower Fraser Valley and in the Nechako Lowlands near Vanderhoof and Prince George (McPhail 2007; Nowosad, 2013). Brassy minnow is classified by the BC CDC (2013) as “S4” (i.e., “Apparently secure. Uncommon but not rare. Some cause for concern due to declines or other factors.”).

Spawning of brassy minnow begins in mid-June and continues to early August (McPhail 2007) (**Table 5.10-3**). Embryo development is rapid and fry emerge in less than one week.

Brassy minnow are too small in size to support recreational or Aboriginal fisheries.

The population structure of brassy minnow in the LSA and RSA is not well understood because of low catches and the absence of microsatellite DNA analyses.



Plate 5.10-5: Brassy Minnow Caught by Minnow Trap at Stream Site AE-014 during Transmission Line Survey, 16 August 2012

5.10.1.6 Mountain Whitefish

Mountain whitefish was the sixth most common species captured in 2011 and 2012 (**Table 5.10-2**), comprising 0.1% of the total number of fish observed and captured.

It is a salmonid fish and one of many species of whitefishes (Subfamily Coregoninae) in the northern hemisphere (**Plate 5.10-6**). It is a lake-resident fish that spawns in tributary streams in late fall (September to October) (Roberge et al., 2002) (**Table 5.10-3**). No nest is prepared. Rather, embryos are broadcast over gravel. Adults return to lakes post-spawning. Embryos develop in the gravel over winter and fry emerge in spring and immediately migrate downstream to residence lakes. Their diet consists mainly of BMI.



Plate 5.10-6: Mountain Whitefish Caught in Hoop Nets in Creek 705 (HN-08), 30 October 2012

In BC, mountain whitefish is a sport fish and historically a food fish. They were probably, and continue to be, fished by Aboriginals in the LSA and RSA. The population structure of mountain whitefish in the LSA and RSA is not well understood because of low catches and the absence of microsatellite DNA analyses. The mountain whitefish spawning survey of fall 2012 showed that mountain whitefish spawners are present in lower Davidson Creek and in Creek 705. This indicates the existence of at least two populations: one population that resides in Tatelkuz Lake and a second population in an unidentified lake in the Fawnie Creek Watershed. The existence of a Tatelkuz Lake population is supported by Walsh and Hale (1977), who reported that mountain whitefish was the predominant fish species in gillnet catches of Tatelkuz Lake.

5.10.1.7 Burbot

Burbot was the seventh most common species captured in 2011 and 2012 (**Table 5.10-2**), comprising 0.01% of the total number of fish observed and captured (**Plate 5.10-7**).



Plate 5.10-7: Burbot Caught by Hoop Net in Creek 705 (HN-08), 24 June 2011

Burbot are the only freshwater relative of the cod family (Family Gadidae). They are also the only species in the LSA and RSA that spawns in mid-winter (January to March), mainly on lake shoals or in the outlets of lakes (Scott and Crossman 1973) (**Table 5.10-3**). Embryos take 1 to 2 months to develop, depending on temperature (McPhail 2007). Juveniles feed on algae and BMI. Adult burbot are predators of fish eggs and juveniles, as well as of BMI.

Burbot are occasionally caught by recreational and Aboriginal fishermen, but are rarely deliberately targeted.

Burbot population structure in the LSA and RSA is not well understood because of low catches and the absence of microsatellite DNA analyses. A total of four burbot were captured in June 2011 as they passed through hoop nets in lower Creek 705. This indicates the presence of at least one burbot population in the Fawnie Creek Watershed. Their capture during the rainbow trout spawning season suggests they were intent on eating rainbow trout eggs. As reported by Walsh and Hale (1977), at least one population of burbot is present in the LSA in Tatelkuz Lake.

5.10.1.8 Longnose Dace

A single longnose dace was captured by backpack electrofishers in the study area (**Plate 5.10-8**). It comprises 0.004% of all fish observed and captured in 2011 and 2012 (**Table 5.10-2**).

Similar to lake chub and brassy minnow, this species is a small fish (adults approximately 100 mm long) and belong to the minnow family (Family Cyprinidae). It resides in lakes and streams and spawns in spring and early summer (**Table 5.10-3**). It feeds on benthic macroinvertebrates. Longnose dace are too small in size to support recreational or Aboriginal fisheries.

The population structure of longnose dace in the LSA and RSA is not well understood because of low catches and the absence of microsatellite DNA analyses. However, at least one population exists in lower Chedakuz Creek.



Plate 5.10-8: Longnose Dace Caught in a Minnow Trap, Lower Chedakuz Creek, 21 September 2011

5.10.1.9 White Sucker

A single white sucker was captured by minnow traps in the study area (**Table 5.10-2**) and, therefore, comprises 0.004% of the total number of fish counted and captured. This species belongs to the sucker family (Family Catostomidae) (**Plate 5.10-9**).

Like the longnose sucker, it resides in lakes and streams and migrates to tributaries in spring to spawn (Scott and Crossman 1975) (**Table 5.10-3**). It feeds on BMI. There are no recreational or Aboriginal fisheries on white sucker. Its population structure in the LSA and RSA and the proposed transmission line and access road corridors is not well understood because of low catches and the absence of microsatellite DNA analyses. However, at least one population exists in watersheds along the transmission line corridor.



Plate 5.10-9: White Sucker Caught in a Minnow Trap, Site AE-021, Transmission Line Survey, 9 September 2012

5.10.2 Catch, Effort, and CPUE

This section describes the detailed catch, effort, and CPUE for all fish sampling programs conducted in the LSA, the RSA, and the proposed transmission line and access road corridors in 2011 and 2012.

5.10.2.1 Total Fishing Effort

Six different types of sampling gear plus streamside visual counts were used to capture or enumerate fish in the LSA and RSA in 2011 and 2012 (**Table 5.10-4**). These included hoop nets, backpack electrofishers, minnow traps, gillnets, angling, and beach seines.

Most hoop netting effort was exerted in June 2011 during the spring rainbow trout spawner survey. Less effort was spent hoop netting during the fall mountain whitefish survey. Hoop netting effort was distributed over watersheds in proportion to the number of hoop net sites: three in Turtle Creek Watershed, two each in Davidson Creek and Creek 661, one in Creek 705. Hoop nets were not used in Tatelkuz Creek Tributaries, or in streams along the proposed transmission line or road access corridors.

For the other five gear types, the Davidson Creek Watershed received a much larger share of total effort than other watersheds. This was because most of the Project infrastructure will be located in the Davidson Creek Watershed, and because of its key importance to project design and environmental mitigation. For example, the Davidson Creek Watershed received 56% of the 74,911 seconds of backpack electrofishing effort exerted in the LSA, whereas Turtle Creek and Creek 661 watersheds received 14% and 19%, respectively, and Creek 705 and the Tatelkuz Lake Tributaries Watersheds received 6% and 5%, respectively.

In addition, 37% of the total minnow trapping effort in the LSA was in the Davidson Creek Watershed. The remainder was distributed approximately evenly (14% to 19%) over the other four watersheds. Sixty percent of all beach seining effort in the LSA was conducted in Davidson Creek Watershed, and the rest was split between Turtle Creek (15%) and Creek 661 (25%) Watersheds. Over half of all stream count effort was spent in Davidson Creek and the remainder was spent in Creek 661 (42%) and Tatelkuz Lake Tributaries (5%) Watersheds.

Gillnetting was conducted in the four headwater lakes in three watersheds: Davidson; Creek 705; and Tatelkuz Lake Tributaries. Snake Lake in the Tatelkuz Lake Tributaries Watershed received 59% of the total gillnet effort, while the rest of the effort was split evenly between Lake 01682LNRS in Davidson Creek Watershed (20%) and Lakes 01538UEUT and 01428UEUT in Creek 705 Watershed (21%). Initial short sets in Snake Lake did not catch any rainbow trout, thus more effort was exerted in Snake Lake than in other lakes. Longer duration sets were used to confirm the absence of rainbow trout.

Angling was only conducted in Turtle Creek and Tatelkuz Lake Tributaries Watersheds, and effort was approximately equal in those watersheds.

Table 5.10-4: Effort by Gear Type for All Fish Sampling, 2011 and 2012

Gear	Unit	Watershed					Transmission Line/ Access Road	RSA	Total
		Davidson Creek	Turtle Creek	Creek 661	Creek 705	Tatelkuz Lake Tributaries			
Hoop netting	hours	1,169	1,786	1,285	758	0	0	0	4,998
Backpack electrofishing	seconds	41,822	10,597	14,366	4,232	3,894	14,030	0	88,941
Minnow trapping	trap-hours	1,811	719	938	757	677	1,383	0	6,285
Gillnetting	hours	20	0	0	21	58	0	0	99
Angling	rod hours	0.0	3.0	0.0	0.0	4.8	0	0	8
Beach seining	m^2	290	75	122	0	0	0	0	487
Stream counts	m	11,704	0	9,945	0	3,508	0	9,900	35,057

Notes: km = kilometre; m^2 = metres squared; RSA = Regional Study Area.

5.10.2.2 Total Fish Catch

A total of 28,034 fish were observed or captured in the LSA and RSA during the 2011 and 2012 surveys (**Table 5.10-2**). This included fish counted in the RSA during the regional kokanee spawning survey and those counted in streams that will be crossed by the proposed transmission line and road access corridors.

Over 84% of these fish were kokanee that were counted during the summer-fall kokanee spawning surveys of 2011 and 2012. The remaining 4,070 fish (14.6% of the total) were counted during the other five major survey programs: the spring rainbow trout spawning survey; the summer stream fish inventory; the summer lake fish inventory; the survey of streams crossed by the proposed transmission line and access road corridors; and the fall mountain whitefish spawning survey.

Of those 4,070 fish, the majority were rainbow trout (88.2%) and the remainder included the following species: unknown species (5.7% (escaped before they could be identified)); lake chub (2.5%); longnose sucker (1.4%); brassy minnow (0.8%); mountain whitefish (0.7%); burbot (0.1%); longnose dace (0.02%); and white sucker (0.02%).

Of those 4,070 fish, 3,196 (11.4% of the total) were assessed for biological information and then released live. Another 427 fish (1.5% of the total) were counted, but escaped live before they could be assessed further. However, a total of 183 of those escapees were identified as rainbow trout and were included in the total rainbow count. The remaining 233 could not be identified. Another 308 fish (1.1% of the total) were assessed for biological information and either died during capture/handling or were killed for collection of otoliths, stomach contents, and/or tissue samples for metals analysis. A final 136 fish (0.5% of the total) were counted, identified, and released live without further assessment of other biological characteristics.

5.10.2.3 Spring Rainbow Trout Spawning Survey

This section describes the results of hoop net sampling at seven sites in the Chedakuz Creek Watershed and one site in the Fawnie Creek Watershed during June 2011. It first describes total catches, effort, and CPUE, then describes daily catches of rainbow trout, their spawner residence timing, and their movement patterns as indicated by the recaptures of fin-clipped trout. These data were used to help identify populations of rainbow trout and the likely locations of spawning, rearing, and overwintering habitat, as well as the relative abundance of those populations.

Effort, Catch and CPUE

For all 16 hoop nets, a total of 3,459 hours, for a total cumulative effort of 144 days, of hoop netting was conducted in June 2011 (**Table 5.10-5**). This included 3,047 hours or 128 cumulative days of hoop netting in the Chedakuz Creek Watershed and 408 hours or 17 cumulative days of hoop netting in the Fawnie Creek Watershed.

Rainbow trout were the predominant species caught in hoop nets, as was expected. The timing of the spring hoop netting program was chosen specifically to coincide with the rainbow trout spring spawning migration in the LSA. A total of 1,319 fish were captured at sites in the Chedakuz Creek Watershed, of which 99.8% were rainbow trout and 0.2% were mountain whitefish (**Table 5.10-5** and **Table 5.10-6**). A total of 524 fish were captured in the Fawnie Creek Watershed, of which 98.5% were rainbow trout and 1.5% were burbot, mountain whitefish, and longnose sucker. The burbot and mountain whitefish presumably entered Creek 705 to feed on rainbow trout eggs because neither species are spring spawners.

Within Davidson Creek, a total of 175 rainbow trout were captured at the two hoop netting sites (**Table 5.10-5**). In addition, three mountain whitefish were also captured in lower Davidson Creek. Presumably, these fish entered the creek to feed on rainbow trout eggs. In comparison, more than double the number of rainbow trout captured in Davidson Creek were captured in hoop nets set in Creek 661 (n = 381 fish) in June 2011, while three times more and four times more rainbow trout were captured in Creek 705 (n = 516) and in Turtle Creek (n = 706 fish), respectively, than in Davidson Creek.

Within Turtle Creek and Creek 661, rainbow trout CPUE was higher at hoop net sites in lower reaches than in upper reaches (**Table 5.10-5**). This result suggests that most rainbow trout spawning in Turtle Creek and Creek 661 occurred between the lower and upper sampling sites.

Table 5.10-5: Number of Fish Captured in Hoop Nets and Total CPUE, Chedakuz and Fawnie Creek Watersheds, June 2011

Watershed	Hoop Net Site	Baseline Map Site ID	Soak Time (Hours) (Days)	Species	Catch	Total CPUE (fish/day)
Chedakuz Creek	Lower Davidson Creek	HN-01	430 (18)	RB	103	5.7
				MW	3	0.2
	Upper Davidson Creek	HN-02	334 (14)	RB	74	5.3
	Lower Creek 661	HN-03	453 (19)	RB	324	17.1
	Upper Creek 661	HN-04	449 (19)	RB	57	3.0
	Lower Turtle Creek	HN-05	502 (21)	RB	584	27.8
	Upper Turtle Creek	HN-06	427 (18)	RB	122	6.8
	Creek 700	HN-07	452 (19)	RB	52	2.7
	Sub-total		**3,047 (128)**		**1,319**	**10.3**
Fawnie Creek	Creek 705	HN-08	408 (17)	RB	516	30.4
				BB	4	0.2
				MW	3	0.2
				LSU	1	0.1
	Sub-total		**408 (17)**		**524**	**30.8**
Total			**3,449 (144)**		**1,873**	**13.0**

Notes: CPUE = Catch-Per-Unit-Effort; BB = burbot; HN = hoop netting; ID = identification; LSU = longnose sucker; MW = mountain whitefish; RB = rainbow trout.

Table 5.10-6: Number of Fish Captured in Hoop Nets by Species and Direction in the Chedakuz and Fawnie Creek Watersheds, June 2011

Watershed	Chedakuz Creek																						Fawnie Creek		
Stream	Lower Davidson Creek			Upper Davidson Creek			Lower Creek 661			Upper Creek 661			Lower Turtle Creek			Upper Turtle Creek			Creek 700				Creek 705		
Baseline Map Site ID	HN-01			HN-02			HN-03			HN-04			HN-05			HN-06			HN-07				HN-08		
Species	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Total	Upstream	Downstream	Total
Rainbow Trout	38	65	**103**	2	72	**74**	17	307	**324**	43	14	**57**	107	477	**584**	71	51	**122**	35	17	**52**	**1,316**	110	406	**516**
Mountain Whitefish	3	0	**3**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	**3**	2	1	**3**
Burbot	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	**0**	2	2	**4**
Longnose sucker	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	**0**	1	0	**1**
Total	**41**	**65**	**106**	**2**	**72**	**74**	**17**	**307**	**324**	**43**	**14**	**57**	**107**	**477**	**584**	**71**	**51**	**122**	**35**	**17**	**52**	**1,319**	**115**	**409**	**524**

Notes: HN = hoop netting; ID = identification.

In contrast, rainbow trout CPUE in Davidson Creek was slightly higher in the upper sampling site than in the lower sampling site (**Table 5.10-5**). This may have been due to the downstream dispersal of rainbow trout from the headwater lake population. Once they swam over the cascade in Reach 11, they may have continued downstream due to the difficulty in ascending the cascade to return to their natal lake (the upper hoop net site was in Reach 8 downstream of the cascade).

Within watersheds, rainbow trout hoop net CPUE was highest in Turtle Creek (13.1 fish/day), followed by Creek 705 (30.4 fish/day), Creek 661 (10.0 fish/day), and Davidson Creek (5.5 fish/day) (**Table 5.10-5**). No information is available on the relative abundance of rainbow trout spawners of the three populations that overwinter in headwater lakes because hoop nets were not installed in the stream reaches through which they migrate in 2011.

In all four watersheds, downstream rainbow trout CPUE, averaged over all sampling sites, was higher than upstream rainbow trout CPUE (**Figure 5.10-3**). High freshet flows in early June meant that hoop nets could not be installed early enough to sample all of the upstream migration. This means that total CPUE in 2011 is a potentially biased index of the relative abundance of the four mainstem-spawning populations. Total downstream CPUE is the least biased index of relative abundance.

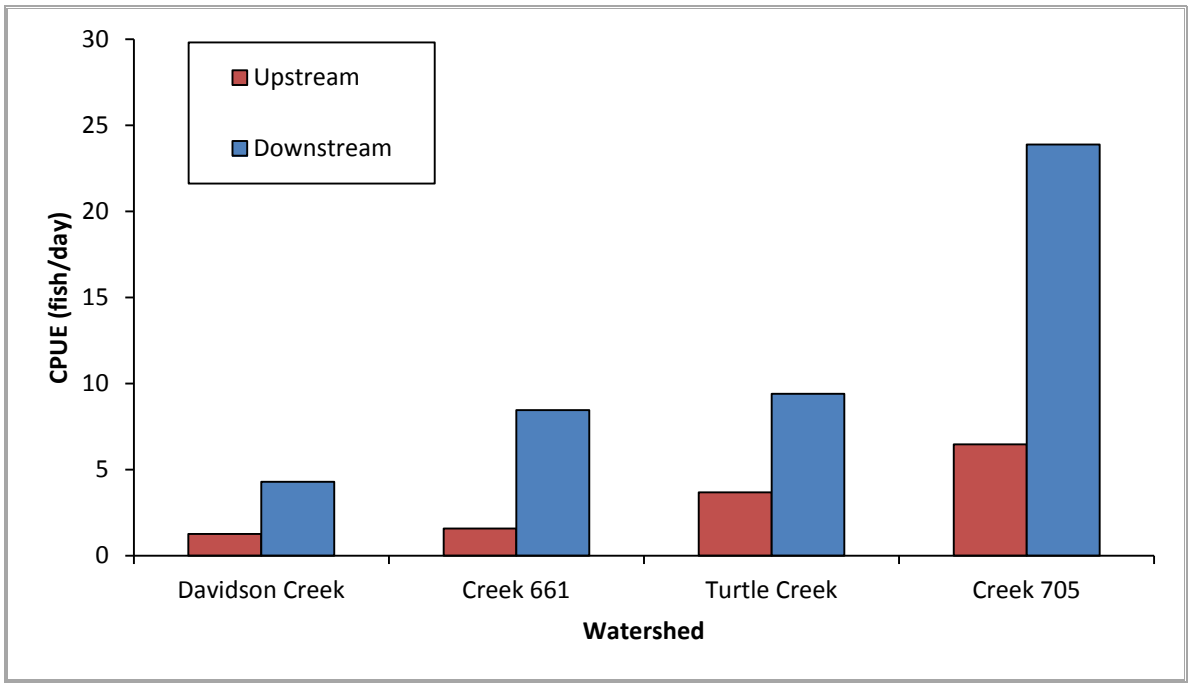


Figure 5.10-3: CPUE by Direction and Watershed for Rainbow Trout Captured in Hoop Nets, June 2011

Daily Catches

This section describes the daily movements of rainbow trout through the upstream and downstream hoop nets located in each of four watersheds.

Davidson Creek

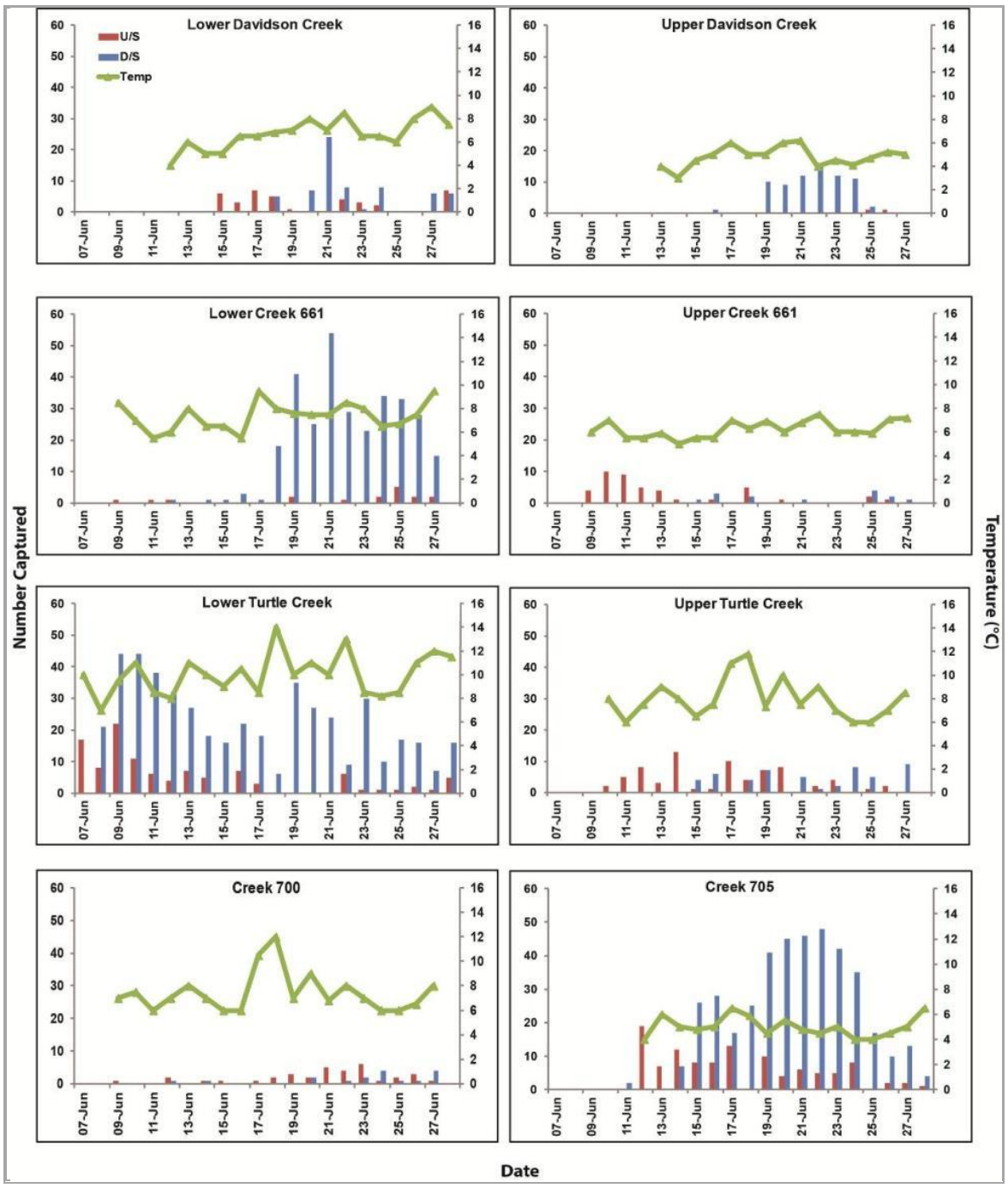
A total of 103 rainbow trout were captured from hoop nets set at site HN-01 in lower Davidson Creek. Of these fish, 38 were moving upstream and 65 were moving downstream (**Table 5.10-6** and **Figure 5.10-4**). The number of downstream migrants peaked on June 21 at a total of 24 rainbow trout. The number of upstream movements was relatively constant over the duration of the study, ranging from zero to seven fish captured daily.

McPhail (2007) reported that rainbow trout generally begin spawning migrations at a temperature of 5°C. Although the HN-01 hoop nets were installed when stream temperature were approximately 4°C, the higher number of downstream captures relative to upstream captures suggests that the hoop nets may have been installed after the majority of rainbow trout had already migrated upstream of this site. The installation of the hoop nets in lower Davidson Creek (and all other sites) was delayed due to high freshet stream flows in 2011.

A total of 74 rainbow trout were captured at site HN-02 in upper Davidson Creek. Two fish were moving upstream and 72 were moving downstream (**Table 5.10-6** and **Figure 5.10-4**). Downstream movements peaked on June 22 at 15 fish. There are two possible interpretations for the higher number of downstream captures than upstream captures, and the fact that downstream captures peaked at an earlier date than upstream captures – the opposite of the pattern seen in the Lower Davidson Creek hoop nets (and all other hoop net pairs in the other three watersheds).

The first interpretation is that spawning occurred earlier in the reaches upstream of the upper hoop net site than in the reaches between the lower and upper site, but that the upstream segment of the migration was largely missed because the upper hoop nets were installed too late. This interpretation has the advantage of simplicity, but is not supported by temperature, which was lower at the upper site than the lower site.

The second interpretation is that many of the spawners that migrated downstream through the upper hoop net site came from a separate population of rainbow trout that overwinters in headwater Lake 01682LNRS. If that is the case, then they were conducting a one-way migration because the cascade in Reach 11 is too steep to allow them to return to their overwintering lake. After spawning, they would have had to continue migrating downstream to Tatelkuz Lake.



Notes: °C = degrees Celsius.

Figure 5.10-4: Daily Movements of Rainbow Trout Captured in Hoop Nets, June 2011

Creek 661

A total of 324 rainbow trout were captured from hoop nets at site HN-03 in lower Creek 661; 17 fish moving upstream and 307 downstream (**Table 5.10-6** and **Figure 5.10-4**). The number of downstream captures peaked at 54 fish on June 21 at a water temperature of 7.5°C. Upstream movements were relatively constant over the duration of hoop netting, ranging from zero to five fish captured daily.

The high number of downstream captures compared to upstream captures suggests that the hoop nets in lower Creek 661 were likely installed after the majority of rainbow trout spawners had migrated upstream of this site. It is important to note that, unlike the upper Davidson Creek capture pattern, some upstream migrants at lower Creek 661 were counted in early June before downstream migrants were counted. This supports the idea that all rainbow trout that spawn in Creek 661 overwinter in Tatelkuz Lake (also because there is no headwater lake in Creek 661 to support overwintering habitat for rainbow trout), and hence only a single population of rainbow trout uses this watershed.

A total of 57 rainbow trout were captured from hoop nets at site HN-04 in upper Creek 661; 43 moving upstream and 14 downstream (**Table 5.10-6** and **Figure 5.10-5**). The number of upstream migrants peaked on June 10 at 10 fish when the water temperature was 7°C. However, upstream migrants were captured on the first day hoop nets were set on June 8, indicating that the upstream migration of rainbow trout to upper Creek 661 was likely already underway prior to net installation and was still ongoing at the upper Creek 661 site. This is in contrast to the lower Creek 661 site where the upstream migration was largely over before the nets were installed on June 8. The maximum daily catch of downstream migrants (four) was observed near the end of the program on June 25.

The higher number of captured fish travelling upstream at the upper Creek 661 site compared to downstream suggests that the hoop nets were removed from this site before the majority of upstream migrants returned downstream after spawning. This pattern of upstream migrants followed by downstream migrants is also similar to the timing observed in lower Davidson Creek and lower Creek 661 (but opposite the pattern observed in upper Davidson Creek), further supporting the idea of a single rainbow trout population using Creek 661 for spawning and rearing, but overwintering in Tatelkuz Lake.

Turtle Creek

A total of 584 rainbow trout were captured from hoop nets set at site HN-05 in lower Turtle Creek; 107 travelling upstream and 477 downstream (**Table 5.10-6** and **Figure 5.10-4**). The maximum daily number of fish captured was 22 upstream on June 9 and were first captured moving upstream on the first day after nets were set on June 7. Downstream moving fish were captured in relatively high numbers throughout the survey, but peaked at 44 on June 9 and 10.

Based on the upstream and downstream catch difference and relatively high water temperature at the beginning of the survey (6.5 to 10°C), it is likely that the hoop nets were installed after the majority of rainbow trout had migrated upstream of this site. As with Davidson Creek and Creek 661, this was due to high freshet stream flows in early June 2011.

This hoop net site showed the same upstream-downstream timing that was observed at hoop net sites in lower Davidson Creek (but not upper Davidson Creek) and in lower and upper Creek 661, supporting the idea that Turtle Creek is used for spawning and rearing by a single population of rainbow trout that overwinters in Tatelkuz Lake. This idea is further supported by the absence of a headwater lake in Turtle Creek that could support overwintering habitat for rainbow trout.

A total of 122 rainbow trout were captured in hoop nets at site HN-06 in upper Turtle Creek; 71 moving upstream and 51 downstream (**Table 5.10-6** and **Figure 5.10-4**).

Fish captures in upper Turtle Creek were dominated by upstream migrants early in the program and captures were dominated by downstream migrants at the end of the program. The largest daily number of fish moving upstream was 13 on June 14, and the largest number of fish moving downstream was nine on June 27. This is the same upstream-downstream pattern observed at all other hoop net sites except upper Davidson Creek, and it supports the idea of a single rainbow trout population using Turtle Creek for spawning and rearing, but overwintering in Tatelkuz Lake.

A total of 52 rainbow trout were captured in hoop nets installed in Creek 700 (HN-07) during June 2011 (**Table 5.10-6** and **Figure 5.10-4**). Of the fish captured, 35 were travelling in an upstream direction and 17 were travelling downstream. Upstream captures peaked at six rainbow trout on June 23, and downstream captures peaked at four on June 24 and 27 (the date of hoop net removal). The low numbers of downstream migrants compared to upstream suggest that additional rainbow trout migrated downstream after the end of the program. The upstream-downstream migration timing is also similar to the timing seen at the other two hoop net sites in Turtle Creek.

Creek 705

A total of 516 rainbow trout were captured in the hoop nets at site HN-08 in Creek 705; 110 moving upstream and 406 downstream (**Table 5.10-6** and **Figure 5.10-4**). The number of fish captured in the downstream hoop net peaked at 48 rainbow trout on June 22. This peak, paired with a decrease in upstream captures, suggests that the majority of rainbow trout had already travelled upstream of this site prior to the installation of the hoop nets. This was common to all hoop net installations – high freshet flows delayed installation until after the rainbow trout migration had begun. The upstream-downstream timing was similar to that observed in all other hoop net sites except the upper Davidson Creek site, and supports the idea that rainbow trout that spawn in the lower and middle reaches of Creek 705 are migrants from Fawnie Creek that overwinter in an unidentified waterbody in that watershed.

Stream Residence Timing

Rainbow trout spawners migrate to their spawning sites during a brief period in spring soon after water temperatures rise above 5°C and when high freshet flows allow access to spawning sites. After spawning, the survivors return to their overwintering lake. The time spent migrating within a stream, including the time spent spawning, is referred to as "stream residence time."

The hoop net catches allow stream residence time to be estimated for each population. The first step was to calculate the daily cumulative percent catch for both upstream and downstream nets (**Figure 5.10-5**). Then, the dates at 50% cumulative catch were identified. Stream residence time is defined as the number of days between the two dates at 50% cumulative catch.

At all sites except upper Davidson Creek, the date of 50% upstream catch was earlier than the date of 50% downstream catch. The difference between the two dates at 50% cumulative catch – the stream residence time – ranged from 3 days for lower Creek 661 to 10 days for upper Creek 661 (**Table 5.10-7**). The mean stream residence time for all populations was 5 days.

Table 5.10-7: Residence Times for Rainbow Trout Captured by Hoop Nets in June 2011

Stream	Baseline Site ID	Residence Time (days)
Lower Davidson Creek	HN-01	4
Upper Davidson Creek	HN-02	4
Lower Creek 661	HN-03	3
Upper Creek 661	HN-04	10
Lower Turtle Creek	HN-05	5
Upper Turtle Creek	HN-06	5
Creek 700	HN-07	4
Creek 705	HN-08	4
Mean		5
SE		1

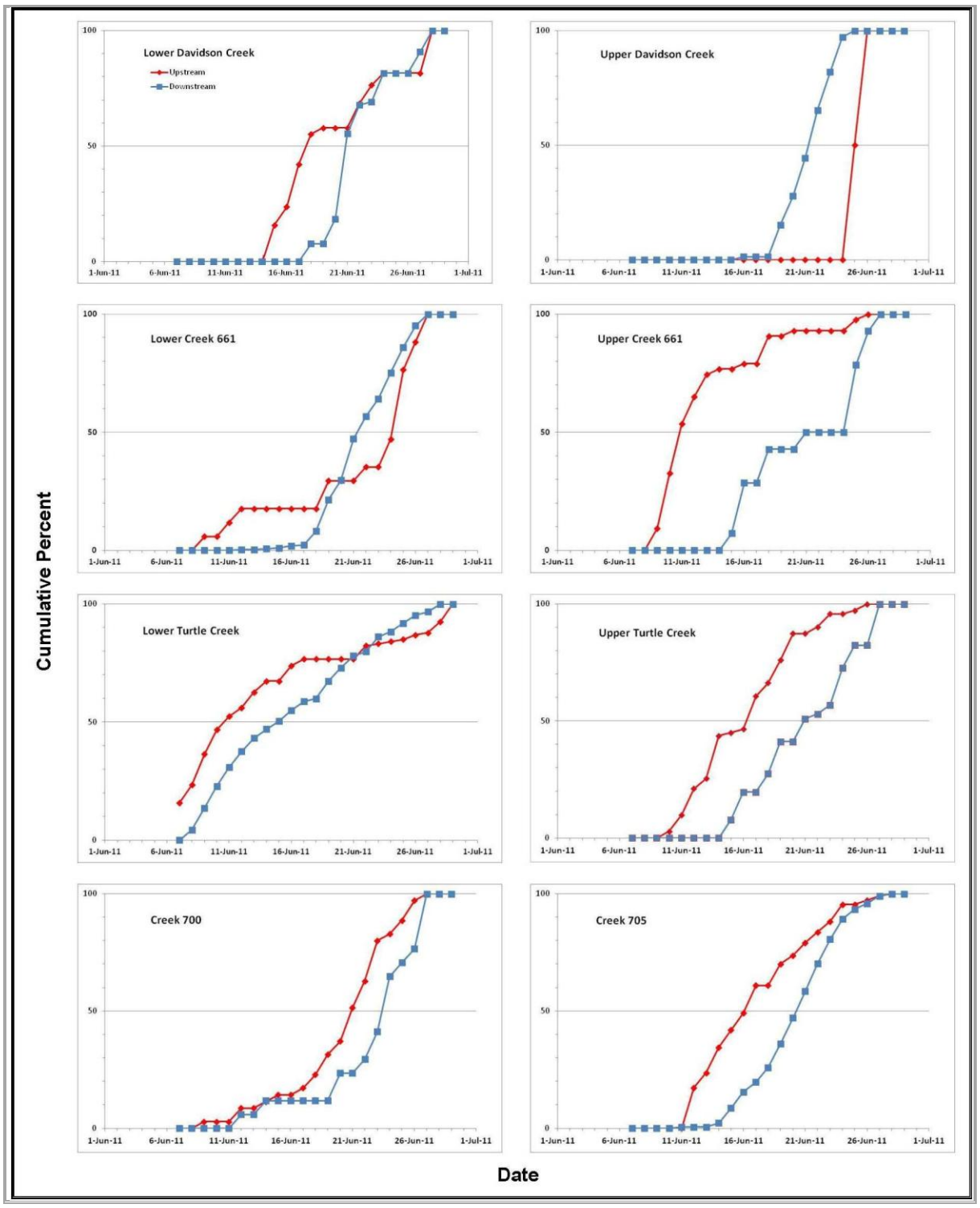


Figure 5.10-5: Cumulative Percent Catches of Rainbow Trout in Hoop Nets, June 2011

Mark/Recaptures

A total of 152 clipped rainbow trout were recaptured in hoop nets in the Chedakuz Creek Watershed during June 2011 (**Table 5.10-8**). The majority (140 fish or 92% of the total) were recaptured at the same site where they were originally clipped, only moving in the opposite direction. For example, 58 rainbow trout originally clipped moving upstream at site HN-05 in lower Turtle Creek were recaptured moving downstream at the same site.

Of the 8% that were recaptured at different sites, all but one had moved between two sites in Turtle Creek: site HN-06 in upper Turtle Creek; and site HN-07 in Creek 700. These sites were the closest to each other. Site HN-07 was approximately 150 m from the confluence with Turtle Creek and 260 m from site HN-06. Between these two sites, two fish moved downstream from Creek 700 to upper Turtle Creek, and nine fish moved upstream from upper Turtle Creek to Creek 700.

The only other rainbow trout recaptured at a different site from where it was originally clipped was a 375 mm-long female rainbow trout that was originally captured at site HN-04 in upper Creek 661. It was recaptured at site HN-03 in lower Creek 661, which was a downstream movement of approximately 15 km.

Within the Fawnie Creek Watershed, a total of 106 rainbow trout from the lower Creek 705 site were recaptured at the same site: 29 returning upstream; and 77 returning downstream. There was no upper hoop net site in that watershed that would have permitted recapture of clipped fish.

Table 5.10-8: Number and Site of Recaptured Rainbow Trout from Hoop Nets in the Chedakuz and Fawnie Creek Watersheds, June 2011

Watershed	Recapture Site		Number and Origin of Recaptured Fish					
			Same Site		Different Site		Total	Original Tagging Site
			U/S	D/S	U/S	D/S		
Chedakuz Creek	Lower Davidson Creek	HN-01	4	1	-	-	5	-
	Upper Davidson Creek	HN-02	-	1	-	-	1	-
	Lower Creek 661	HN-03	3	3	-	1	7	Upper Creek 661 (HN-04)
	Upper Creek 661	HN-04	1	1	-	-	2	-
	Lower Turtle Creek	HN-05	34	58	-	-	92	-
	Upper Turtle Creek	HN-06	6	21	-	2	29	Creek 700 (HN-07)
	Creek 700	HN-07	2	5	9	-	16	Upper Turtle Creek (HN-06)
	Total		**50**	**90**	**2**	**10**	**152**	-
Fawnie Creek	Creek 705	HN-08	29	77	-	-	106	-

Notes: D/S = downstream; HN = hoop netting; U/S = upstream.

A comparison of the total number of rainbow trout that were clipped at each hoop net site with the number of clipped trout from each site that were recaptured at the same site

showed that recaptures ranged from a low of 1.4% for the upper Davison Creek site to a high of 44.4% for the Creek 700 site (**Table 5.10-9**).

Table 5.10-9: Number of Clipped and Recaptured Rainbow Trout in the Chedakuz and Fawnie Creek Watersheds, June 2011

Site	Number Clipped	Number of Clipped Fish Recaptured	Percent Recapture
Lower Davidson Creek (HN-01)	98	5	5.1
Upper Davidson Creek (HN-02)	73	1	1.4
Lower Creek 661 (HN-03)	317	7	2.2
Upper Creek 661 (HN-04)	55	2	3.6
Lower Turtle Creek (HN-05)	492	92	18.7
Upper Turtle Creek (HN-06)	93	29	31.2
Creek 700 (HN-07)	36	16	44.4
Creek 705 (HN-08)	410	106	25.9

This means that between 56% and 99% of all marked fish were never recaptured. The main reason so many marked fish were never recaptured was that the systems were not closed to emigration. Fish that were moving downstream to their summer foraging and overwintering lake had left the sampling area and would not be expected to return for at least one year. This was especially true for the June 2011 study because the hoop nets were installed after the migration had begun. Hence, the majority of counts were of fish moving downstream after spawning.

A second reason was that some fish likely remained upstream of the hoop nets until the nets were removed. These fish would then have migrated downstream later in the year. Even if the mean residence time in a spawning creek is relatively short, late arrivals would still have been upstream of the nets when the nets were removed.

A third reason was that some fish died during spawning and/or migration to and from the spawning site. Spawning is a stressful event, and fish were exposed to predators that may have aggregated on the spawning run.

Finally, it is possible that some fish were not recognized as marked during their passage back through the hoop nets. However, this is unlikely. All fish captured in hoop nets were handled and closely examined. Also, the clipped fins could not have re-grown in the time the nets were operating. Some fish may also have bypassed the hoop nets; however, the number of fish that were able to do this was likely small. The wings of the hoop nets were firmly packed against the substrate and the sides of the creek, and nets were checked daily.

For these reasons, but mainly because the systems were not closed to emigration, these data could not be used to calculate population abundance with mark-recapture methods. Rather, the hoop net data represent only an index of relative spawning run size in each watershed.

5.10.2.4 Summer Fish Inventories – Streams

This section describes the results of electrofishing and minnow trap surveys of the fish communities of streams in the LSA that were conducted in August of 2011 and 2012. The purpose of the surveys was to:

- Define the spatial distribution of fish species – mainly rainbow trout, the predominant species in streams;
- Determine the relative importance of different habitats for juvenile fish; and
- Estimate the relative abundance of stream populations of rainbow trout among watersheds.

Electrofishing CPUE ranged from 0.0 to 7.2 fish/100 s, and electrofishing density ranged from 0.0 to 28.3 fish/100 m^2 (**Table 5.10-10** and **Figure 5.10-6**). Over 70% of the 78 values of electrofishing CPUE were below 1.0 fish/100 s, and over 75% of fish densities were below 5.0 fish/100 m^2. This range of densities includes the BC provincial "biostandards" developed for stream populations of rainbow trout surveyed before and after watershed habitat restoration (Keeley et al., 1996; Koning and Keeley, 1997). (The primary restoration activity was adding habitat complexes such as LWD to streams.) The mean "before" density reported by Koning and Keeley (1997) was 3.6 fish/100 m^2 and the mean "after" density was 9.7 fish/100 m^2. Hence, the "before" biostandard is most applicable to rainbow trout in streams of the LSA.

Minnow trapping CPUE was also low. Over 75% of the 37 values of minnow trapping CPUE were below 1.0 fish/trap-hour (**Table 5.10-10** and **Figure 5.10-7**).

With few exceptions, the rainbow trout sampled in streams of the LSA in August and September of 2011 and 2012 were juveniles between the ages of 0 and 3 years. Most were less than 100 mm long. Adults returned to their lakes of residence after spawning ended in late June. Hence, the rainbow trout CPUE and minnow trapping CPUE is an index of the abundance and density of juvenile rainbow trout during the summer rearing period.

Davidson Creek Watershed

A total of 355 rainbow trout were captured in the mainstem of Davidson Creek by backpack electrofishing and minnow trapping in August 2011 and August 2012 (**Table 5.10-10**). Kokanee were the only other species observed in Davidson Creek, and only 18 kokanee in total. Electrofishing in Davidson Creek was stopped the same day spawning kokanee were observed. Electrofishing and minnow trapping effort for all Davidson Creek mainstem reaches sampled totalled 23,453 seconds and 378 trap-hours, respectively.

Table 5.10-10: Fish Sampling Results by Gear Type in Streams within the Chedakuz Creek and Fawnie Creek Watersheds, 2011 and 2012

Watershed	Stream	Site ID	Reach	Gear Type	Date	Site Length (m)	Site Width (m)	Site Area (m^2)	No. Traps/ Rods	Effort[1]	Species	Fish Catch	CPUE[2]	Density (No./100 m^2)
Davidson Creek	Davidson Creek	FS-66	1	MT	4-Aug-12	-	-	-	10	229	RB	8	3.49	-
		FS-67	2	EF	4-Aug-12	40	4.00	160	-	236	RB	1	0.42	0.63
						40	4.00	160	-	236	KO	17	7.20	10.63
				MT	4-Aug-12	-	-	-	5	65	RB	3	4.65	-
		FS-01	4	EF	5-Aug-12	100	5.67	567	-	928	RB	22	2.37	3.88
						100	5.67	567	-	928	KO	1	0.11	0.18
		FS-02	5	EF	6-Aug-11	174	4.55	792	-	1,527	RB	20	1.31	2.53
				MT	6-Aug-11	-	-	-	5	84	RB	3	0.04	-
				EF	10-Aug-12	100	4.55	455	-	767	RB	19	2.48	4.18
		FS-03	6	EF	17-Aug-11	100	4.75	475	-	1,637	RB	27	1.65	5.68
				EF	10-Aug-12	100	4.75	475	-	1,853	RB	24	1.30	5.05
		FS-04	7	EF	17-Aug-11	100	4.74	474	-	2,007	RB	23	1.15	4.85
		FS-05	7.1	EF	19-Aug-11	100	4.86	486	-	1,888	RB	41	2.17	8.44
		FS-06	8	EF	11-Aug-11	100	2.02	202	-	1,746	RB	19	1.09	9.41
		FS-07	9	EF	18-Aug-11	100	5.01	501	-	1,617	RB	3	0.19	0.60
				EF	9-Aug-12	100	4.00	400	-	2,142	RB	8	0.37	2.00
		FS-08	10	EF	20-Aug-11	100	2.27	227	-	1,875	RB	33	1.76	14.54
		FS-09	11	EF	13-Aug-11	100	1.42	142	-	1,481	RB	54	3.65	38.03
				EF	8-Aug-12	100	1.50	150	-	1,378	RB	10	0.73	6.67
		FS-10	12	EF	13-Aug-11	100	2.62	262	-	1,264	RB	18	1.42	6.87
				EF	8-Aug-12	100	3.00	300	-	1,107	RB	19	1.72	6.33
	Creek 428073	FS-70	1	EF	5-Aug-12	100	0.90	90	-	309	RB	8	2.59	8.89
	Creek 636713	FS-72	3	EF	1-Aug-12	100	3.00	300	-	845	NFC	0	0.00	0.00
				MT	1-Aug-12	-	-	-	3	62	NFC	0	0.00	-
	Creek 636713	FS-73	4	EF	1-Aug-12	100	0.50	50	-	523	NFC	0	0.00	0.00
				MT	1-Aug-12	-	-	-	3	67	NFC	0	0.00	-

Table continues...

Table 5.10-10 (cont'd)

Watershed	Stream	Site ID	Reach	Gear Type	Date	Site Length (m)	Site Width (m)	Site Area (m^2)	No. Traps/ Rods	Effort[1]	Species	Fish Catch	CPUE[2]	Density (No./100 m^2)
Davidson Creek (cont'd)	Creek 688328	FS-94	1	EF	1-Aug-12	100	2.50	250	-	669	RB	3	0.45	1.20
				MT	1-Aug-12	-	-	-	3	52	NFC	0	0.00	-
		FS-49	2	EF	7-Aug-12	100	2.10	210	-	624	RB	3	0.48	1.43
				MT	7-Aug-12	-	-	-	3	63	NFC	0	0.00	-
				EF	15-Sep-12	100	2.00	200	-	401	NFC	0	0.00	0.00
		FS-48	3	EF	8-Aug-12	100	1.10	110	-	785	NFC	0	0.00	0.00
		FS-50	4	EF	8-Aug-12	100	0.90	90	-	486	NFC	0	0.00	0.00
	Unnamed Creek	FS-95	1	EF	2-Aug-12	100	0.60	60	-	336	NFC	0	0.00	0.00
				MT	2-Aug-12	-	-	-	3	82	NFC	0	0.00	-
	Creek 634527	FS-46	1	EF	7-Aug-12	100	0.80	80	-	391	NFC	0	0.00	0.00
				MT	7-Aug-12	-	-	-	3	50	NFC	0	0.00	-
	Creek 667871	FS-47	1	EF	8-Aug-12	100	0.70	70	-	335	NFC	0	0.00	0.00
	Creek 704454	FS-74	1	EF	9-Aug-12	100	3.50	350	-	1,370	RB	4	0.29	1.14
				MT	9-Aug-12	-	-	-	3	66	NFC	0	0.00	-
		FS-75	2	EF	7-Aug-12	100	3.20	320	-	929	NFC	0	0.00	0.00
				MT	7-Aug-12	-	-	-	3	211	RB	2	0.95	-
		FS-76	3	EF	7-Aug-12	100	3.20	320	-	1,014	NFC	0	0.00	0.00
				MT	7-Aug-12	-	-	-	3	221	NFC	0	0.00	-
		FS-77	4	EF	5-Aug-12	100	2.60	260	-	852	RB	1	0.12	0.38
				MT	5-Aug-12	-	-	-	3	71	NFC	0	0.00	-
		FS-27	5	EF	20-Aug-11	100	2.24	224	-	1,060	NFC	0	0.00	0.00
				EF	22-Aug-11	100	2.24	224	-	888	RB	2	0.23	0.89
				MT	20-Aug-11	-	-	-	6	164	NFC	0	0.00	-
		FS-78	5	EF	5-Aug-12	100	2.20	220	-	956	RB	1	0.10	0.45
				MT	5-Aug-12	-	-	-	3	60	NFC	0	0.00	-
		FS-62	6	EF	5-Aug-12	100	1.70	170	-	,1000	RB	1	0.10	0.59
				MT	5-Aug-12	-	-	-	3	68	NFC	0	0.00	-
	Unnamed Creek	FS-98	1	EF	7-Aug-12	100	1.00	100	-	371	NFC	0	0.00	0.00
	Creek 853864	FS-99	1	EF	8-Aug-12	150	0.85	100	-	649	NFC	0	0.00	0.00
	Creek 076095	FS-63	1	EF	4-Aug-12	100	1.60	160	-	350	NFC	0	0.00	0.00
				MT	6-Aug-12	-	-	-	3	141	NFC	0	0.00	-
	Creek 776798	FS-81	1	EF	01-Aug-12	100	1.83	183	-	642	NFC	0	0.00	0.00
				MT	02-Aug-12	-	-	-	3	58	NFC	0	0.00	-

Table continues...

Table 5.10-10 (cont'd)

Watershed	Stream	Site ID	Reach	Gear Type	Date	Site Length (m)	Site Width (m)	Site Area (m^2)	No. Traps/ Rods	Effort[1]	Species	Fish Catch	CPUE[2]	Density (No./100 m^2)
Turtle Creek	Turtle Creek	FS-17	1	EF	9-Aug-12	100	3.00	300	-	757	RB	9	1.19	3.00
		FS-18	2	EF	16-Aug-11	100	4.26	426	-	1,256	RB	4	0.32	0.94
				EF	15-Aug-11	100	4.71	471	-	1,010	RB	2	0.2	0.42
		FS-19	3	EF	10-Aug-11	100	4.65	465	-	419	RB	1	0.24	0.22
		FS-20	4	EF	8-Aug-12	100	4.30	430	-	564	RB	2	0.35	0.47
		FS-21	5	MT	8-Aug-12	-	-	-	5	74	RB	5	6.78	-
				EF	10-Aug-11	100	3.47	347	-	1,203	RB	2	0.17	0.58
	Creek 700	FS-22	1	EF	9-Aug-11	100	8.90	890	-	835	NFC	0	0.00	0.00
		FS-23	2	EF	16-Aug-11	100	2.18	218	-	1,093	RB	3	0.27	1.38
				EF	9-Aug-11	30	2.78	83	-	140	RB	5	2.86	6.00
				MT	10-Aug-11	-	-	-	-	565	RB	9	0.02	-
		FS-24	3	EF	15-Sep-12	100	3.50	350	-	338	NFC	0	0.00	0.00
		FS-25	4	EF	5-Sep-11	100	2.25	225	-	1193	NFC	0	0.00	0.00
				EF	15-Sep-12	100	0.70	70	-	359	NFC	0	0.00	0.00
		FS-101	5	EF	15-Sep-12	100	1.50	150	-	388	NFC	0	0.00	0.00
				MT	15-Sep-12	-	-	-	3	80	NFC	0	0.00	-
Creek 661	Creek 661	FS-82	1	EF	2-Aug-12	100	4.00	400	-	854	RB	45	5.27	11.25
						100	4.00	400	-	854	KO	4	0.47	1.00
				MT	2-Aug-12	-	-	-	5	114	RB	5	4.38	-
		FS-83	2	EF	2-Aug-12	100	4.70	470	-	917	RB	61	6.65	12.98
						100	4.70	470	-	917	KO	1	0.11	0.21
				MT	2-Aug-12	-	-	-	5	116	RB	8	6.88	-
		FS-12	3	EF	11-Aug-11	100	3.38	338	-	1,403	RB	2	0.14	0.59
				MT	11-Aug-11	-	-	-	6	124	RB	1	0.01	-
		FS-13	4	EF	12-Aug-11	100	2.94	294	-	1,525	RB	4	0.26	1.36
		FS-14	5	EF	10-Aug-11	100	2.09	209	-	785	RB	6	0.76	2.87
				MT	10-Aug-11	-	-	-	6	104	RB	4	0.04	-
		FS-15	6	EF	15-Aug-11	100	1.77	177	-	1,012	RB	20	1.98	11.30
		FS-16	7	EF	15-Aug-11	100	1.78	178	-	1,202	RB	10	0.83	5.62
		FS-84	11	EF	6-Aug-12	100	1.00	100	-	440	NFC	0	0.00	0.00
	Creek 505659	FS-86	1	EF	3-Aug-12	100	2.20	220	-	1,243	RB	6	0.48	2.73
				MT	3-Aug-12	-	-	-	3	52	RB	2	3.84	-
		FS-87	2	EF	3-Aug-12	100	2.00	200	-	755	RB	2	0.26	1.00
				MT	3-Aug-12	-	-	-	3	52	RB	3	5.74	-
		FS-88	3	EF	3-Aug-12	100	2.10	210	-	672	RB	4	0.60	1.90

Table continues...

Table 5.10-10 (cont'd)

Watershed	Stream	Site ID	Reach	Gear Type	Date	Site Length (m)	Site Width (m)	Site Area (m^2)	No. Traps/ Rods	Effort[1]	Species	Fish Catch	CPUE[2]	Density (No./100 m^2)
Creek 661 (cont'd)				MT	3-Aug-12	-	-	-	3	57	RB	2	3.51	-
		FS-89	4	EF	3-Aug-12	100	10.00	1,000	-	1,104	NFC	0	0.00	0.00
				MT	3-Aug-12	-	-	-	3	63	NFC	0	0.00	-
		FS-90	7	EF	2-Aug-12	100	0.70	70	-	464	NFC	0	0.00	0.00
				MT	2-Aug-12	-	-	-	3	65	NFC	0	0.00	-
	Creek 146920	FS-91	2	EF	6-Aug-12	100	1.70	170	-	877	RB	1	0.11	0.59
		FS-38	3	EF	20-Aug-11	100	1.42	142	-	566	NFC	0	0.00	0.00
				MT	20-Aug-11	-	-	-	5	309	NFC	0	0.00	-
	Creek 543585	FS-92	1	EF	3-Aug-12	100	1.00	100	-	547	NFC	0	0.00	0.00
				MT	3-Aug-12	-	-	-	3	67	NFC	0	0.00	-
Creek 705	Creek 705	FS-103	4	EF	15-Sep-12	100	1.50	150	-	662	RB	23	3.47	15.33
				MT	15-Sep-12	-	-	-	3	66	RB	1	1.52	-
						-	-	-	3	66	LSU	1	1.52	-
		FS-45	10	EF	19-Sep-12	100	1.50	150	-	391	NFC	0	0.00	0.00
	Creek 606013	FS-102	1	EF	15-Sep-12	100	1.20	120	-	471	RB	34	7.22	28.33
				MT	15-Sep-12	-	-	-	3	82	RB	6	7.33	-
		FS-61	4	EF	19-Sep-12	100	2.00	200	-	509	RB	15	2.95	7.50
Tatelkuz Lake Tributaries	Chedakuz Creek	FS-113	14	AG	5-Sep-12	-	-	-	2	3	RB	8	2.46	-
		FS-97	15	EF	7-Aug-12	300	6.00	1,800	-	876	RB	4	0.46	0.22
						300	6.00	1,800	-	876	MW	1	0.11	0.06
						300	6.00	1,800	-	876	LNC	1	0.11	0.06
				MT	7-Aug-12	-	-	-	6	150	RB	1	0.67	-
		FS-112	15	MT	18-Sep-12	-	-	-	-	263	RB	2	0.76	-
	Creek 549629	FS-51	1	EF	17-Sep-12	100	0.90	90	-	370	NFC	0	0.00	0.00
	Creek 579340	FS-52	5	EF	17-Sep-12	100	0.90	90	-	248	NFC	0	0.00	0.00
		FS-107	8	EF	17-Sep-12	100	4.00	400	-	519	NFC	0	0.00	0.00
				MT	17-Sep-12	-	-	-	3	52	NFC	0	0.00	-
		FS-59	9	EF	18-Sep-12	100	1.08	108	-	333	NFC	0	0.00	0.00
	Creek 737376	FS-108	1	EF	17-Sep-12	100	0.90	90	-	446	NFC	0	0.00	0.00

Notes: [1]Angling effort is in rod hours; electrofishing effort is in seconds; minnow trapping effort is in trap-hours
[2] CPUE for angling is number fish/rod hour; CPUE for electrofishing is number fish/100 EF seconds; and CPUE for minnow trapping is number fish/100 trap-hour
AG = angling; CPUE = Catch-Per-Unit-Effort; NFC = no fish captures, EF = backpack electrofishing; MT = minnow trapping; m = metre; m^2 = metres squared; number/m^2 = number per metres squared

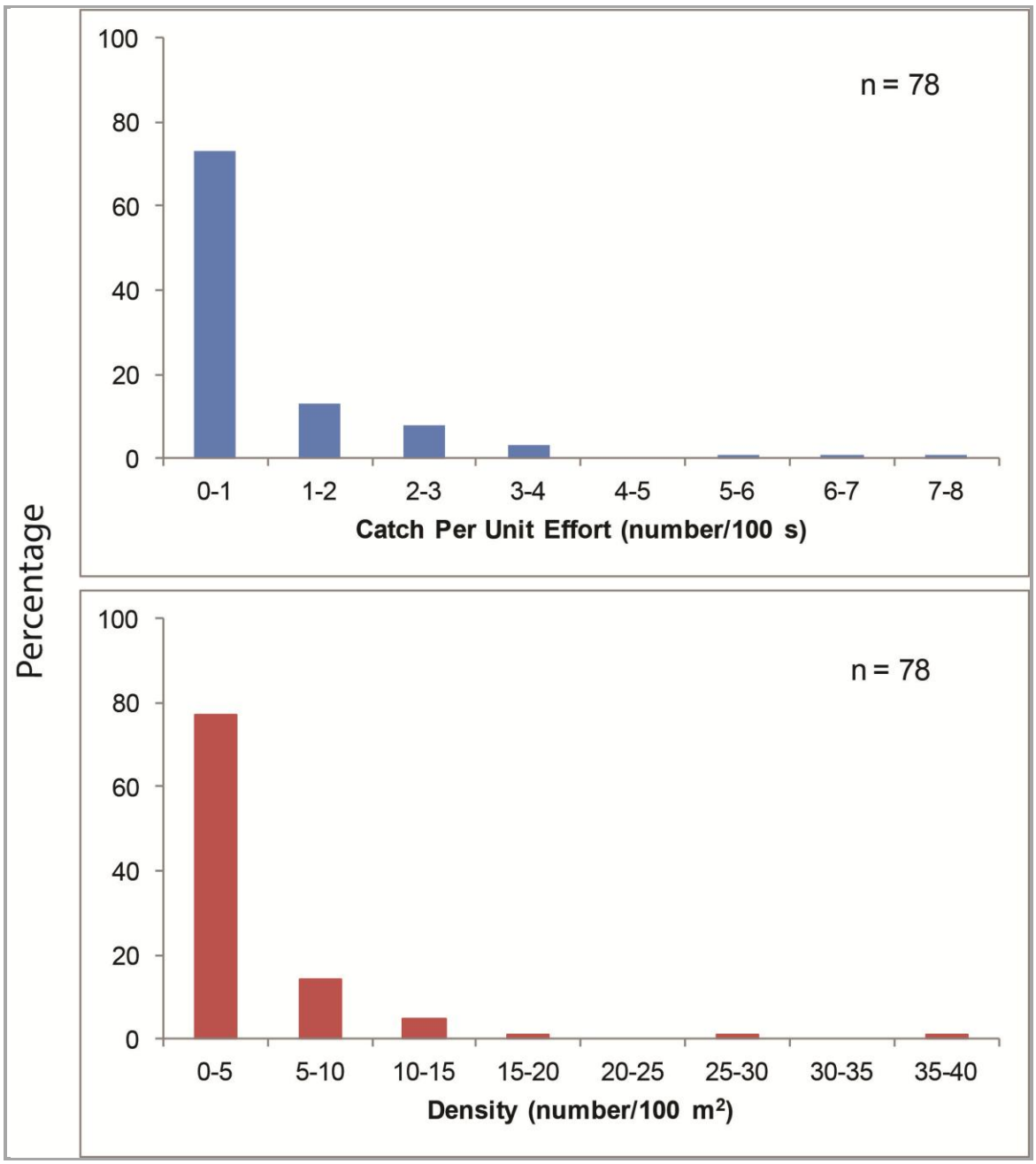


Figure 5.10-6: Frequency Distribution of Electrofishing CPUE and Density in the LSA, 2011 and 2012

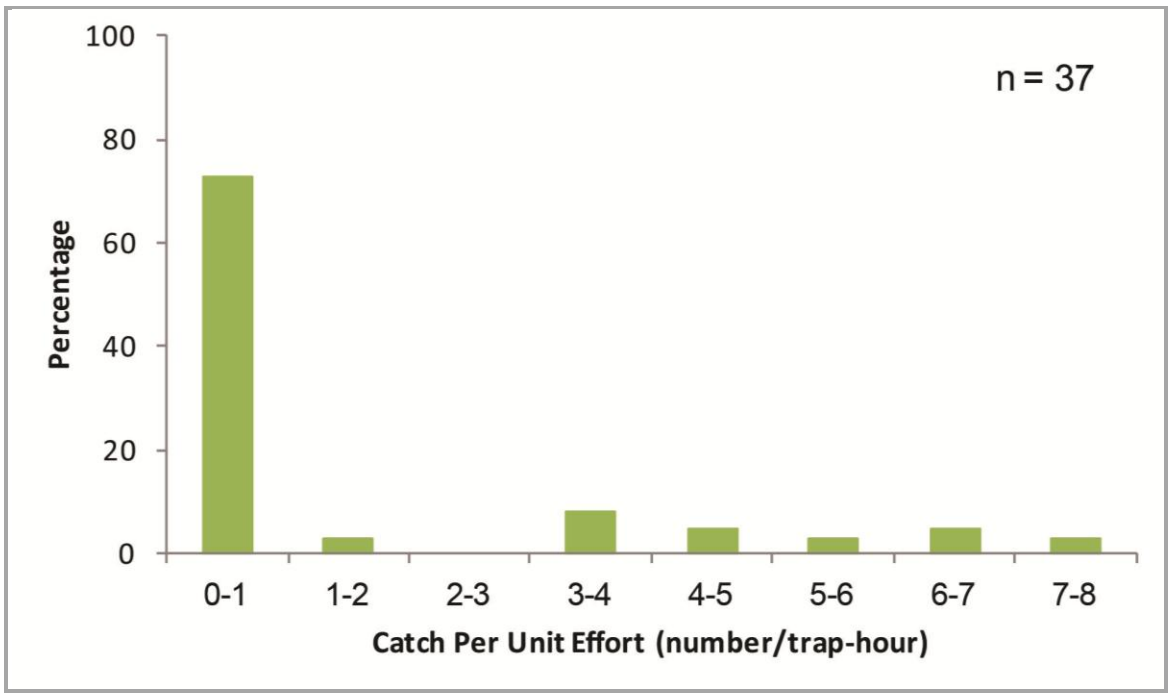


Figure 5.10-7: Frequency Distribution of Minnow Trap CPUE in the LSA, 2011 and 2012

In the mainstem of Davidson Creek, electrofishing CPUE of rainbow trout was highest at site FI-09 in Reach 11 in August 2011 (3.65 fish/100 s), as was rainbow trout density (38.03 fish/100 m^2) (**Table 5.10-10**). CPUE and density were also relatively high in Reaches 12 and 10. The presence of relatively high numbers of juvenile rainbow trout in Reach 12 indicates that rainbow trout spawning occurs just downstream of the outlet of Lake 01682LNRS. Therefore, these fish are assumed to be juveniles of the Davidson Headwater population that overwinters in Lake 01682LNRS.

Since site FI-09 is immediately downstream of the cascade in Reach 11, the high rainbow trout CPUE and density observed at that site and at sites in Reach 10 suggests either that juveniles of the headwater lake population washed downstream over the cascade or that juveniles produced by spawning in the middle and lower reaches of Davidson Creek aggregated below the cascade because they could not swim upstream of it. The latter interpretation makes more sense because the headwater population could only sustain itself if most of its juveniles were able to avoid being swept over the cascade.

Apart from the relatively high densities and CPUE in lower Reach 11 and in Reach 10, there is a clear gradient of decreasing electrofishing CPUE with upstream distance in the mainstem of Davidson Creek from Reach 1 up to Reach 9. The lowest electrofishing CPUE for rainbow trout was observed in Reach 9 in August 2011 (0.19 fish/100 s), as was fish density (0.60 fish/100 m^2). Electrofishing CPUE and densities were an order of magnitude higher in Reaches 2 and 4.

Rainbow trout minnow trapping CPUE showed the same spatial trend: highest in Reach 2 of Davidson Creek in August 2012 (4.65 fish/trap-hour); second-highest in Reach 1 (3.49 fish/trap-hour); and lowest in Reach 5 (0.04 fish/trap-hour).

If the spatial distribution of juvenile rainbow trout is an indicator of the spatial distribution of spawning, then these trends in CPUE suggest that spawning of the Davidson Creek rainbow trout population is concentrated in the lower few reaches of the creek. It also suggests that rearing habitat in the lower reaches of Davidson Creek is probably better than in the upper reaches, at least between Reaches 1 and 9.

A total sampling effort of 15,785 electrofishing seconds and 1,367 trap-hours of minnow trapping was conducted at 21 sites in tributaries to Davidson Creek in 2011 and 2012. No fish were captured at 11 (50%) of those sites. Fish were captured in Creek 428073, Creek 688328, and Creek 704454 only, with a total capture of 23 rainbow trout (**Table 5.10-10**). No other fish species were captured.

Electrofishing CPUE of rainbow trout was highest in Reach 1 of Creek 428073 (2.59 fish/100 s), and lowest in Reach 5 of Creek 704454 (0.45 fish/100 s). Reach 1 of Creek 428073 also had the highest fish density (8.89 fish/100 m^2). Reach 1 of Creek 704454 was the only site in that creek where fish were captured by minnow trapping (0.95 fish/trap-hour).

These results indicate that the quantity and quality of tributary habitat in Davidson Creek is generally lower than that in the mainstem of the creek.

Creek 661 Watershed

Total effort of electrofishing and minnow trapping in all mainstem reaches of Creek 661 sampled was 8,138 seconds and 458 trap-hours, respectively (**Table 5.10-10**).

From this effort, a total of 166 rainbow trout and five kokanee were captured by electrofishing and minnow trapping in the mainstem of Creek 661 in 2011 and 2012 (**Table 5.10-10**). Fish were captured in all reaches sampled, with the exception of Reach 11.

Reach 2 had the highest electrofishing CPUE for rainbow trout in August 2012 (6.65 fish/100 s) and the highest density 2 (12.98 fish/100 m^2). The lowest electrofishing CPUE for rainbow trout was in Reach 3 (0.14 fish/100 s), as was density (0.59 fish/100 m^2). This pattern resembles the pattern observed in Davidson Creek: relatively high CPUE and densities at the downstream end of a creek and decreasing CPUE and density with upstream distance.

Minnow trapping CPUE was generally low in the Creek 661 mainstem, ranging from 0.01 to 0.07 fish/trap-hour.

A total of 6,228 s of electrofishing and 666 trap-hours of minnow trapping were completed at eight sites in tributaries to Creek 661 in 2011 and 2012. No fish were captured in four of the

eight sites. A total of 20 rainbow trout were captured in the other four sites. Electrofishing CPUE was highest in Reach 3 of Creek 505659 (0.60 fish/100 s), and fish density was highest in Reach 1 (2.73 fish/100 m^2) of that creek. Minnow trapping CPUE was highest in Reach 2 of Creek 505659 (0.06 fish/trap-hour).

Turtle Creek Watershed

Rainbow trout was the only species observed in this watershed during the stream fish inventories in summers of 2011 and 2012 (**Table 5.10-10**). Rainbow trout were captured at all sites in the Turtle Creek mainstem and at one of five sites in Creek 700. No fish were captured in the three most upstream reaches of Creek 700 (Reaches 3, 4, and 5) that were sampled.

A total of 42 rainbow trout were captured in the Turtle Creek Watershed in August 2011 and August 2012. These fish were captured through a total combined sampling effort of 7,527 s of electrofishing and 718 trap-hours of minnow trapping. No fish were captured in 3.2 rod-hours of angling in Turtle Creek in October 2012.

Electrofishing CPUE was highest in Reach 2 of Turtle Creek (2.86 fish/100 s), as was fish density (6.00 fish/100 m^2). Electrofishing CPUE was lowest in Reach 2 of Creek 700 (0.17 fish/100 s), and fish density was lowest in Reach 5 of Turtle Creek (0.22 fish/100 m^2). Successful minnow trapping was conducted only in Reach 5 of Turtle Creek in August 2012 (6.78 fish/100 trap-hour) and in Reach 2 of Creek 700 (0.02 fish/100 trap-hour).

This pattern resembles the pattern observed in Davidson Creek and Creek 661: relatively high CPUE and densities at the downstream end of a creek and decreasing CPUE and density with upstream distance.

Creek 705 Watershed

A total of 79 rainbow trout and one longnose sucker were captured through the application of 662 seconds of electrofishing effort and 148 trap-hours of minnow trapping effort at four sites in the Creek 705 Watershed (**Table 5.10-10**). Fish were captured at three of the four sites sampled. The only site where no fish were captured was located in Reach 10 of the Creek 705 mainstem, upstream of Lake 01538UEUT. CPUE for electrofishing and minnow trapping were highest in Reach 1 of Creek 606013 (7.22 fish/100 s and 7.33 fish/100 trap-hour, respectively), which is located directly downstream of headwater Lake 01428UEUT.

Tatelkuz Lake Tributaries Watershed

A total effort of 876 electrofishing seconds, 413 trap-hours of minnow trapping, and 3 rod-hours of angling were completed in Reaches 14 and 15 of lower Chedakuz Creek. The main purpose of this effort was to obtain sculpins for measurement of fish tissue metal concentrations, rather than for the purpose of a fish community inventory purposes. The results of this sampling are not directly comparable with the results of summer fish inventories conducted in other parts of the LSA in 2011 and 2012.

No sculpin were captured in Chedakuz Creek, and none were captured at any other site in the LSA in 20911 and 2012. However, a total of 15 rainbow trout, one mountain whitefish, and one longnose dace were captured.

A total of 1,916 s of electrofishing and 52 trap-hours of minnow trapping was conducted in one direct tributary (Creek 579340) and two indirect tributaries (Creek 549629 and Creek 737376) to Tatelkuz Lake. No fish were captured in any of these streams.

Comparisons among Watersheds

Pooling electrofishing CPUE of rainbow trout by population over both the 2011 and 2012 surveys showed that the Creek 705 Headwaters South population had the highest mean CPUE (**Table 5.10-11**), followed by the Creek 705 Headwaters South population, the Davidson Creek Headwaters population, and the Creek 661 population. The Tatelkuz Lake Tributaries Watershed (lower Chedakuz Creek) had the lowest CPUE.

Table 5.10-11: Rainbow Trout Mean Electrofishing CPUE and Fish Density by Population or Watershed, 2011 and 2012

Population	Number Captured	Electrofishing Effort (s)	Mean CPUE (fish/100 s)	Area Sampled (m^2)	Mean Fish Density (No./100 m^2)
Davidson Creek	263	34,008	0.8	9,262	2.8
Davidson Creek Headwaters	101	5,230	1.9	854	11.8
Turtle Creek	28	7,527	0.4	3,310	0.8
Creek 661	160	14,366	1.1	4,278	3.7
Creek 705 Headwaters North	49	980	5.0	320	15.3
Creek 705 Headwaters South	23	1,053	2.2	300	7.7
Tatelkuz Lake Tributaries	4	2,792	0.1	2,578	0.2
Total or Mean	**628**	**65,956**	**1.0**	**20,902**	**3.0**
SE			**0.6**		**2.2**

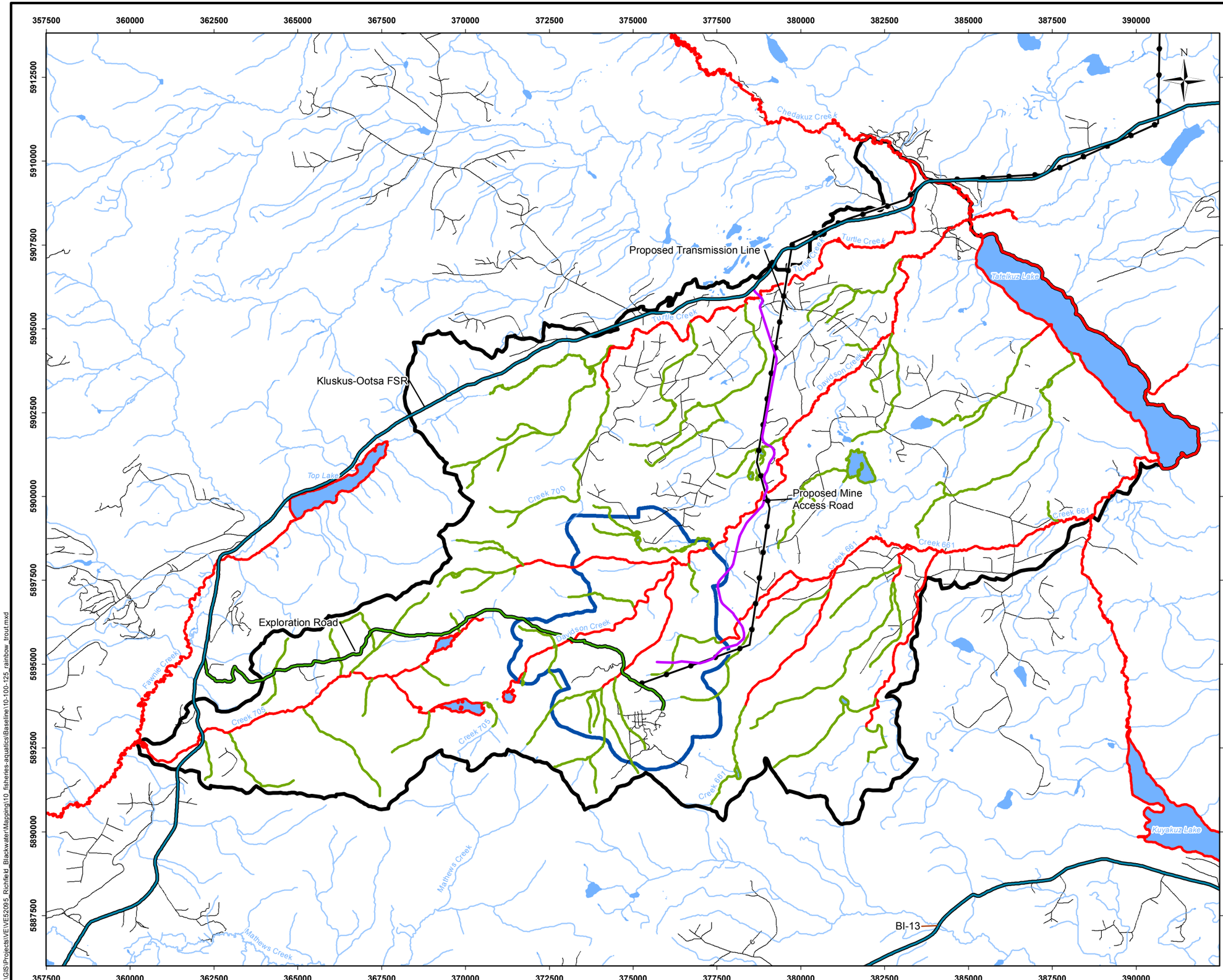
Distribution of Rainbow Trout

The stream inventory data summarized in this section were used to develop a map of rainbow trout distribution in the LSA (**Figure 5.10-8**). The stream sections outlined in red indicate where rainbow trout were captured or observed. The green sections indicate where rainbow trout are believed to reside, but were not observed or captured because those sections were not surveyed.

Summer Habitat Use by Species and Life Stage

The stream inventory data summarized in this section were used to search for relationships between rainbow trout electrofishing CPUE and mesohabitat types by pooling all data

among watersheds and years. No clear linear or curvilinear relationships were observed between electrofishing CPUE and percent riffles, percent pools, and percent glides for each stream sampling site (**Figure 5.10-9**). Similar plots of rainbow trout density on mesohabitat types (**Figure 5.10-10**), and minnow trap CPUE and mesohabitat types (**Figure 5.10-11**) also found no clear relationships with percent riffles, percent pools, and percent glides for each stream sampling site. The most likely reason for the absence of apparent habitat preferences by juvenile rainbow trout is that the low density of juvenile rainbow trout in streams of the LSA obscured any relationships that exist.



Legend

- Existing Road
- Exploration Road
- Kluskus-Ootsa FSR
- Proposed Mine Access Road
- Proposed Transmission Line
- Watercourse
- Lake
- Wetland
- Proposed Mine Site
- Aquatic Local Study Area
- Known Rainbow Trout Distribution
- Unconfirmed Rainbow Trout Distribution

Scale:1:110,000

0 0.5 1 2 3 4 5

Kilometres

Reference
BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Distribution of Rainbow Trout in the LSA, 2011-2012

DATE:	ANALYST:	**Figure** 5.10-8
June, 2013	MY	
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GIS FILE: 10-100-125_rainbow_trout.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-125_rainbow_trout.mxd

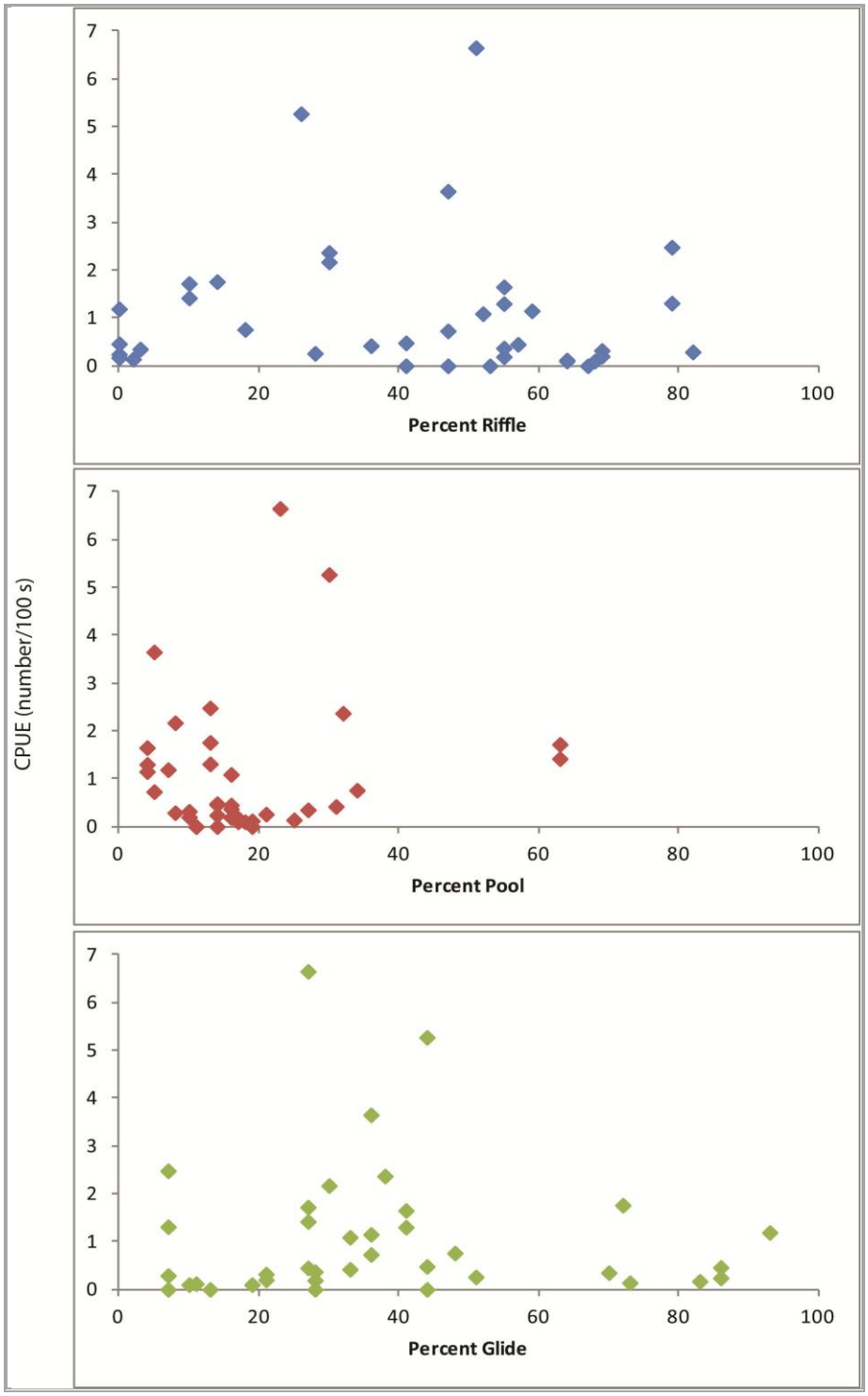


Figure 5.10-9: Plots of Rainbow Trout Electrofishing CPUE on Percent Riffles, Pools, and Glides at Stream Sampling Sites of the LSA, 2011-2012

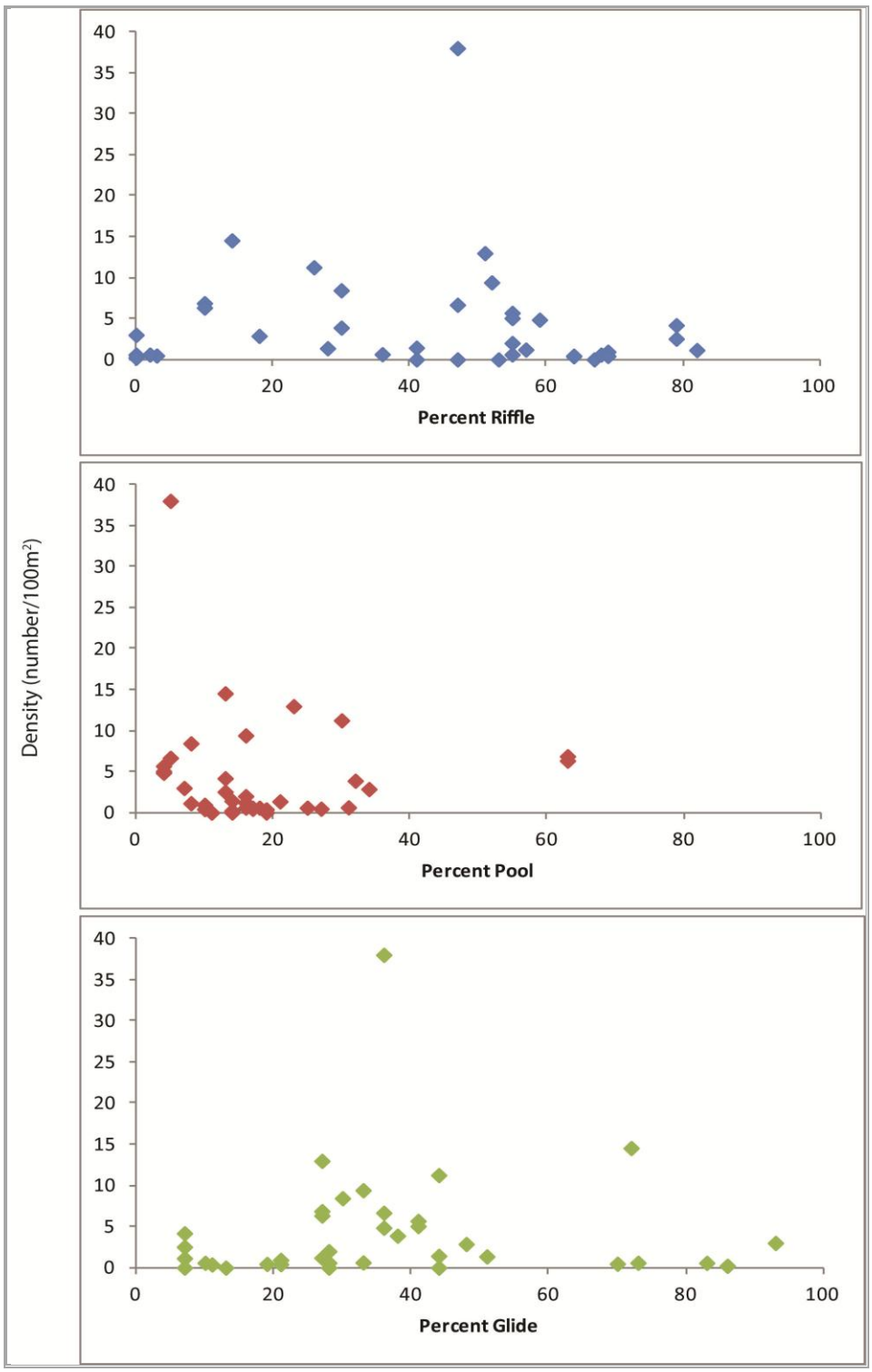


Figure 5.10-10: Plots of Rainbow Trout Electrofishing Density on Percent Riffles, Pools, and Glides at Stream Sampling Sites of the LSA, 2011-2012

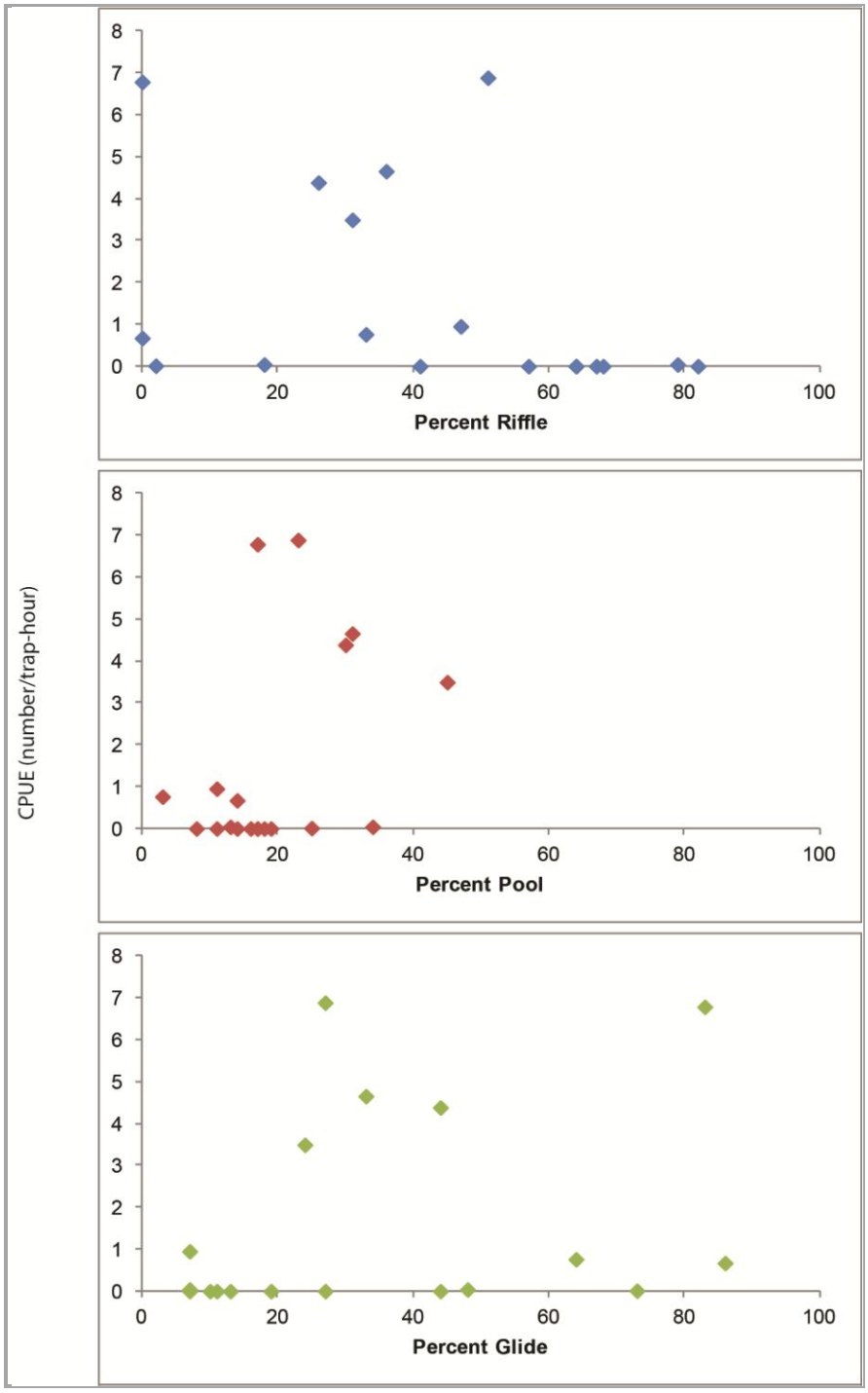


Figure 5.10-11: Plots of Rainbow Trout Minnow Trout CPUE on Percent Riffles, Pools, and Glides at Stream Sampling Sites of the LSA, 2011-2012

5.10.2.5 Summer Fish Inventories – Lakes

This section describes the results of sampling fish communities of four headwater lakes in August 2011 and September to October 2012. These include the headwater lake of Davidson Creek (Lake 01682LNRS), two headwater lakes in the Creek 705 Watershed (the southern Lake 0153UEUT and the northern Lake 01428UEUT), and Snake Lake, a headwater lake of the Tatelkuz Lake Tributaries Watershed.

Lake 01682LNRS

No fish were captured in Lake 01682LNRS in August 2011, despite a total fishing effort of 11.6 hours of gillnetting and 192 trap-hours of minnow trapping (**Table 5.10-12**). However, 17 rainbow trout were captured in September 2012: 11 in a sinking gillnet set for 2.9 hours (CPUE = 55.1 fish/100 m^2/day) and 6 in a floating gillnet set for 4.0 hours (CPUE = 15.9 fish/100 m^2/day). Mean rainbow trout CPUE for 2011 and 2012 was 35.5 fish/100 m^2/day (n = 2, SE = 19.6).

No fish were captured in minnow traps in September 2012 despite an total effort of 102 trap-hours.

Lake 01538UEUT

A total of 19 rainbow trout and 92 longnose suckers were captured in Lake 01538UEUT in August 2011 (**Table 5.10-12**). Rainbow trout catches included 13 fish in a 2.5-hour sinking gill-net set, 4 in a 1.5 hour floating gill-net set, and 2 fish in minnow traps. An additional 12 rainbow trout were captured in sinking gill-nets in September 2012.

All of the longnose suckers were juveniles caught in minnow traps. Surprisingly, given the relatively large number of juveniles captured in the minnow traps, no adult longnose suckers were captured in any gillnets set in the lake in 2011 and 2012.

In August 2011, CPUE for rainbow trout was 55.5 fish/100 m^2/day for the sinking gillnet and 28.4 fish/100 m^2/day for the floating gillnet. In September 2012, sinking gillnet CPUE ranged from 3.7 to 34.7 fish/100 m^2/day in those sets that captured any fish.

A total of 265 trap-hours of minnow trapping in August 2011 resulted in the capture of two rainbow trout and 92 juvenile longnose suckers for CPUE of 0.8 and 34.7 fish/100 trap-hours, respectively.

Mean CPUE for rainbow trout in 2011 and 2012 was 30.0 fish/100 m^2/day (n = 5, SE = 8.2).

Table 5.10-12: Fish Inventory Results by Gear Type in Lakes 01682LNRS, 01538UEUT, and 01428UEUT, and Snake Lake, 2011 and 2012

Lake	Sampling Date	Gear Type /Number	Total Net Area (m^2) or Total Trap Numbers	No. of Sets	Effort[1]	Species	Catch	CPUE[2]
Lake 01682LNRS	Aug-14-11	Sinking Gillnet 1	225	1	1.8	NFC	0	0.0
	Aug-15-11	Sinking Gillnet 1	225	2	3.8	NFC	0	0.0
	Aug-14-11	Floating Gillnet 1	225	1	2.0	NFC	0	0.0
	Aug-15-11	Floating Gillnet 1	225	2	4.0	NFC	0	0.0
	Sep-19-12	Sinking Gillnet 2	225	1	2.1	RB	11	55.1
	Sep-19-12	Floating Gillnet 2	225	1	2.1	NFC	0	0.0
	Sep-19-12	Floating Gillnet 2	225	2	4.0	RB	6	15.9
	Aug-14-11	Minnow Traps 1	8	1	192	NFC	0	0.0
	Sep-19-12	Minnow Traps 2	7	1	42	NFC	0	0.0
	Sep-20-12	Minnow Traps 3	7	2	60	NFC	0	0.0
Lake 01538UEUT	Aug-13-11	Sinking Gillnet 1	225	1	2.5	RB	13	55.5
	Aug-13-11	Floating Gillnet 1	225	1	1.5	RB	4	28.4
	Sep-10-12	Sinking Gillnet 2	225	1	1.0	RB	3	32.0
	Sep-10-12	Sinking Gillnet 2	225	2	1.9	NFC	0	0.0
	Sep-10-12	Sinking Gillnet 3	225	1	2.8	RB	8	30.2
	Sep-10-12	Sinking Gillnet 4	225	1	2.9	RB	1	3.7
	Aug-12-11	Minnow Traps 1	10	1	265	LSU	92	34.7
						RB	2	0.8
Lake 01428UEUT	Aug-16-11	Sinking Gillnet 1	225	1	2.5	RB	16	68.3
	Aug-16-11	Floating Gillnet 1	225	1	2.5	RB	27	115.2
	Sep-8-12	Sinking Gillnet 2	225	1	3.5	RB	34	104.5
						LSU	3	9.2
	Aug-17-11	Minnow Traps 1	16	1	384	LSU	3	0.8
Snake Lake	Oct-16-12	Angling 1	2	1	1.5	NFC	0	0.0
	Oct-16-12	Backpack Electrofishing 1	-	1	352.0	NFC	0	0.0
	Oct-16-12	Backpack Electrofishing 2	-	2	487.0	NFC	0	0.0
	Oct-17-12	Floating Gillnet 1	225	1	2.3	NFC	0	0.0
	Oct-17-12	Sinking Gillnet 1	225	1	3.5	NFC	0	0.0
	Oct-17-12	Floating Gillnet 2	225	1	2.8	NFC	0	0.0
	Oct-18-12	Floating Gillnet 1	225	2	15.8	LKC	3	2.0
	Oct-18-12	Sinking Gillnet 1	225	2	15.5	LKC	57	39.2
	Oct-18-12	Floating Gillnet 2	225	2	18.0	LKC	26	15.4
	Oct-16-12	Minnow Traps 1	6	1	157.8	LKC	2	1.3
	Oct-16-12	Minnow Traps 2	6	2	153.6	NFC	0	0.0
	Oct-16-12	Minnow Traps 3	7	3	163.8	LKC	1	0.6

Notes: [1] Gill-netting effort is in soak hours; minnow trapping effort is in trap-hours; angling effort is in rod hours; electrofishing effort is in seconds
[2] CPUE for gill-netting is number of fish/100 m^2/day; CPUE for minnow trapping is number of fish per 100 trap-hours; CPUE for angling is number of fish/rod hour; CPUE for electrofishing is number of fish/100 seconds
CPUE = Catch-Per-Unit-Effort; LKC = lake chub; LSU = longnose sucker; m^2 = metres squared; NFC = no fish captured; RB = rainbow trout

Lake 01428UEUT

A total of 43 rainbow trout and three longnose suckers were captured in Lake 01428UEUT in August 2011 (**Table 5.10-12**). Rainbow trout included 16 captured during a 2.5-hour sinking gill-net set, and 27 captured during a 2.5 hour floating gill-net set. CPUE of rainbow trout was 68.3 fish/100 m^2/day for the sinking gillnet and 115.2 fish/100 m^2/day for the floating gillnet.

A total of 384 trap-hours of minnow trap effort in August 2011 resulted in the capture of three juvenile longnose suckers for a CPUE of 0.8 fish/100 trap hours.

An additional 34 rainbow trout and three longnose suckers were captured in a single sinking gillnet set in September 2012. CPUE of rainbow trout was 104.5 fish/100 m^2/day for this sinking gillnet, which was similar to the CPUE for the floating gillnet in 2011.

Mean CPUE for rainbow trout in 2011 and 2012 was 96.0 fish/100 m^2/day (n = 3, SE = 14.2).

Snake Lake

In October 2012, a total effort of 57.8 hours of gillnetting, 475 trap-hours of minnow trapping, 839 seconds of shoreline electrofishing, and 1.5 rod-hours of angling were conducted in Snake Lake (**Table 5.10-12**). A total of 86 lake chub were captured. Most of these fish (97%) were captured in gillnets. No other fish species were captured. Minnow trapping CPUE was relatively low, with a total capture of three lake chub and a mean CPUE of 0.6 fish/100 trap-hour. No fish were captured by angling or electrofishing.

The absence of rainbow trout from Snake Lake in the 2012 sampling survey is contrary to anecdotal information which suggests that Snake Lake is a popular fly-fishing site (BC ILMB 1997). It is unlikely this lake was misidentified in the provincial records because it was described as having a unique esker formation that splits the lake into roughly two equal basins. The long thin shape of this esker gives the lake its local name. No other lakes in the area have this feature and it is, therefore, highly unlikely that the lake sampled in 2012 by AMEC was not the locally known “Snake Lake.”

Summary

In summary, Lake 01428UEUT had the highest mean rainbow trout gillnet CPUE, followed by Lake 01682LNRS and Lake 01538UEUT. However, the variance of CPUE was high enough that there was little difference in mean CPUE between lakes 01682LNRS and 01538UEUT.

This rank order follows the same rank order of mean zooplankton density and biomass (**Figures 5.5-1** and **5.5-2**), but it does not follow the rank order of phytoplankton density and biomass (**Figures 5.4-1** and **5.4-2**). Lake 01428UEUT also had the highest percentage of littoral zone habitat (97%) compared to 62% for Lake 01682LNRS and 52% for Lake

01538UEUT, and the lowest Secchi depth (mean = 3.5 m) compared to 4.8 m for Lake 01538UEUT and 5.6 m for Lake 01682LNRS.

5.10.2.6 Summer-Fall Kokanee Spawning Surveys

This section describes the results of streamside surveys of the location and numbers of kokanee spawners and redds in Davidson Creek and Creek 661 in August of 2011 and 2012, and in Chedakuz Creek from August to October 2012.

The kokanee counted in Davidson Creek and Creek 661 are assumed to have emigrated from Tatelkuz Lake, as did the kokanee counted in all inlets and the outlet of Tatelkuz Lake. The kokanee counted in the downstream half of middle Chedakuz Creek (between Tatelkuz Lake and Kuyakuz Lake) are also assumed to have emigrated out of Tatelkuz Lake. The kokanee counted in upper Chedakuz Creek (upstream of Kuyakuz Lake) and in the upstream half of middle Chedakuz Creek are assumed to have emigrated out of Kuyakuz Lake.

Davidson Creek

In Davidson Creek, kokanee spawning surveys were conducted from 8 August to 11 August 2011, and on 22 August 2012. During these periods, water temperature ranged from 7 to 10°C in 2011 and was 12°C in 2012.

In August 2011, a total of 6,763 spawning kokanee and 515 redds were counted in the lower 5.2 km of Davidson Creek (**Table 5.10-13**). The upstream distribution of kokanee spawners and redds extended approximately 5.2 km upstream from the confluence with lower Chedakuz Creek into the upper part of Reach 4 (**Figure 5.10-12**). The total estimated area for kokanee spawning in those four reaches was 27,022 m^2. Density of kokanee spawners did not show a consistent pattern with upstream distance. The highest density was in Reach 3 (41.9 fish/100 m^2) and lowest density was in Reach 2 (18.8 fish/100 m^2). However, redd density decreased with increasing upstream distance. Reach 1 had the highest redd density (2.9 redd/100 m^2) and Reach 4 had the lowest redd density (1.1 redd/100 m^2).

In August 2012, a total of 1,154 spawning kokanee and 188 redds were observed in the lower 4.2 km of Davidson Creek (**Table 5.10-14**). The observed upstream distribution of kokanee spawners and redds again extended into Reach 4, and was approximately 1 km downstream from its limit observed in 2011. These numbers were less than 20% of those counted in August 2011. The habitat area for spawning kokanee in 2012 was estimated to be 21,885 m^2, which was 80% the area estimated in August 2011.

Both kokanee density (13.8 fish/100 m^2) and redd density (1.6 redd/100 m^2) were highest in Reach 2 in 2012, and then decreased with upstream distance.

Table 5.10-13: Kokanee/Redd Survey Counts and Densities by Reach for Davidson Creek and Creek 661, August 2011

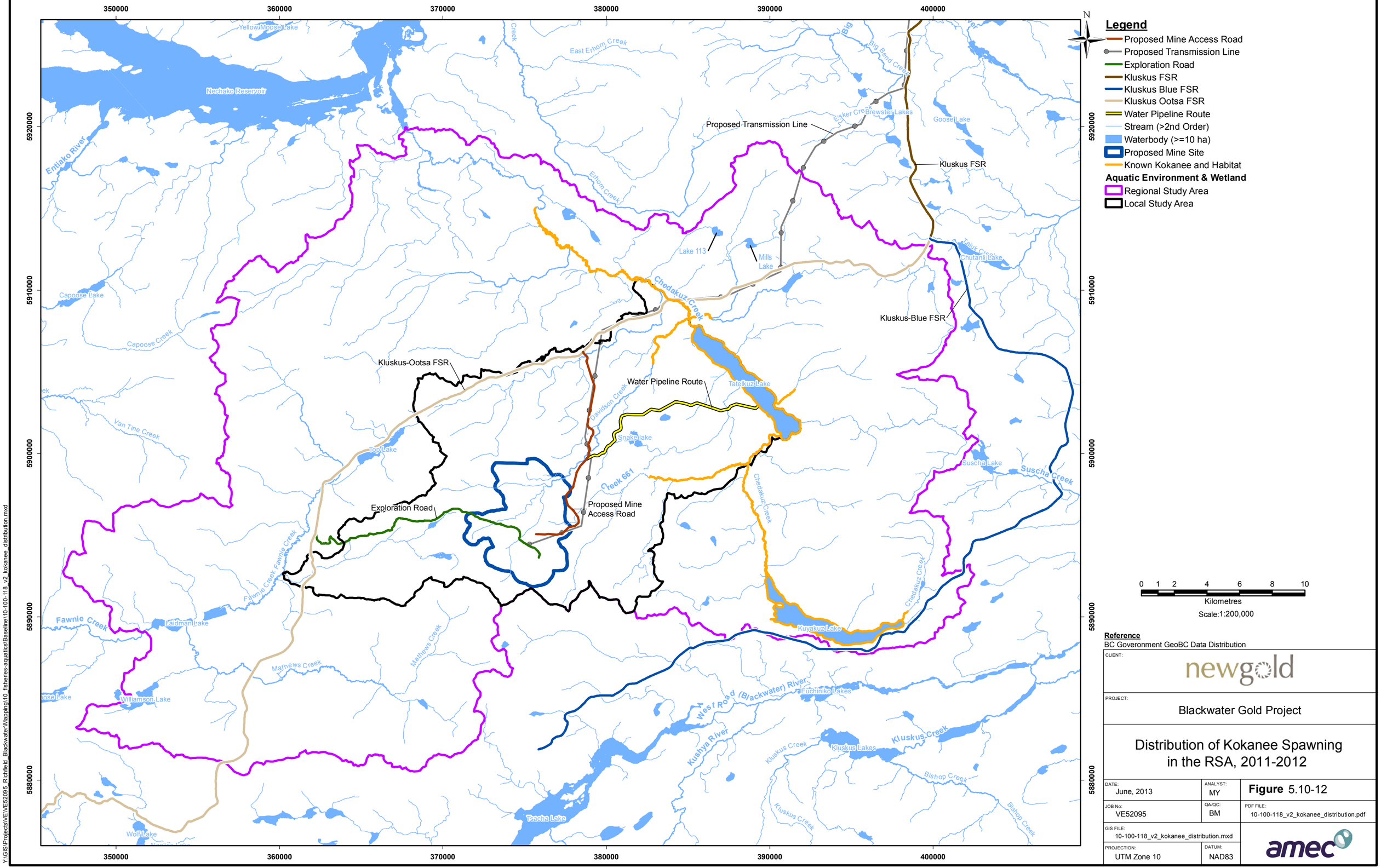
Stream	Reach No.	Stream Length (Kokanee Presence) (m)	Average Wetted Width (m)	Estimated Habitat Area (m^2)	No. of Kokanee	No. of Redds	Kokanee Density (#/100 m^2)	Redd Density (#/100 m^2)
Davidson Creek	1	1,375	5.30	7,288	1,677	210	23.0	2.9
	2	499	5.02	2,505	470	50	18.8	2.0
	3	1,182	4.33	5,118	2,145	122	41.9	2.4
	4	2,136	5.67	12,111	2,471	133	20.4	1.1
	Total	**5,192**	**-**	**27,022**	**6,763**	**515**	**-**	**-**
Creek 661	1	3,484	3.64	12,681	3,824	679	33.0	5.9
	2	824	3.96	3,263	634	48	23.1	1.7
	3	3,043	3.38	10,270	1,548	7	14.8	0.1
	Total	**7,351**	**-**	**24,788**	**6,006**	**734**	**-**	**-**

Notes: m = metre; m^2 = metres squared; No. = number; NS = not surveyed; number/m^2 = number per metres squared

Table 5.10-14: Kokanee/Redd Survey Counts and Densities by Reach for Davidson Creek and Creek 661, August 2012

Stream	Reach No.	Stream Length (Kokanee Presence) (m)	Average Wetted Width (m)	Estimated Habitat Area (m^2)	No. of Kokanee	No. of Redds	Kokanee Density (No./100 m^2)	Redd Density (No./100 m^2)
Davidson Creek	1	1,375	5.30	7,288	358	75	4.9	1.03
	2	499	5.02	2,505	346	40	13.8	1.60
	3	1,182	4.33	5,118	381	54	7.4	1.06
	4	1,177	5.67	6,674	69	19	1.0	0.28
	Total	**4,233**	**-**	**21,885**	**1,154**	**188**	**-**	**-**
Creek 661	1	2,159	3.64	7,859	2,878	517	36.6	6.58
	2	-	3.96	NS	NS	NS	NS	NS
	3	-	3.38	NS	NS	NS	NS	NS
	Total	**2,159**	**-**	**7,859**	**2,878**	**517**	**-**	**-**

Notes: m = metre; m^2 = metres squared; No. = number; NS = not surveyed; number/m^2 = number per metres squared



Reference
BC Goverenment GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Distribution of Kokanee Spawning in the RSA, 2011-2012

DATE: June, 2013	ANALYST: MY	**Figure** 5.10-12
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GIS FILE: 10-100-118_v2_kokanee_distribution.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Creek 661

Kokanee spawning surveys were conducted from 12 August to 21 August 2011, and on 24 August 2012, in Creek 661. During these periods, water temperature ranged from 8 to 11°C in 2011 and was 9°C in 2012.

In August 2011, a total of 6,006 spawning kokanee and 734 redds were counted in Creek 661 (**Table 5.10-13**). The upstream distribution of spawning kokanee extended to the upper part of Reach 3, which is located approximately 7.4 km above the confluence with middle Chedakuz Creek (**Figure 5.10-7**). Although kokanee were distributed over a longer section of Creek 661 than of Davidson Creek, the total area of kokanee spawning habitat was estimated to be 24,788 m^2, which was lower than in Davidson Creek because the mean width of Creek 661 is lower than in Davidson Creek.

Similar to Davidson Creek, both kokanee density and redd density decreased with upstream distance in Creek 661 in 2011. Kokanee density decreased from 33 fish/100 m^2 in Reach 1 to 14.8 fish/100 m^2 in Reach 4. Redd density decreased from 5.9 redds/100 m^2 in Reach 1 to 0.1 redds/100 m^2 in Reach 4.

In August 2012, a 1-day index count was conducted over the first 2.1 km of Reach 1 of Creek 661. A total of 2,878 spawning kokanee and 517 redds were counted (**Table 5.10-14**). The estimated habitat area was 7,859 m^2. Thus, in an index section comprising one-third the area surveyed in 2011, the 2012 count was half the total 2011 kokanee spawner count and two-thirds the total 2011 redd count. Although the intervening reaches were not surveyed in 2012, the upstream limit of kokanee distribution in 2012 was confirmed, and was found to be similar to that observed in 2011. Therefore, a total 2012 count is not available. The density of spawners and redds was higher in 2012 than in 2011. Spawner densities in the section surveyed in both 2011 and 2012 were similar (33.0 and 36.6 fish/100 m^2, respectively). This suggested that the total kokanee runs were similar in 2011 and 2012.

Kokanee and redd densities in Creek 661 in 2012 were also higher than those in Davidson Creek in 2012.

Chedakuz Creek

From August to October 2012, 32 sites along the mainstem of Chedakuz Creek and in tributaries to Chedakuz Creek were surveyed for kokanee presence/absence and for habitat suitability (**Table 5.10-15** and **Figure 5.10-12**). Two additional sites were surveyed to obtain kokanee tissue samples for microsatellite DNA analysis: one in the Fawnie Creek Watershed and a second in Meadow Creek, upstream of Kootenay Lake in the Kootenays.

Table 5.10-15: Presence/Absence of Kokanee and Kokanee Spawning Habitat in Streams and Lakes in the LSA and RSA, 2012

Stream/Lake Name	Baseline Site ID	Presence of Kokanee Spawning Habitat[1]	Kokanee Presence			
			Early August 2012	Late August 2012	September 2012	October 2012
Lower Chedakuz Creek	KO-01	P	-	A	P	A
Lower Chedakuz Creek	KO-11	P	A	P	P	-
Tatelkuz Lake	KO-15	P	-	P	-	-
Middle Chedakuz Creek	KO-23	P	-	P	P	-
Middle Chedakuz Creek	KO-28	P	-	P	A	A
Kuyakuz Lake	KO-29	P	-	P	-	-
Upper Chedakuz Creek	KO-30	P	-	P	P	-
Upper Chedakuz Creek	KO-32	P	-	-	-	-
Creek 101550	KO-02	P	-	A	P	A
Creek 116704	KO-03	A	-	A	-	-
Creek 116704	KO-04	A	-	A	-	-
Creek 138219	KO-05	A	-	A	-	-
Creek 302288	KO-06	A	-	A	-	-
Creek 366679	KO-07	P	-	A	A	-
Creek 399693	KO-08	A	-	A	-	-
Creek 405454	KO-09	A	A	A	A	-
Turtle Creek	KO-10	A	-	A	-	-
Creek 522107	KO-12	P	-	A	P	-
Creek 063231	KO-13	P	-	A	A	A
Creek 522107	KO-14	P	-	A	A	A
Creek 564954	KO-16	A	-	A	-	-
Creek 571602	KO-17	A	-	A	-	-
Creek 579340	KO-18	A	-	A	A	-
Creek 601947	KO-19	P	-	P	P	-
Creek 622056	KO-20	A	A	A	A	-
Creek 622056	KO-21	A	A	A	A	-
Creek 622056	KO-22	P	A	A	A	-
Creek 564954	KO-24	P	-	-	A	-
Creek 712749	KO-25	P	-	A	A	-
Creek 720589	KO-26	A	-	A	-	-
Creek 720589	KO-27	A	-	A	-	-
Creek 878530	KO-31	A	-	-	A	-
Fawnie Creek	KO-33	P	-	-	P	-
Meadow Creek	KO-34	P[2]	-	-	P	-

Notes: [1] Kokanee not visually observed, but assumed to be present in Tatelkuz Lake and Kuyakuz Lake
[2] Spawning habitat assumed to be present (site sampled for genetics only)
A = Absent; P = Present; dash indicates not surveyed

Five of eight sites along the mainstem of Chedakuz Creek had kokanee present during one or more of the field surveys conducted between August and October 2012. Two sites were kokanee residence lakes – Tatelkuz and Kuyakuz Lakes – where shoreline surveys were not conducted, but where kokanee are known to reside year-round. The only site on the mainstem of Chedakuz Creek where kokanee were not observed was site KO-32, which was located in upper Chedakuz Creek, upstream of two in-line ponds and above Kuyakuz Lake. However, suitable spawning gravels are present at site KO-32.

Of the remaining 24 sites on direct or indirect tributaries to Chedakuz Creek (i.e., an indirect tributary flows into a tributary that flows directly to Chedakuz Creek), kokanee were absent from 21 sites. Fifteen of those sites have no suitable kokanee spawning habitat so the absence of kokanee from those site is not unexpected. However, six of those sites (Creek 366679, Creek 063231, Creek 522107, Creek 622056, Creek 564954, and Creek 712749) appear to have suitable kokanee spawning habitat. The absence of kokanee from those sites is either due to survey timing before or after spawning had occurred or the absence of some other habitat feature besides substrate composition or water depth.

Spawning kokanee were only present at three sites during one or more surveys (Creek 101550, Creek 522107, and Creek 601947), and all three sites have habitat conditions suitable for spawning.

A total of 6,536 kokanee and 983 redds were counted in three mainstem sites (KO-11, KO-23, and KO-30) in reaches of lower, middle, and upper Chedakuz Creek (**Table 5.10-16**). Three other sites along the mainstem were recorded as having kokanee (KO-01, KO-02, and KO-28), but numbers were too low (<10) to allow estimation of either kokanee spawner numbers or redd numbers.

Another 642 kokanee and 48 redds were counted at sites KO-12 and KO-19 in Creeks 522107 and 601947. Kokanee were observed at site KO-02 in Creek 101550, but they were too few to estimate fish or redd numbers.

Of the streams where kokanee and redd counts were conducted from the ground, the highest kokanee linear density was measured at site KO-12 in Creek 522107 (2.99 fish/m) (**Table 5.10-16**). This result was likely due to the presence of a beaver dam that prevented upstream passage of kokanee spawners beyond the lower 188 m of the creek. Several hundred kokanee were counted below this dam, likely resulting in a more inflated estimate of linear density in Creek 522107 than if the dam was breached.

Lowest kokanee linear density was measured in Creek 601947 (0.05 fish/m), followed closely by Davidson Creek (0.27 fish/m).

The highest redd linear density was measured at site KO-23 in middle Chedakuz Creek (0.31 redds/m). The lowest redd density was measured in Davidson Creek (0.04 redds/m).

Table 5.10-16: Kokanee/Redd Survey Counts and Densities, 2012

Stream	Baseline Site ID	Length of Kokanee Presence Surveyed (m)	No. Kokanee	No. Redds	Kokanee Linear Density (No./m)	Redd Linear Density (No./m)	Total Accessible Length (m)	Estimated Number Kokanee
Davidson Creek	-	4,233	1,139	188	0.27	0.04	4,233	1,139
Creek 661	-	2,159	2,878	517	1.33	0.24	5,007	6,674
Lower Chedakuz Creek	KO-11	1,238	2,464	218	1.99	0.18	3,043	6,057
Middle Chedakuz Creek	KO-23	2,270	3,419	698	1.51	0.31	10,345	15,581
Upper Chedakuz Creek	KO-30	302	653	67	2.16	0.22	547	1,183
Creek 522107	KO-12	188	563	17	2.99	0.09	1,888	5,654
Creek 601947	KO-19	1,642	79	31	0.05	0.02	1,642	79

Notes: m = metre, No. = number.

The estimates of linear density shown in **Table 5.10-16** were used to extrapolate the total number of kokanee spawners and redds over the total accessible length of stream. For example, the linear density of spawners at site KO-12 in Creek 522107 (2.99 fish/m) was multiplied by the total accessible length of 1,888 m to calculate an estimated number of 5,654 kokanee spawners. This extrapolation assumed that the accessible length of stream contained suitable spawning habitat. Extrapolated numbers of kokanee ranged from 79 in Creek 601947 to 10,345 in middle Chedakuz Creek.

Aggregating those estimates by lake of origin gives a total of 27,393 for Tatelkuz Lake (i.e., Davidson Creek, Creek 661, lower Chedakuz Creek, half of the estimate for Middle Chedakuz Creek, and Creeks 522107 and 601947), and 8,973 for Kuyakuz Lake (i.e., upper Chedakuz Creek and one-half of the estimate for middle Chedakuz Creek). These totals assume that all kokanee observed in inlets or outlets of a lake emigrated from that lake.

5.10.2.7 Survey of Streams Crossed by Transmission Line and Access Road Corridors

From September to October 2012, inventories of fish and fish habitat were conducted at 247 sites in drainages in the Mt. Davidson/Nechako Plateau region using both desktop reviews and field surveys. Each of the 247 drainages contained sites identified as potential stream crossing locations for the proposed transmission line or access road. **Annex 5.10-5** shows the detailed report of that study (Avison, 2013). This section summarizes the main results of the study.

At sites with temporal overlap in sampling, the majority of the stream classifications verified by the 2012 field study were similar to the classifications reported in the FISS from inventories carried out from 2002 to 2006. However, there were some differences that can be explained in part by the increase in forest harvest activity in the area over the last 10

years. This activity has likely led to altered hydrology and changes in stream discharge. Additionally, the rapid regeneration of streamside deciduous trees in logged areas often leads to increased beaver activity that can also alter stream flows and channel morphology.

Most of the drainages that were classified as streams in 2012 were known as fish-bearing or defaulted to fish-bearing status from historical inventories and were observed to contain good overall habitat.

Rainbow trout was the most common species observed or captured during field sampling along the proposed transmission line and access road corridors. Other species identified during sampling included brassy minnow, lake chub, and white sucker. No anadromous fish were captured, although there are records of Chinook salmon (*Oncorhynchus tshawytscha*) and sockeye salmon in the Nechako River and Stellako River, as well as in the lower reaches of Greer Creek and Swanson Creek.

The nearest species at risk to the proposed transmission line and access road corridors is the white sturgeon (*Acipenser transmontanus*), which is located in the middle reaches of the Nechako River, approximately 4.5 km from the nearest stream crossing.

Riparian vegetation at stream crossings was variable and largely dependent on soil moisture and surrounding forestry activity. Wetlands and recently burned or harvested areas were dominated by shrubs and mature forests contained mainly tree cover. Riparian tree species common to most sites include hybrid white spruce, lodgepole pine, and true fir, and common shrubs include black twinberry, willow, and alder. The majority of mature pine was dead standing timber as a result of the recent mountain pine beetle infestation. Dead timber has contributed to notable blowdown across many stream channels, causing impediments to potential navigation and fish passage. The average amount of canopy that will be lost due to transmission-line related clearing activities (as estimated to a specified cut height) is 5.8%.

There were twelve existing road crossings with closed-bottom culverts that were determined to be barriers to fish passage during all or part of the year. Most culverts were undersized and unembedded, and should be replaced with a structure appropriate for the gradient and habitat quality if the road is upgraded in the future.

5.10.2.8 Fall Mountain Whitefish Survey

At intervals in October and November 2012, hoop nets were re-installed at four of the seven sites that had been used in June 2011 to sample migrating rainbow trout spawners (**Table 5.10-17**). This time, the target species was mountain whitefish during their fall spawning migration. Hoop net effort totalled 1,516 trap-hours, electrofishing effort totalled 4,956 seconds, and a total stream area of 487 m^2 was sampled by beach seining.

Table 5.10-17: Fish Catch, Effort, and CPUE, Fall Mountain Whitefish Survey, Chedakuz and Fawnie Creek Watersheds, October and November 2012

Stream	Site ID	Reach	Sample Date/Range	Gear Type	Effort[1]	Fish Species[2]	Fish Catch	CPUE[3]
Davidson Creek	HN-01	1	Oct 10-15	HN	117.5	NFC	0	0.00
			Oct 26 to Nov 1	HN	144.4	NFC	0	0.00
			14-Nov-12 - 20-Nov-12	HN	142.8	NFC	0	0.00
			13-Oct-12	BS	60	NFC	0	0.00
			13-Oct-12	BS	80	RB	15	18.75
					80	MW	4	5.00
			13-Oct-12	BS	40	RB	7	17.50
					40	MW	4	10.00
			14-Oct-12	BS	30	RB	2	6.67
			14-Oct-12	BS	80	RB	7	8.75
Turtle Creek	HN-05	1	10-Oct-12 - 15-Oct-12	HN	117.8	RB	66	13.45
			26-Oct-12 - 01-Nov-12	HN	145.3	RB	62	10.24
			14-Nov-12 - 20-Nov-12	HN	142.3	RB	25	4.22
			11-Oct-12	EF	851	RB	10	1.18
			12-Oct-12	EF	191	NFC	0	0.00
			12-Oct-12	EF	629	RB	13	2.07
			13-Oct-12	EF	1086	RB	34	3.13
			13-Oct-12	BS	75	RB	3	4.00
Creek 661	HN-03	1	10-Oct-12 - 15-Oct-12	HN	116.3	RB	5	1.03
			26-Oct-12 - 31-Oct-12	HN	121	NFC	0	0.00
			15-Nov-12 - 20-Nov-12	HN	118.8	NFC	0	0.00
			13-Oct-12	BS	12	RB	1	8.33
			13-Oct-12	BS	60	RB	2	3.33
			14-Oct-12	BS	30	NFC	0	0.00
			14-Oct-12	BS	20	RB	3	15.00
Creek 705	HN-08	1	11-Oct-12 - 15-Oct-12	HN	94.7	RB	1	0.25
			26-Oct-12 - 01-Nov-12	HN	136.4	MW	14	2.46
					136.4	RB	1	0.18
			15-Nov-12 - 20-Nov-12	HN	118.8	NFC	0	0.00
			12-Oct-12	EF	734	RB	48	6.54
			13-Oct-12	EF	489	RB	11	2.25
			14-Oct-12	EF	976	RB	50	5.12

Notes: [1] Electrofishing effort is measured in seconds; hoop netting effort is measured in trap-hours, and beach seine effort is measured in m^2 sampled
[2] MW – mountain whitefish; NFC – no fish captured; RB – rainbow trout
[3] CPUE for hoop netting is # fish/24 trap-hours; CPUE for electrofishing is # fish/100 EF seconds; CPUE for beach seining is #fish/m^2 sampled
BS = beach seine; CPUE = Catch-Per-Unit-Effort; EF = backpack electrofishing; HN = hoop netting; m = metre; m^2 = metres squared

Hoop nets were not installed for the duration of the mountain whitefish spawning migration. Backpack electrofishers and beach seines were used near the hoop nets sites. No fish were captured by hoop nets in lower Davidson Creek (**Table 5.10-17**). Five beach seine sets resulted in the capture of 31 rainbow trout and eight mountain whitefish.

No mountain whitefish were captured by any gear type in lower Turtle Creek (**Table 5.10-17**). A total of 153 rainbow trout were captured in hoop nets, 57 rainbow trout were captured in four electrofishing runs, and the beach seine captured an additional three rainbow trout.

Similarly, no mountain whitefish were captured by hoop nets in lower Creek 661 (**Table 5.10-17**), but five rainbow trout were captured, and an additional six rainbow trout were captured in three beach seine sets.

A total of 14 adult mountain whitefish were captured in lower Creek 705 by hoop netting over a two-day span in late October (**Table 5.10-17**). One rainbow trout was captured in each of the mid- and late October hoop net sets, but no fish were captured in the mid-November hoop net set. Three electrofishing runs captured 109 rainbow trout at this site in mid-October.

In summary, the survey showed that mountain whitefish were present in lower Davidson Creek and in Creek 705 in the fall of 2012, indicating the existence of one population that resides in Tatelkuz Lake and a second population in Top Lake and/or Laidman Lake in the Fawnie Creek Watershed. The survey also showed that numbers of mountain whitefish using streams in the LSA and RSA were very low compared to rainbow trout and kokanee.

5.10.3 Biological Characteristics

This section describes the biological characteristics of fish captured in the LSA and RSA in 2011 and 2012. The majority of biological information was collected on rainbow trout and kokanee – the two most common fish species captured or observed in both years.

5.10.3.1 Size, Age, and Growth

Rainbow trout

On average, the Creek 705 population of rainbow trout has the longest, heaviest, and oldest specimens, but with the lowest mean condition of any of the four main watersheds sampling in 2011 and 2012 (**Table 5.10-18**). The Davidson Creek Headwater population has the shortest mean length, but the highest mean condition. The Turtle Creek population has the lowest mean weight.

Table 5.10-18: Mean Length, Weight, Condition Factor, and Age of Rainbow Trout, Blackwater Study Area, 2011-2012

Population	Sampling Time		Fork Length (mm)				Weight (g)				Condition Factor				Age (year)			
	2011	2012	n	Mean	SE	Range	n	Mean	SE	Range	n	Mean	SE	Range	n	Mean	SE	Range
Davidson Creek	Jun, Aug	Aug, Oct	479	131	4	15 - 415	390	79	8	1 - 744	390	1.13	0.01	0.64 - 2.71	102	2	0.1	0 - 6
Davidson Headwaters	Aug	Aug, Sept	116	125	8	47 - 380	116	65	13	1 - 587	116	1.17	0.02	0.64 - 2.71	51	2	0.3	0 - 8
Turtle Creek	Jun, Aug	Aug - Nov	1,021	151	2	34 - 390	977	56	3	1 - 660	977	1.03	0.01	0.43 - 3.08	73	2	0.2	0 - 6
Creek 661	Jun, Aug	Aug, Oct	535	150	5	22 - 460	501	113	10	1 - 840	501	1.06	0.01	0.46 - 2.03	88	2	0.2	0 - 7
Creek 705	Jun	Oct	626	246	5	33 - 431	526	298	9	4 - 836	526	0.95	0.01	0.54 - 1.59	61	4	0.2	1 - 6
705 Headwaters North	Aug	Sept	115	153	10	28 - 380	102	104	14	1 - 295	102	1.11	0.02	0.45 - 1.94	27	4	0.3	1 - 7
705 Headwaters South	Aug	Sept	55	153	13	32 - 298	54	86	12	1 - 275	55	1.06	0.03	0.00 - 1.68	29	5	0.3	3 - 9

Notes: mm = millimetre; g = gram; n = sample size; SE = standard error.

Mean age of the three Chedakuz Creek tributary populations is 2 years (**Table 5.10-18**). By comparison, mean age of the three Creek 705 populations is 4 to 5 years. Age ranges between 0 and 8 years for most populations, with the exception of the 705 Headwaters South population that has an age range of 3 to 9 years.

With the exception of growth, the differences in mean biological characteristics are largely the result of differences in the seasonal distribution of sampling effort and gear type.

Plots of ln(weight) on ln(length) for individual fish in each population showed no obvious outliers (**Figure 5.10-13**). All of the linear regressions of ln(weight) on ln(length) were highly significant (P<0.001), and explained at least 98% of the variation in ln(weight). Regression slopes ranged from 2.8 to 3.0, which was close to the value of 3.0 assumed by the formula for condition, thereby validating the use of that index.

Length frequency plots showed that Davidson Creek and Davidson Headwaters populations were dominated by small (<150 mm) fish (**Figure 5.10-14**). The Turtle Creek population and Creek 661 population were also dominated by these small fish, but the distributions were skewed to slightly larger fish than the two Davidson Creek Watershed populations. In contrast, the length frequency plots for Creek 705 and the two Creek 705 headwater populations showed higher proportions of fish longer than 200 mm. This contrast was largely due to the greater amount of summer electrofishing effort, and hence the greater capture of juvenile trout, that was exerted in Davidson Creek, Turtle Creek, and Creek 661 than in Creek 705. Additionally, most of the sampling effort in Creek 705 was hoop net sampling of spring spawners rather than electrofishing of summer rearing juveniles. These two factors were largely, but not completely, responsible for the differences in mean size among populations.

Comparison of mean lengths and ages, of age frequency distributions (**Figure 5.10-15**), and of length-age plots (**Figure 5.10-16**) show that rainbow trout from the three headwater populations (i.e., Davidson Creek Headwater, Creek 705 Headwaters North, and Creek 705 Headwaters South) are smaller than rainbow trout of the other four stream populations (i.e., Davidson Creek, Turtle Creek, Creek 661, and Creek 705), and that the reason is slower growth rather than differences in sampling timing and effort. The Davidson Creek, Creek 661, and Turtle Creek populations have similar mean lengths and mean ages, indicating similar growth rates. The two headwater populations in Creek 705 have slightly greater mean lengths than those three populations, but their mean ages are twice as great, suggesting slower growth.

Plots of mean length on age show clearly that growth is slower in the three headwater populations than in the other four populations that are derived from migrants from Tatelkuz Lake. L_{∞} ranges from 261 to 436 mm for the three headwater lakes and from 575 to 1,148 mm for the other four populations. The most likely reasons are resource limitation, lower water temperatures, and, perhaps, lower nutrient concentrations in headwater lakes compared to Tatelkuz Lake and lakes in the Fawnie Creek Watershed.

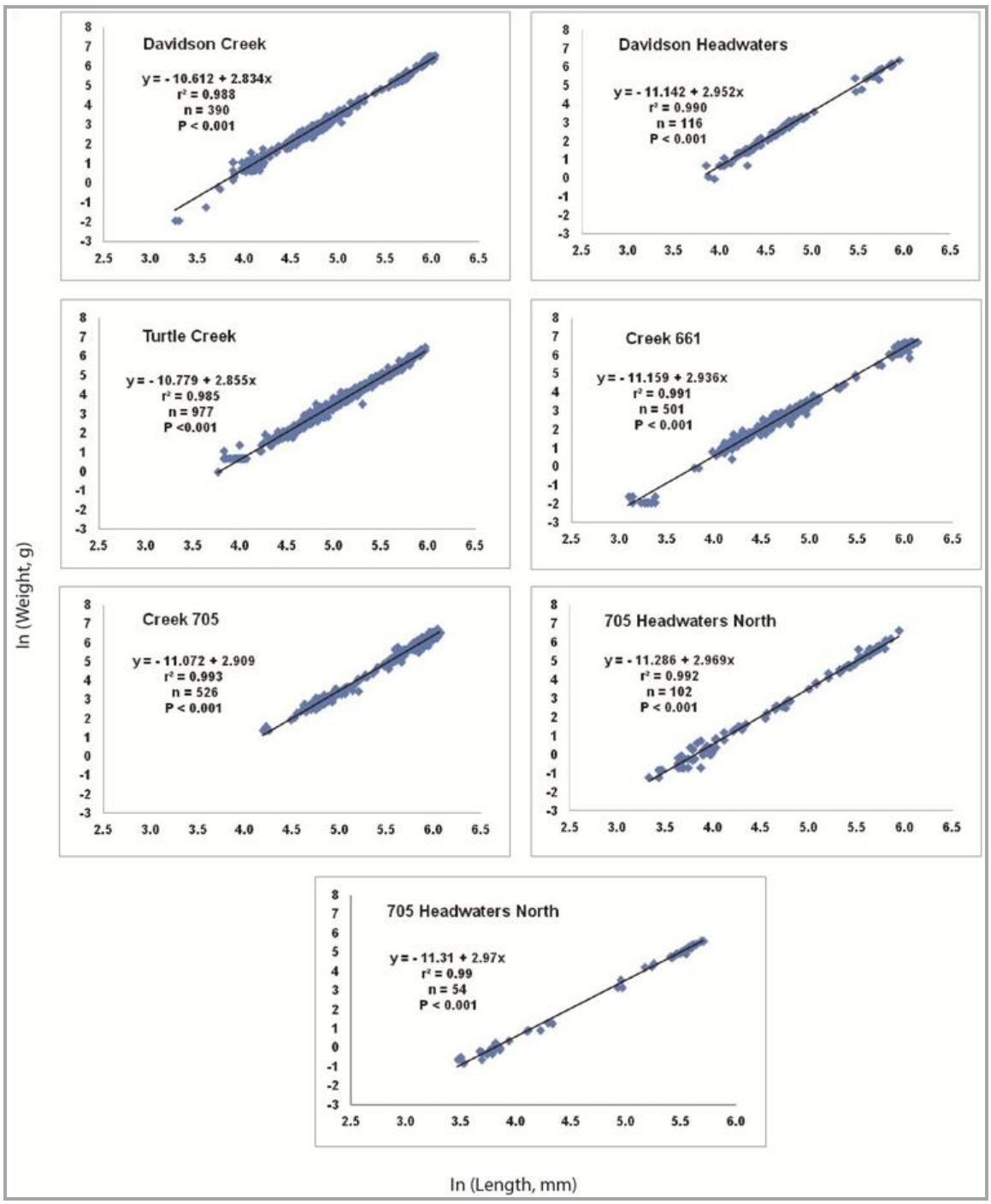


Figure 5.10-13: Linear Regressions of Weight on Length for Rainbow Trout, LSA and RSA Areas, 2011-2012

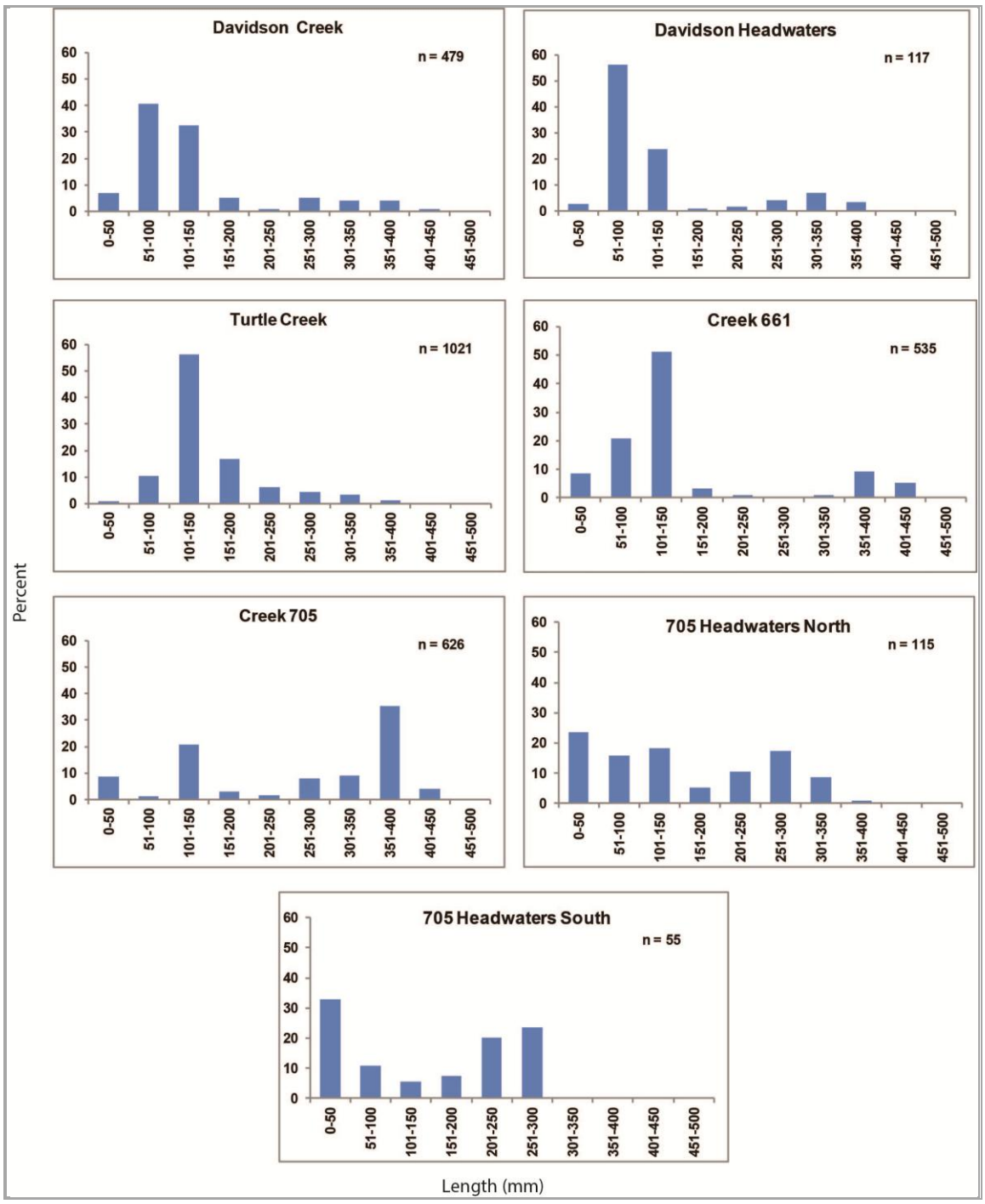


Figure 5.10-14: Length Frequency Distributions for Rainbow Trout, LSA and RSA, 2011-2012

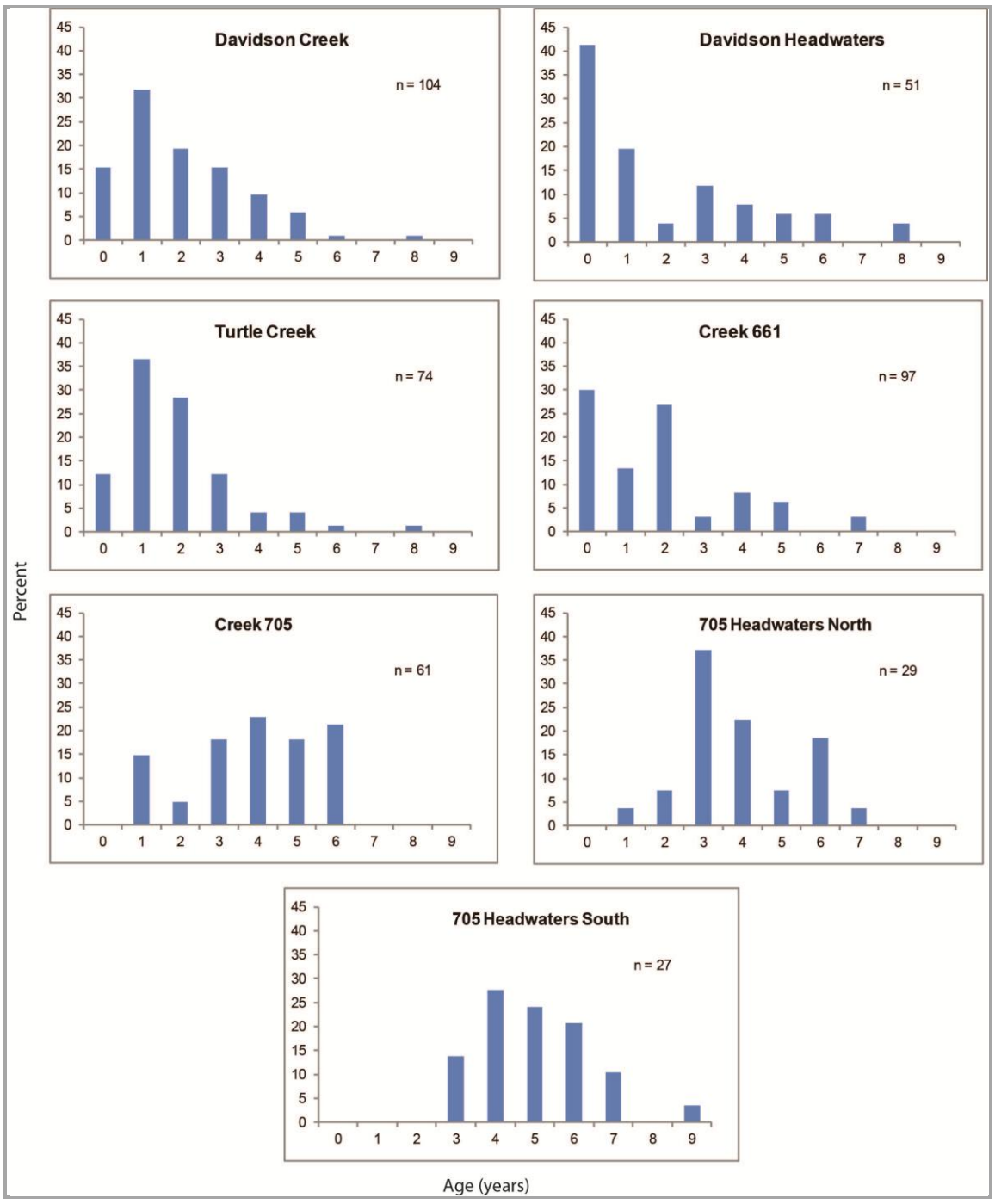


Figure 5.10-15: Age Frequency Distributions for Rainbow Trout, LSA and RSA, 2011-2012

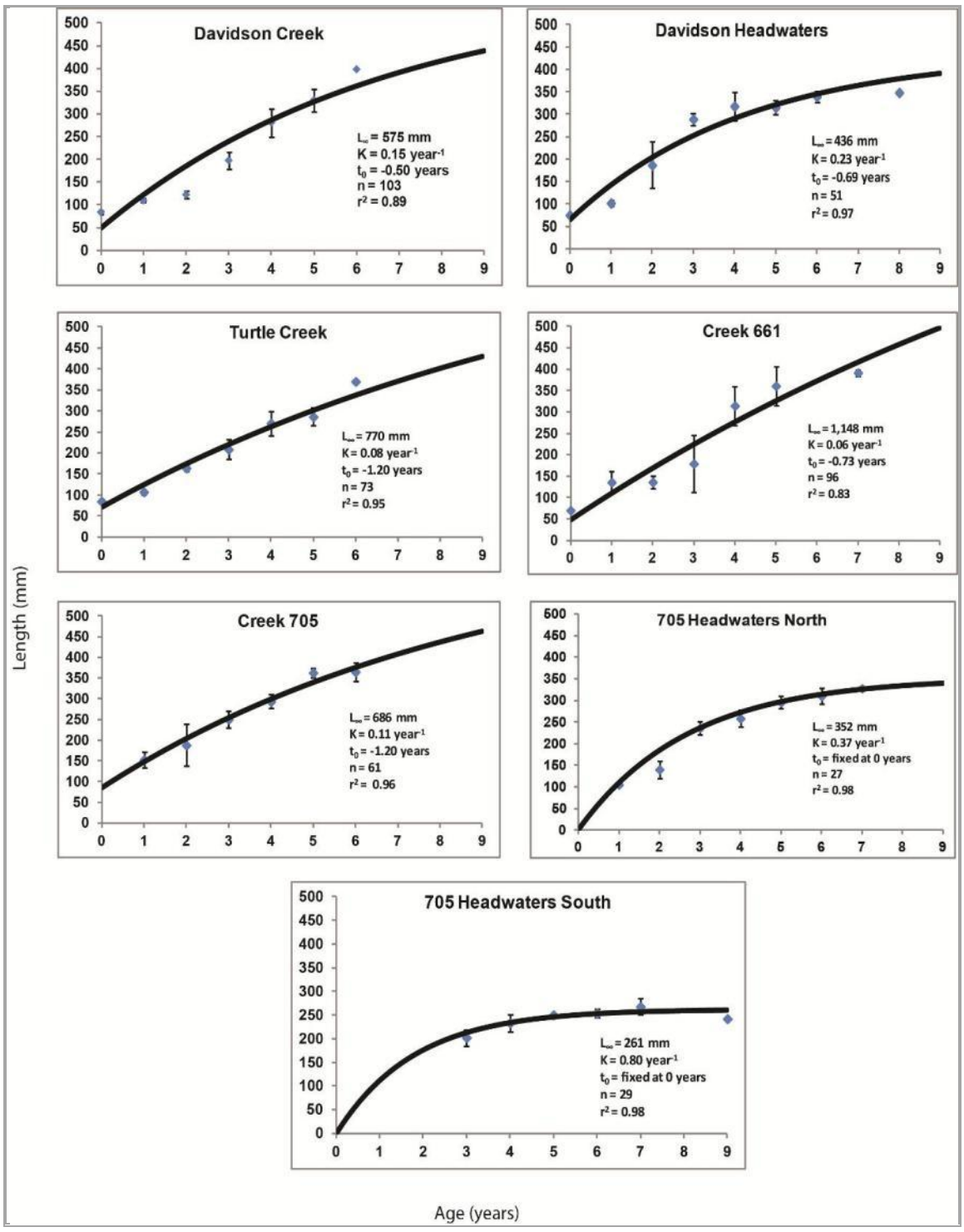


Figure 5.10-16: Length-Age Plots for Rainbow Trout, LSA and RSA, 2011-2012

Despite lower growth rates, mean condition is the same or higher in headwater lakes than in the other four populations, indicating that rainbow trout in the headwater lakes are as healthy as fish in the other populations. It also supports the idea that growth differences reflect temperature differences, not differences in food quantity.

Kokanee

Analysis of kokanee populations was restricted to Tatelkuz Lake and its tributaries and to Kuyakuz Lake and its tributaries. Kokanee from the Tatelkuz group have lower mean length, weight, and condition than kokanee from the Kuyakuz group (**Table 5.10-19**). Weight-length regressions for each group showed that ln(length) explained between 79% and 82% of the variance in ln(weight), and that slopes were close to the expected value of 3.0 (**Figure 5.10-17**).

Other Species

Rainbow trout and kokanee accounted for 93% of the fish captured in the LSA and RSA and the proposed transmission line and access road corridors. The other 7% of species included burbot, lake chub, longnose dace, longnose sucker, brassy minnow, mountain whitefish, and white sucker. Burbot were the largest fish, and longnose dace were the smallest (**Table 5.10-20**). Burbot had the lowest condition of all other fish species, including kokanee and rainbow trout, and lake chub had the highest condition. These differences are partly due to differences in body shape. Burbot are slender and eel-like, and lake chub are typically short and chubby. However, mean condition of burbot was low, indicating that these fish may have been in poor condition when captured. Body size data were not collected for the brassy minnows and white sucker that were captured.

Table 5.10-19: Mean Length, Weight, and Condition Factor of Kokanee, Blackwater Study Area, 2012

Population	Sampling Time	Fork Length (mm)				Weight (g)				Condition Factor			
	2012	n	Mean	SE	Range	n	Mean	SE	Range	n	Mean	SE	Range
Tatelkuz Tributaries	Aug, Sept	163	209	1	173 - 263	163	97	2	50 - 197	163	1.05	0.01	0.75 - 1.43
Kuyakuz Tributaries	Sept	30	283	3	236 - 332	30	280	11	157 - 442	30	1.22	0.02	0.97 - 1.45

Notes: mm = millimetre; g = gram; n = sample size; SE = standard error.

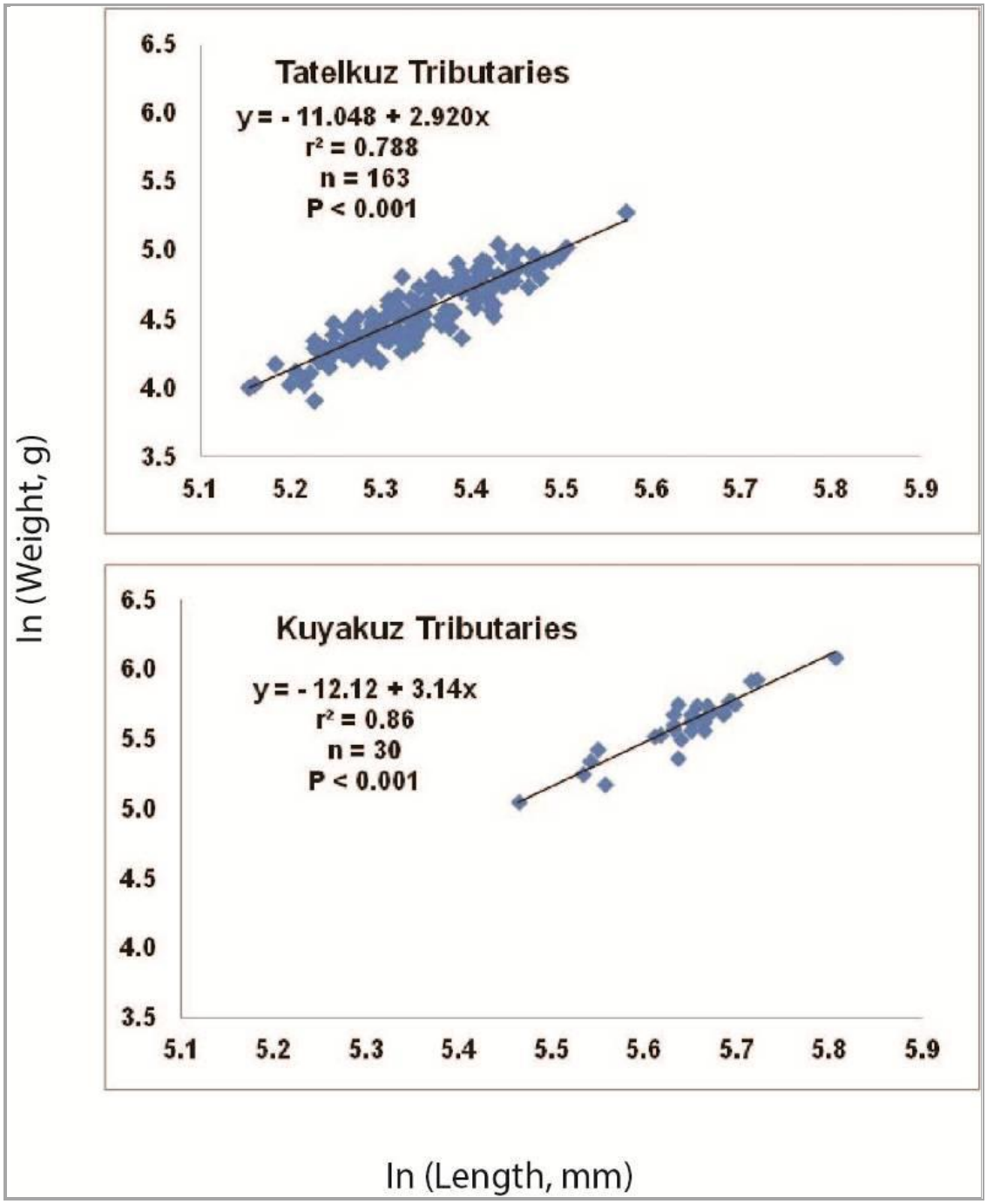


Figure 5.10-17: Linear Regressions of Weight on Length for Kokanee, LSA and RSA, 2012

Table 5.10-20: Mean Fork Length, Weight, and Condition Factor, of Other Fish Species, Blackwater Study Area, 2011-2012

Species	Sampling Time		Fork Length (mm)				Weight (g)				Condition Factor			
	2011	2012	n	mean	SE	Range	n	mean	SE	Range	n	mean	SE	Range
Burbot	Jun	–	4	184	15	156 - 225	4	37	8	21 - 58	4	0.59	0.09	0.39 - 0.82
Lake chub	–	Oct	91	102	1	48 - 118	61	16	1	1 – 25	61	1.44	0.03	0.87 - 2.12
Longnose dace	–	Aug	1	68	–	–	1	4	–	–	1	1.18	–	–
Longnose sucker	Aug	Sep	56	92	8	50 - 330	45	10	3	2 - 158	45	1.14	0.04	0.63 - 2.20
Mountain whitefish	Jun	Aug, Oct	30	143	9	67 - 248	17	40	11	2.7 - 152	17	0.92	0.03	0.45 - 1.09

Notes: mm = millimetre; g = gram; n = sample size; SE = standard error; dash indicates no data.

5.10.3.2 Sex Ratios

Sex ratios for rainbow trout in the LSA ranged from a low of 0.2 for the 705 Headwaters North population to a maximum of 5.0 for the Davidson Headwaters population (**Table 5.10-21**). The mean sex ratio for all populations combined was 0.7. The wide variation in sex ratio among populations is most likely a function of small sample sizes and the large number of fish that could not be assigned a sex due to their immaturity. In general, the larger the sample size, the closer the ratio approached the value of 1.0 expected for a stable population.

Table 5.10-21: Sex Ratio of Rainbow Trout, Blackwater Study Area, 2011-2012

Population	No. Females	No. Males	No. Immature	Total	Sex Ratio
Davidson Creek	38	74	233	345	0.5
Davidson Headwaters	5	1	79	85	5.0
Turtle Creek	83	191	518	788	0.4
Creek 661	55	83	290	428	0.7
Creek 705	124	101	290	515	1.2
705 Headwaters North	2	10	39	51	0.2
705 Headwaters South	11	11	8	30	1.0
Total	318	471	1,457	2,246	0.7

Notes: No. = number of; sex ratio = number of females/number of males.

5.10.3.3 Sexual Maturation

The length at 50% maturity of rainbow trout ranged from 100 to 300 mm among populations in the LSA, with a pooled estimate over all populations of 150 mm (**Figure 5.10-18**). No fish were mature at lengths below 100 mm. Rainbow trout in the 705 Headwaters North and South populations both showed longer lengths at 50% maturity than the other five populations. This likely reflects slower growth in those headwater habitats. For all populations pooled, 95% of fish were mature at a length of 300 mm.

Both mature and immature rainbow trout were captured passing through the hoop nets in spring 2011 (**Table 5.10-22**). The participation of immatures in the spawning migration suggests some social interaction between the age classes.

With the exception of upper Davidson Creek and Creek 705, the percent of ripe rainbow trout was greater in fish passing upstream than those passing downstream, which would be expected if they spawned upstream of the hoop net. At five of eight hoop nets, the percent of spent fish was greater in fish passing downstream than in fish passing upstream. The exceptions were upper Davidson Creek, upper Turtle Creek, and upper Creek 661.

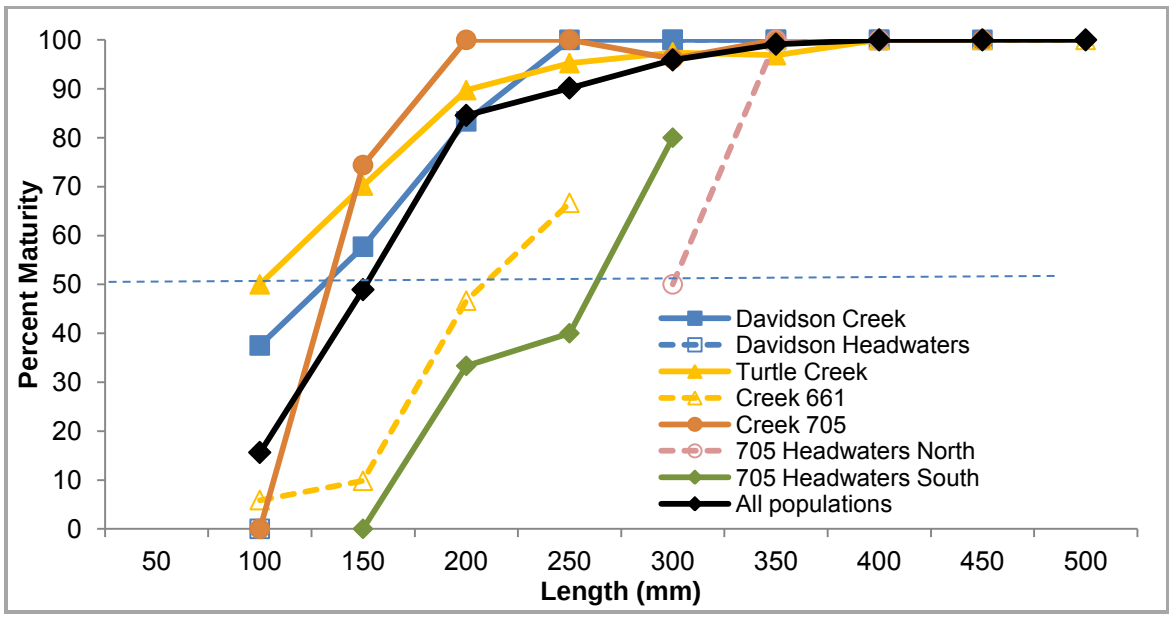


Figure 5.10-18: Plot of Percent Maturity on Length of Rainbow Trout, Blackwater Study Area, 2011 and 2012

Mean GSI (the ratio of gonad weight to body weight) of female rainbow trout increased from immature to ripe stages, as expected. A similar trend was not observed for males (**Table 5.10-23**) (there were insufficient numbers to show separate means for each population). Mean GSI for male immatures was higher than that for male matures, likely due to variability introduced by small sample sizes. The two mean GSI are not significantly different from each other. Male rainbow trout had a greater mean GSI than females, which was not expected and can only be due to sampling variability caused by low sample sizes.

Table 5.10-22: Sexual Maturity of Rainbow Trout Captured by Hoop Nets in the Chedakuz and Fawnie Creek Watersheds, June 2011

Watershed	Chedakuz Creek														Fawnie Creek	
Stream	Lower Davidson Creek		Upper Davidson Creek		Lower Creek 661		Upper Creek 661		Lower Turtle Creek		Upper Turtle Creek		Creek 700		Creek 705	
Baseline Site Map ID	HN-01		HN-02		HN-03		HN-04		HN-05		HN-06		HN-07		(HN-08)	
Direction of Migration	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Number of Fish	38	65	2	72	17	307	43	14	104	476	71	51	35	17	106	406
% Immature	8	20	50	32	82	70	2	43	16	15	8	8	0	6	5	5
% Mature	8	9	0	21	0	3	9	0	12	18	30	35	29	12	23	12
% Ripe	71	11	0	21	12	5	86	21	36	14	34	29	37	47	46	11
% Spent	11	58	50	18	0	14	0	21	13	17	11	10	9	6	17	61
% Unknown	3	2	0	8	6	8	2	14	23	35	17	18	26	29	9	12

Note: HN = hoop netting; D/S = downstream; ID = identification; % = percent; U/S = upstream

Table 5.10-23: Mean Gonadosomatic Index for Rainbow Trout, Blackwater Study area, 2011-2012

Sex	Maturity	n	mean	SE	Range
Female	Immature	1	0.9	–	–
	Mature	2	1.2	0.4	0.8 - 1.6
	Ripe	1	1.4	–	–
	Spent	–	–	–	–
	unknown	8	1.0	0.1	0.6 - 1.5
Male	Immature	2	4.7	2.1	2.6 - 6.8
	Mature	8	2.8	0.6	0.4 - 6.1
	Ripe	–	–	–	–
	Spent	–	–	–	–
	unknown	7	2.0	0.4	0.3 - 4.2

Notes: n = sample size; SE = standard error; dash indicates no data.

5.10.3.4 Energy Storage and Use

The liver serves as a major storage site for glycogen, hence HSI (hepatosomatic index: the ratio of liver weight to body weight) indicates the nutritional state and energy reserve of fish. Mean HSI of rainbow trout ranged from 0.87 to 1.51 with a pooled mean of 1.11 (**Table 5.10-24**). Rainbow trout in two headwater populations (705 Headwaters North and 705 Headwaters South) had lower mean HSI values than those found in the stream populations, suggesting lower energy storage in lakes than in streams. This is supported by lower length-at-age in headwater lakes than in mainstem populations (**Figure 5.10-16**), likely due to differences in diet between headwater lake populations which primarily consume plankton and stream populations which primarily consume BMI.

Table 5.10-24: Mean Hepatosomatic Index (HSI) for Rainbow Trout, Blackwater Study Area, 2011-2012

Population	n	Mean	SE	Range
Davidson Creek	13	1.51	0.11	1.08 - 2.23
Davidson Headwaters	–	–	–	–
Turtle Creek	17	1.18	0.06	0.77 - 1.69
Creek 661	9	1.40	0.16	0.71 - 2.15
Creek 705	–	–	–	–
705 Headwaters North	14	0.95	0.07	0.48 - 1.48
705 Headwaters South	28	0.87	0.06	0.15 - 1.40
Total	**81**	**1.11**	**0.04**	**0.15 - 2.23**

Notes: n = sample size; SE = standard error; dash indicates no data.

There was no significant (P>0.05) correlation of HSI with condition factor. There was a significant negative correlation (P = 0.001) with length, but it only explained 18% of the variation in HSI.

5.10.3.5 Diet

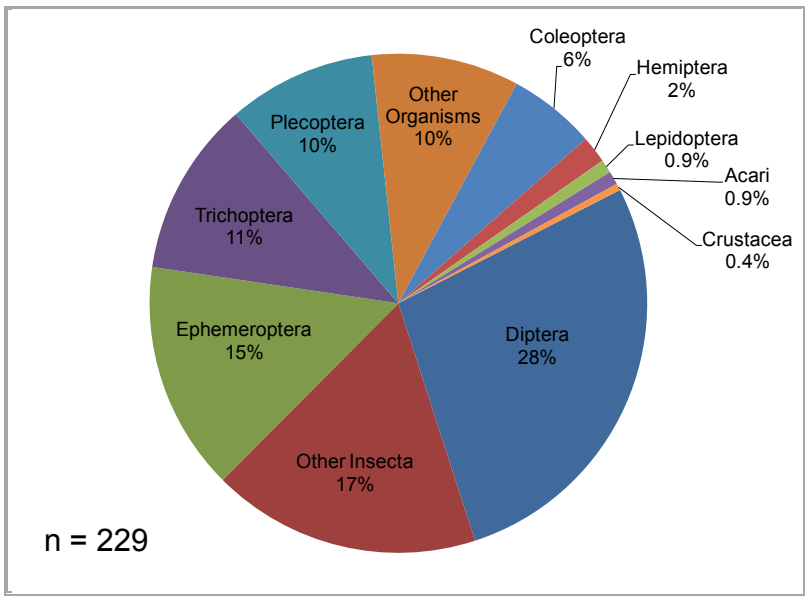
Davidson Creek

Between two and 98 prey items were identified in individual stomachs of the seven trout sampled from the Davidson Creek population in 2011 (**Table 5.10-25**). Dipterans (true flies) were the most abundant prey item consumed, comprising 27.5% of all items identified, followed by Insecta (ants, bees, and wasps; 17.5%), Ephemeroptera (mayflies; 14.8%), and Trichoptera (caddisflies; 11.4%) (**Figure 5.10-19**). The most commonly consumed prey items were caddisflies, which occurred in six of seven stomachs, followed by mayflies, stoneflies (Plecoptera), beetles (Coleoptera), and insects, which occurred in five of seven stomachs each.

Table 5.10-25: Stomach Contents of Rainbow Trout from Davidson Creek, 2011

Common Name	Taxonomy	Sample Number (Fish Length)							Total Abundance	Relative Abundance (%)	Frequency of Occurrence
		1-025 (158 mm)	1-026 (150 mm)	1-162 (149 mm)	1-165 (130 mm)	3-092 (132 mm)	3-093 (121 mm)	3-094 (116 mm)			
Mayfly	Ephemeroptera	16	6	1	0	0	4	7	34	14.8	5/7
Stonefly	Plecoptera	5	8	0	1	2	6	0	22	9.6	5/7
Caddis fly	Trichoptera	4	4	2	0	4	6	6	26	11.4	6/7
True bug	Hemiptera	0	2	0	0	0	0	2	4	1.7	2/7
Beetle	Coleoptera	2	8	0	0	1	1	1	13	5.7	5/7
True fly	Diptera	3	36	0	0	0	0	24	63	27.5	3/7
Moth, butterfly	Lepidoptera	0	0	1	0	1	0	0	2	0.9	2/7
Insect	Insecta	3	23	0	1	0	2	11	40	17.5	5/7
Mite, tick	Acari	0	0	0	0	0	0	2	2	0.9	1/7
Crustacean	Crustacea	1	0	0	0	0	0	0	1	0.4	1/7
Other organisms		1	11	8	0	0	1	1	22	9.6	5/7
Total Number of Prey Items		**35**	**98**	**12**	**2**	**8**	**20**	**54**	**229**	-	-

Notes: mm = millimetre; % = percent; dash indicates no data.



Notes: n = number of samples; % = percent

Figure 5.10-19: Relative Abundance of Prey Items of Rainbow Trout, Davidson Creek, August 2011

Turtle Creek

Of the seven stomachs of the rainbow trout sampled in the Turtle Creek population in 2012, only five contained contents and two were empty. In the five stomachs with contents, each had between one and 10 identifiable prey items (**Table 5.10-26**). The most abundant prey were terrestrial insects (31.6%), followed by Trichoptera (21.1%) (**Figure 5.10-20**). The most commonly consumed prey item were Trichoptera, which were found in three of seven fish stomachs sampled.

Table 5.10-26: Stomach Contents of Rainbow Trout from Turtle Creek, August 2012

Common Name	Taxonomy	Sample Number (Fish Length)							Total Abundance	Relative Abundance (%)	Frequency of Occurrence
		7-001 (204 mm)	7-002 (180 mm)	7-003 (190 mm)	7-004 (228 mm)	7-005 (262 mm)	7-006 (298 mm)	7-008 (308 mm)			
Terrestrial		0	0	1	5	0	0	0	6	31.6%	2/7
Mayfly	Emphemeroptera	0	0	1	0	0	0	0	1	5.3%	1/7
Stonefly	Plecoptera	0	1	0	0	0	0	1	2	10.5%	2/7
Caddisfly	Trichoptera	0	1	0	1	2	0	0	4	21.1%	3/7
Beetle	Coleoptera	0	0	0	2	0	0	0	2	10.5%	1/7
True Fly	Diptera	0	0	1	0	0	0	0	1	5.3%	1/7
Snail	Gastropoda	0	0	1	0	0	0	0	1	5.3%	1/7
Worm	Nemata	0	0	0	2	0	0	0	2	10.5%	2/7
Total Number of Prey Items		**0**	**2**	**4**	**10**	**2**	**0**	**1**	**19**	–	–

Notes: mm = millimetre; % = percent; dash indicates no data

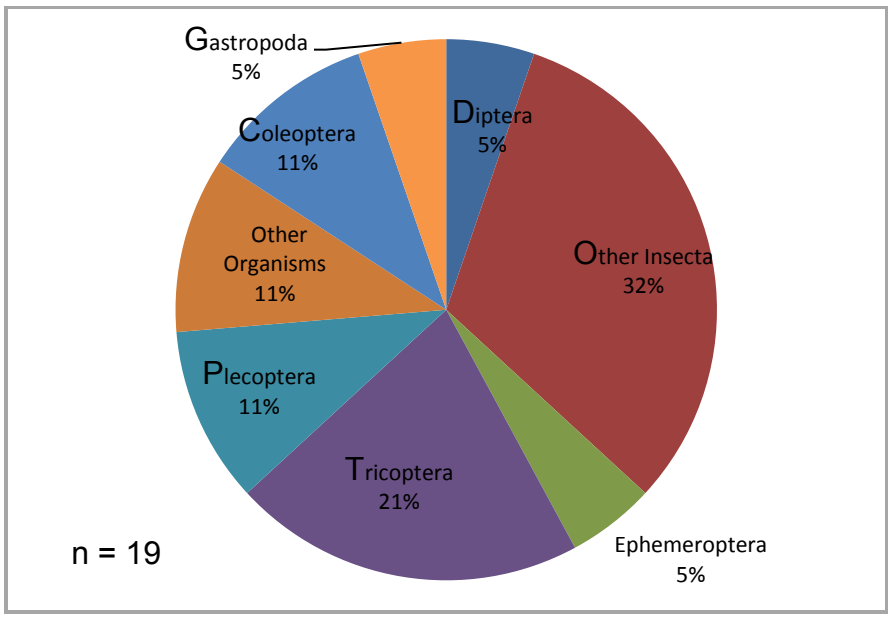


Figure 5.10-20: Relative Abundance of Prey Items from Rainbow Trout, Turtle Creek, August 2012

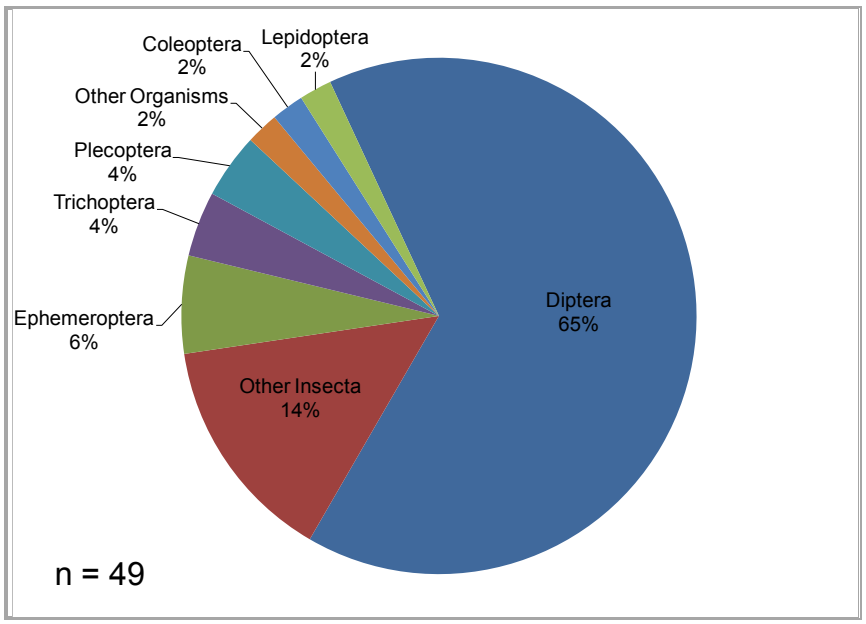
Creek 661

Stomach contents of four fish sampled from Creek 661 in 2011 had between one and 24 prey items (**Table 5.10-27**). Dipterans comprised the majority of identifiable prey items (65.3%), followed by Insecta (14.3%), and Ephemeroptera (6.1%) (**Figure 5.10-21**). The most commonly consumed prey items were Diptera and Insecta, which were found in three of the four stomachs sampled.

Table 5.10-27: Stomach Contents of Rainbow Trout from Creek 661, August 2011

Common Name	Taxonomy	Sample Number (Fish Length)				Total Abundance	Relative Abundance (%)	Frequency of Occurrence
		3-009 (85 mm)	3-010 (78 mm)	3-012 (87 mm)	3-017 (92 mm)			
Mayfly	Ephemeroptera	0	3	0	0	3	6.1	1/4
Stonefly	Plecoptera	1	1	0	0	2	4.1	2/4
Caddisfly	Trichoptera	2	0	0	0	2	4.1	1/4
Beetle	Coleoptera	0	0	0	1	1	2.0	1/4
True Fly	Diptera	7	18	0	7	32	65.3	3/4
Moth, Butterfly	Lepidoptera	0	1	0	0	1	2.0	1/4
Insect	Insecta	0	1	1	5	7	14.3	3/4
Other Organisms	-	1	0	0	0	1	2.0	1/4
Total Number of Prey Items		**11**	**24**	**1**	**13**	**49**	**-**	-

Notes: mm = millimetre; % = percent, dash indicates no data.



Notes: n = number of samples; % = percent

Figure 5.10-21: Relative Abundance of Prey Items from Rainbow Trout, Creek 661, August 2011

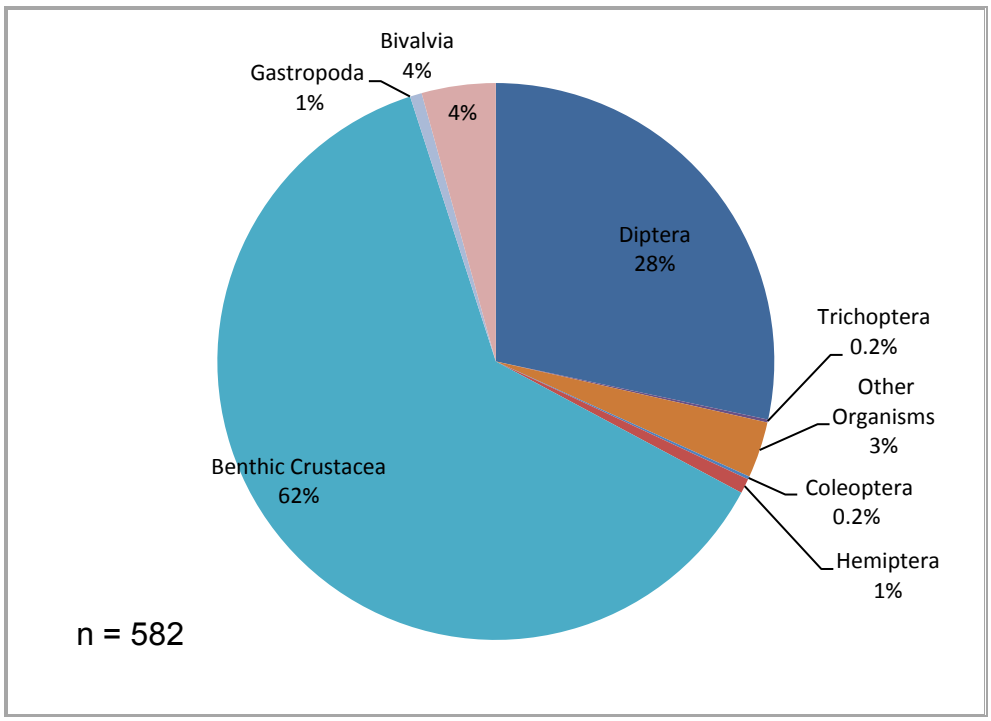
Lake 01428UEUT

Benthic crustaceans were the main prey item consumed by the 13 rainbow trout collected from Lake 01428UEUT in 2011 and 2012, comprising 62.2% of the total prey items identified (**Table 5.10-28** and **Figure 5.10-22**). The majority of the benthic crustacea consisted of Gammaridae (scuds), which live on the lake bottom, particularly in the littoral zone.

Table 5.10-28: Stomach Contents of Rainbow Trout from Lake 01428UEUT, 2011-2012

Common Name	Taxonomy	Sample Number (Fish Length)													Total Abundance	Relative Abundance (%)	Frequency of Occurrence
		2-011 (300 mm)	2-013 (310 mm)	2-017 (280 mm)	2-018 (310 mm)	2-024 (280 mm)	9-017 (290 mm)	9-018 (256 mm)	9-019 (268 mm)	9-020 (274 mm)	9-021 (271 mm)	9-022 (222 mm)	9-023 (296 mm)	9-024 (300 mm)			
Terrestrial		0	0	0	0	0	0	0	0	0	10	7	1	1	19	3.3%	4/13
Caddisfly	Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.2%	1/13
Beetle	Coleoptera	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.2%	1/13
True Fly	Diptera	6	2	47	1	8	1	0	0	100	0	0	0	0	165	28.4%	7/13
True Bug	Hemiptera	0	0	0	0	0	0	0	2	2	0	1	0	0	5	0.9%	3/13
Freshwater Mollusc	Bivalvia	7	9	0	4	0	2	0	0	0	0	0	3	0	25	4.3%	5/13
Snail	Gastropoda	0	0	0	1	0	0	0	0	0	2	0	1	0	4	0.7%	3/13
Scud	Benthic Crustacea	50	219	7	59	0	27	0	0	0	0	0	0	0	362	62.2%	5/13
Total Number of Prey Items		**63**	**230**	**54**	**65**	**8**	**30**	**0**	**2**	**102**	**13**	**8**	**5**	**2**	**582**	–	–

Notes: mm = millimetre; % = percent; dash indicates no data.



Notes: n = number of samples; % = percent

Figure 5.10-22: Relative Abundance of Prey Items in Rainbow Trout Stomachs from Lake 01428UEUT, 2011-2012

As Lake 01428UEUT consists mainly of littoral habitat (97%), abundance of prey items is consistent with available habitat. The most common consumed prey item was Diptera (true flies), which was found in seven out of the thirteen stomachs sampled. The next most common consumed prey items were bivalves and crustaceans, which were both found in five out of the thirteen stomachs sampled.

Generally, there were two size classes of rainbow trout sampled for stomach contents; each with distinctive prey items. Fish longer than 300 mm consumed more scud prey items than the fish shorter than 300 mm.

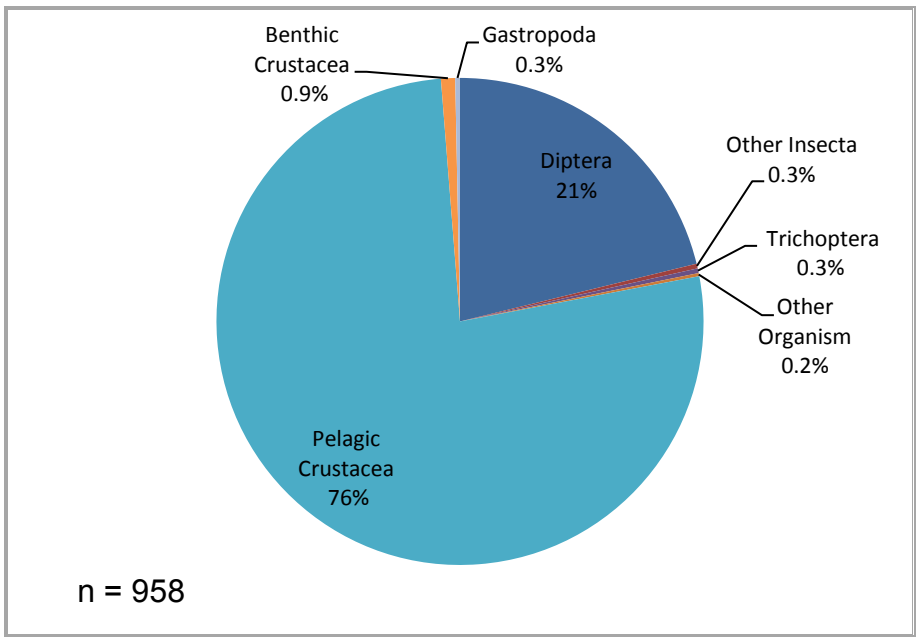
Lake 01538UEUT

The 19 rainbow trout sampled from Lake 01538UEUT in 2011 and 2012 were consuming mainly small, pelagic crustaceans (76.7%) (**Table 5.10-29** and **Figure 5.10-23**). They were also the main prey items in 8 of the 19 stomachs sampled. The majority of the crustaceans (734 out of 735) consisted of daphnids. Five stomachs were dominated by dipterans, and three stomachs contained no identifiable prey items.

Table 5.10-29: Stomach Contents of Rainbow Trout from Lake 01538UEUT, 2011-2012

Common Name	Taxonomy	Sample Number (Fish Length)																			Total Abundance	Relative Abundance (%)	Frequency of Occurrence
		V705LK-002 (267 mm)	V705LK-003 (250 mm)	V705LK-006a (250 mm)	V705LK-010 (262 mm)	V705LK-012 (245 mm)	V705LK-013 (242 mm)	V705LK-015 (255 mm)	V705LK-016 (265 mm)	9-038 (255 mm)	9-039 (189 mm)	9-040 (141 mm)	9-041 (190 mm)	9-042 (230 mm)	9-043 (249 mm)	9-044 (233 mm)	9-045 (260 mm)	9-046 (281 mm)	9-047 (254 mm)	9-048 (298 mm)			
Caddisfly	Trichoptera	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	3	0.3%	2/19
Midge	Diptera	0	0	0	0	4	2	16	5	1	0	1	17	0	5	118	0	19	0	15	203	21.2%	11/19
Insect	Insecta	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	3	0.3%	3/19
Water Flea	Pelagic Crustacea	281	85	0	48	197	45	0	38	20	0	0	0	0	21	0	0	0	0	0	735	76.7%	8/19
Scud/ Seed Shrimp	Benthic Crustacea	1	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	0	1	0	9	0.9%	4/19
Snail	Gastropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0.3%	1/19
Other Organisms		0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0.2%	1/19
Total Number of Prey Items		**282**	**85**	**0**	**48**	**202**	**47**	**19**	**46**	**21**	**0**	**7**	**17**	**0**	**26**	**118**	**5**	**19**	**1**	**15**	**958**	–	–

Notes: mm = millimetre; % = percent; dash indicates no data.



Notes: n = number of samples; % = percent

Figure 5.10-23: Relative Abundance of Prey Items in Rainbow Trout Stomachs from Lake 01538UEUT, 2011-2012

In summary, dipterans dominated the diet of small trout in Creek 661 (<100 mm long) and Davidson Creek (<120 mm), and terrestrial insects were found only in the diet of larger fish from Turtle Creek (>180 mm), indicating that prey selection in stream-dwelling rainbow trout changes with body size. Davidson Creek trout had more prey items and more taxonomic diversity than did the Creek 661 trout. This conclusion is based on low sample size – only four stomachs were sampled from Creek 661.

For the lake populations, there appears to be a clear relationship between rainbow trout diet and habitat availability. Daphnids were the most abundant prey item for trout from Lake 01538UEUT, and daphnids are pelagic zooplankton that migrate vertically in the water column (Green 1997). In contrast, benthic gammarids were the dominant prey item for trout from Lake 01428UEUT. The surface area of Lake 01538UEUT is 52% littoral and 48% pelagic, but the area of Lake 01428UEUT is 97% littoral and 3% pelagic. Feeding on zooplankton is common for rainbow trout when other forms of prey are not available.

These results support the idea that rainbow trout are opportunistic feeders, consuming the most common prey available from both benthic and pelagic habitat (Cada et al., 1987). These include aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, and other small fish (DFO, 2009). Their diet also shifts as they grow in size, and are better able to exploit multiple niches (Scott and Crossman 1973).

5.10.3.6 Tissue Metal Concentrations

Annex 5.10-8 shows the metals concentrations in rainbow trout tissue samples collected from the LSA and **Annex 5.10-9** shows the statistical summaries of metal concentrations by watershed and tissue type.

Size and Age of Fish

The rainbow trout from which tissue samples were taken were representative of the rainbow trout populations in the LSA in summer. They were collected from both streams and headwater lakes, and cover a wide range of lengths and ages (**Table 5.10-30**) (note that none of the large rainbow trout sampled during the June spawning migration were collected for tissue metals analysis). Approximately half of the fish collected were sexually mature, and the sex ratio was 0.65 females per male.

Table 5.10-30: Biological Data of Rainbow Trout Analyzed for Metal Concentrations, Blackwater LSA

Variable	Units	Mean	SE	n	minimum	maximum
Length	mm	197	9	102	67	380
Weight	g	139	14	101	3	587
Condition	g/mm^3	1.07	0.01	101	0.80	1.37
Age	year	3	0	90	0	9
Percent mature	%	42	-	102	-	-
Sex ratio (F/M)	-	0.65	-	43	-	-

Notes: SE = standard error; n = sample size; F = female; M = male.

Mean Tissue Metal Concentrations

Mean concentrations of a number of metals differed substantially among the three tissue types (**Table 5.10-31**). This was expected because of the different biological functions of liver and muscle tissue and the presence of cartilage and bone in whole-body samples. For example, mean zinc concentration in liver tissue was six times greater than in muscle tissue, and mean calcium concentration in whole-body tissue was 20 times higher than in muscle and 57 times higher than in liver. A PCA of these metals data (shown below) examined in more detail the differences in metal profiles among tissue types.

PCA of Blackwater Project Fish Tissue Metals Concentrations

A PCA of rainbow trout tissue metal concentrations was done to identify major trends in the data. To conduct the PCA, metals that contained little or no information were removed from the dataset. A threshold of 10% of values above detection limits was set, which meant that six metals were removed: rhenium (0%>MDL), beryllium (0.5%>MDL), lithium and tellurium (1.4%>MDL), bismuth (1.8%>MDL), and antimony (3.2%>MDL).

Methyl-mercury, lipids, and titanium were also removed from the data matrix, even though the majority of concentrations were above detection limits and there were too many missing values: 205 for methyl-mercury (or 94% of the 218 cells in the data matrix), 120 for lipids (or 55%), and 94 for titanium (or 43%). This follows from the general guideline that variables should not be included in a PCA if more than 10% of the values are missing. For all other metals, values below detection limits were replaced with one-half the detection limit. Percent moisture was removed because all metal concentrations were already expressed as mg/kg wet weight.

Lengths and weights of rainbow trout were added to the data matrix because some metals such as mercury bind permanently to protein and increase in concentration as fish grow in size. Length and weight for each composite liver sample were the mean length and weight for the fish from which the livers were taken. Age was not included as a variable because there were too many empty cells in the data matrix (>35%). One record for a whole-body sample was removed because there were no recorded length, weight, and sampling site for that sample. This left a data matrix with 35 variables and 217 records or 7,595 cells. All values of the 35 variables were then transformed with natural logarithms to normalize their variance.

The first three principle components extracted by PCA explained 66% of the total variance of the data matrix (**Table 5.10-32**). Each subsequent component explained less than 5% of the remaining variance. A scree plot showed that the first three components were the only meaningful components. Hence, PCA reduced a data matrix of 7,595 cells to one of 651 cells (i.e., 217 records for each of three components) – an eightfold reduction.

The first component, PC1, explained 36.2% of the total variance and was significantly ($P<0.01$) positively correlated with 22 metals including many heavy metals such as zinc, vanadium, manganese, iron, cobalt, uranium, molybdenum, cadmium, copper, arsenic and lead (**Table 5.10-32**). PC1 was not significantly ($P<0.01$) negatively correlated with any metal, nor was it significantly correlated with fish length or weight or with calcium and potassium – both key structural metals. Structural metals are found in high concentrations in biological structures such as bone and cartilage. This component was interpreted as representing the magnitude of heavy metal concentrations.

Table 5.10-31: Mean Metal Concentrations in Rainbow Trout Tissues, Blackwater LSA, 2011-2012

Variable	Whole-body						Muscle						Liver					
	n	n>MDL	mean	SE	min	max	n	n>MDL	mean	SE	min	max	n	N>MDL	mean	SE	min	max
Percent moisture	76	76	72.4	0.3	65.5	80.6	83	83	76.5	0.3	72.1	95.7	59	59	69.6	0.8	51.1	78.3
Aluminum (Al)	76	76	7.25	0.97	0.41	37.40	83	13	0.40	0.07	<0.40	3.83	59	55	2.10	0.21	0.20	9.74
Antimony (Sb)	76	2	0.0011	0.0000	<0.0020	0.0039	83	0	0.0010	0.0000	<0.0020	<0.0020	59	5	0.0012	0.0001	<0.0020	0.0063
Arsenic (As)	76	76	0.0572	0.0043	0.0157	0.2470	83	83	0.0341	0.0040	0.0062	0.2690	59	59	0.0466	0.0032	0.0154	0.1420
Barium (Ba)	76	76	0.717	0.065	0.206	3.020	83	68	0.031	0.004	<0.010	0.256	59	57	0.047	0.007	0.005	0.405
Beryllium (Be)	76	1	0.0010	0.0000	<0.0020	0.0023	83	0	0.0010	0.0000	<0.0020	<0.0020	59	0	0.0011	0.0000	<0.0020	<0.0040
Bismuth (Bi)	76	0	0.0010	0.0000	<0.0020	<0.0020	83	3	0.0010	0.0000	<0.0020	0.0023	59	1	0.0011	0.0000	<0.0020	0.0021
Boron (B)	76	8	0.15	0.02	<0.20	1.43	83	4	0.12	0.01	<0.20	0.78	59	13	0.32	0.08	<0.20	2.77
Cadmium (Cd)	76	64	0.0108	0.0015	<0.0020	0.0940	83	22	0.0025	0.0004	<0.0020	0.0192	59	59	0.0808	0.0096	0.0050	0.4140
Calcium (Ca)	76	76	7,259	358	2340	15800	83	83	363	44	57	2680	59	59	128	13	42	562
Cesium (Cs)	76	76	0.1054	0.0220	0.0020	0.9210	83	82	0.1431	0.0282	0.0005	1.4000	59	58	0.1359	0.0292	<0.0005	1.0700
Chromium (Cr)	76	74	0.061	0.007	<0.010	0.376	83	51	0.016	0.001	<0.010	0.069	59	35	0.101	0.027	<0.010	1.520
Cobalt (Co)	76	76	0.0218	0.0015	0.0043	0.0793	83	48	0.0068	0.0007	<0.0040	0.0354	59	59	0.0282	0.0023	0.0110	0.0983
Copper (Cu)	76	76	1.028	0.062	0.347	2.850	83	83	0.397	0.017	0.053	0.769	59	59	90.493	9.161	9.4	420.0
Gallium (Ga)	76	14	0.0028	0.0002	<0.0040	0.0140	83	0	0.0020	0.0000	<0.0040	<0.0040	59	0	0.0021	0.0001	<0.0040	<0.0040
Iron (Fe)	76	76	23.1	1.2	6.9	58.9	83	83	3.6	0.1	0.7	7.9	59	59	207.8	14.9	37.5	505.0
Lead (Pb)	76	66	0.0262	0.0043	<0.0040	0.2200	83	25	0.0043	0.0007	<0.0040	0.0534	59	36	0.0126	0.0023	<0.0040	0.1130
Lithium (Li)	76	1	0.010	0.000	<0.020	0.022	83	0	0.010	0.000	<0.020	<0.020	59	2	0.011	0.001	<0.020	0.03
Magnesium (Mg)	76	76	350	8	194	573	83	83	273	4	67	338	59	59	235	11	158	781
Manganese (Mn)	76	76	4.07	0.30	0.58	12.00	83	83	0.19	0.02	0.04	1.00	59	59	1.61	0.07	0.65	3.56
Mercury (Hg)	76	76	0.0650	0.0029	0.0225	0.1550	83	83	0.0974	0.0054	0.0122	0.2940	59	59	0.1610	0.0124	0.0153	0.5180
Molybdenum (Mo)	76	76	0.0171	0.0009	0.0073	0.0381	83	34	0.0034	0.0002	<0.0040	0.0090	59	59	0.2886	0.0106	0.1430	0.5560
Nickel (Ni)-Total	76	63	0.044	0.005	<0.02	0.222	83	54	0.017	0.001	<0.010	0.065	59	28	0.055	0.008	<0.02	0.334
Phosphorus (P)	76	76	5,669	196	2,630	10,400	83	83	2,477	40	528	3,770	59	59	4,236	110	2,780	7,320
Potassium (K)	76	76	3,547	68	2,460	5,370	83	83	4,427	71	1,120	6,040	59	59	3,635	80	2,500	5,150
Rhenium (Re)	76	0	0.0010	0.0000	<0.0020	<0.0020	83	0	0.0010	0.0000	<0.0020	<0.0020	59	0	0.0010	0.0000	<0.0020	<0.0040
Rubidium (Rb)	76	76	3.30	0.19	1.23	8.79	83	83	3.96	0.22	0.58	10.70	59	59	3.98	0.24	1.11	11.10
Selenium (Se)	76	76	0.49	0.04	0.104	1.530	83	83	0.32	0.03	0.043	0.910	59	59	5.66	0.76	1.400	41.400
Silver (Ag)	76	74	0.0094	0.0010	<0.0010	0.0426	83	34	0.0012	0.0001	<0.0010	0.0069	59	59	1.9232	0.1316	0.113	4.7800
Sodium (Na)	76	76	921	22	500	1,550	83	83	599	22	116	1,140	59	59	1,339	33	900	2,000
Strontium (Sr)	76	76	9.35	0.58	2.01	27.60	83	83	0.43	0.06	0.04	3.32	59	59	0.27	0.03	0.06	0.95
Tellurium (Te)	76	0	0.0020	0.0000	<0.0040	<0.0040	83	0	0.0020	0.0000	<0.0040	<0.0040	59	3	0.0027	0.0004	<0.0040	0.0202
Thallium (Tl)	76	76	0.00586	0.00031	0.0009	0.0122	83	83	0.00447	0.00025	0.0004	0.0106	59	59	0.04500	0.00406	0.0042	0.1860
Thorium (Th)	76	11	0.0014	0.0001	<0.0020	0.0096	83	2	0.0011	0.0001	<0.0020	0.0060	59	0	0.0011	0.0000	<0.0020	<0.0040
Tin (Sn)	76	64	0.0236	0.0021	<0.0040	0.1160	83	59	0.0092	0.0007	<0.0040	0.0344	59	48	0.0582	0.0072	<0.0040	0.2510
Titanium (Ti)	45	45	0.571	0.097	0.013	2.630	83	28	0.019	0.004	0.005	0.245	59	51	0.072	0.013	0.005	0.521
Uranium (U)	76	76	0.00515	0.00057	0.00064	0.03270	83	11	0.00031	0.00004	<0.00040	0.00203	59	57	0.00378	0.00056	0.00020	0.02630
Vanadium (V)	76	66	0.0429	0.0046	<0.0040	0.249	83	11	0.0027	0.0002	<0.0040	0.013	59	59	0.0479	0.0166	0.0040	0.9480
Yttrium (Y)	76	52	0.0069	0.0008	<0.0020	0.0381	83	3	0.0011	0.0000	<0.0020	0.0034	59	21	0.0019	0.0002	<0.0020	0.0070
Zinc (Zn)	76	76	39.4	1.6	12.8	75.2	83	83	6.5	0.3	0.9	14.2	59	59	39.4	1.9	24.6	123.0
Zirconium (Zr)	76	1	0.021	0.001	<0.040	0.074	83	0	0.020	0.000	<0.040	<0.040	59	3	0.023	0.001	<0.040	0.086
Methyl Mercury	6	6	0.0407	0.0076	0.0161	0.0560	5	5	0.0432	0.0235	0.0112	0.1360	2	2	0.0810	0.0520	0.0290	0.1330
Lipid Content	56	55	6.3	0.3	<0.5	11.2	52	50	2.1	0.2	<0.5	7.6	12	12	4.7	0.4	2.7	7.6

Notes: All means and SE calculated by replacing values below MDL by one-half of the MDL
n = sample size; MDL -method detection limit; SE = standard error; min = minimum; max = maximum.

Table 5.10-32: Loading Table of the PCA of Fish Tissue Metal Concentrations

Variable	PC1	PC2	PC3
% Variance	36.2	18.9	10.6
lnZn	**0.93**	-0.05	0.13
lnV	**0.90**	-0.20	-0.06
lnMn	**0.90**	-0.31	0.10
lnFe	**0.87**	**0.43**	0.04
lnCo	**0.86**	-0.03	-0.26
lnU	**0.85**	-0.16	0.30
lnMo	**0.83**	**0.52**	-0.04
lnAl	**0.83**	**-0.37**	0.05
lnNa	**0.81**	0.24	-0.22
lnCd	**0.81**	0.32	-0.30
lnP	**0.79**	-0.37	-0.03
lnAg	**0.72**	**0.64**	0.04
lnCu	**0.70**	**0.69**	-0.05
lnSe	**0.68**	**0.54**	**-0.44**
lnCr	**0.68**	-0.02	0.12
lnSn	**0.58**	0.12	-0.16
lnY	**0.58**	**-0.50**	0.07
lnNi	**0.57**	-0.09	-0.07
lnBa	**0.55**	**-0.68**	0.35
lnTl	**0.54**	**0.68**	0.26
lnAs	**0.51**	-0.13	0.15
lnPb	**0.45**	-0.21	**0.50**
lnCa	0.27	**-0.89**	0.20
lnSr	0.35	**-0.76**	**0.45**
lnMg	0.12	**-0.71**	-0.05
lnHg	0.02	**0.69**	0.12
lnweight	-0.08	**0.40**	**0.80**
lnlength	-0.07	**0.38**	**0.79**
lnCe	-0.14	0.31	**0.76**
lnRb	-0.08	0.31	**0.53**
lnK	-0.39	0.00	-0.39
lnB	0.27	0.14	-0.21
lnZr	0.19	0.05	-0.15
lnTh	0.24	-0.31	-0.15
lnGa	0.33	**-0.40**	-0.19

Notes: Bolded correlation coefficients are significant at the P<0.01 level
Greyed components are significant at the P<0.05 level. Non-bolded coefficients are not significant (P<0.05).

A plot of mean PC1 scores on watersheds or lakes for each of the three tissue types showed that muscle tissue has the lowest scores for all watersheds or lakes, that liver tissue has the highest scores in almost all localities, and that whole-body tissue samples have scores only slightly lower than liver (**Figure 5.10-24**). There is little variation among watersheds and lakes in mean PC1 scores within tissue types, suggesting that the distribution of heavy metal concentrations was similar in rainbow trout from all watersheds in the LSA. This result is expected for an area where most rainbow trout likely reside in a single large overwintering lake (i.e., Tatelkuz Lake).

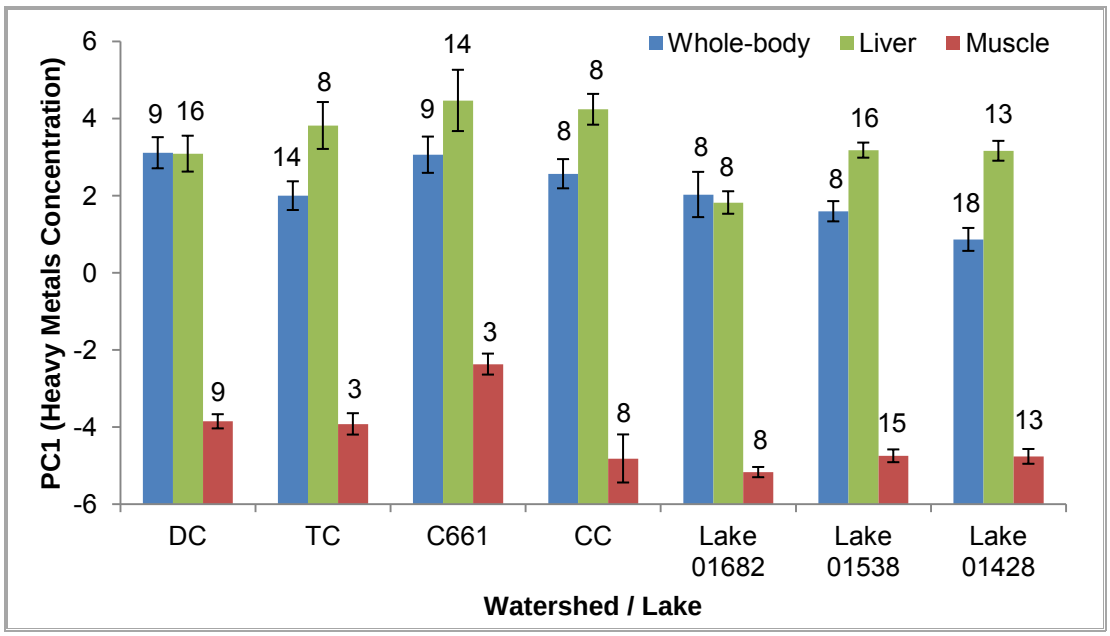
PC2 explained 18.9% of the total variance of the dataset and was significantly ($P<0.01$) negatively correlated with calcium (a major structural metal), strontium (an analogue of calcium), and magnesium (also a structural metal). PC2 was significantly ($P<0.01$) positively correlated with copper and mercury, thallium and selenium – all highly toxic metals for fish and all metals that would be expected to be concentrated in liver tissue (**Table 5.10-32**). PC2 was not significantly ($P>0.05$) correlated with fish length or weight. This component was interpreted as representing tissue type.

A plot of PC2 scores on PC1 scores for all samples showed that the two components clearly separated the three types of tissue (**Figure 5.10-25**). Liver samples had the highest PC2 scores, followed by muscle samples and whole-body samples. The plot also shows that liver and whole-body samples fall within similar ranges of PC1 scores, but that muscle samples have substantially lower PC1 scores. Hence, PC1 not only represents heavy metal concentrations due to environmental exposure, but heavy metal concentrations on a tissue-specific basis.

The interpretation of PC2 as a tissue type component was confirmed by a plot of mean PC2 scores on tissue type (**Figure 5.10-26**). Whole-body tissue had the lowest mean PC2 score and liver had the highest mean PC2 score with muscle tissue having an intermediate mean PC2 score.

The third component, PC3, explained 10.6% of the total variance and was highly significantly ($P<0.01$) positively correlated with fish length and weight. This component was interpreted as representing fish body size. A plot of mean PC3 on watershed confirmed this interpretation (**Figure 5.10-27**).

The three headwater lakes have the three highest mean PC3 scores and the four creeks have the four lowest mean PC3 scores. The rainbow trout sampled from the three lakes were large (>180 mm), adult fish captured in gillnets, which tend to capture the largest fish in a population. In contrast, most of the fish sampled from streams were smaller (<100 mm) juveniles captured with electrofishing and minnow trapping during summer stream inventories. Large adult fish are present in streams during the spawning period only, and were not sampled for tissue metals concentrations because they represent conditions in both streams and residence lakes.



Notes: Error bars are SE; numbers are sample sizes of means; DC = Davidson Creek; TC = Turtle Creek; C661 = Creek 661; CC = Chedakuz Creek.

Figure 5.10-24: Mean PC1 Scores for Rainbow Trout by Tissue Type and Watershed/Lake

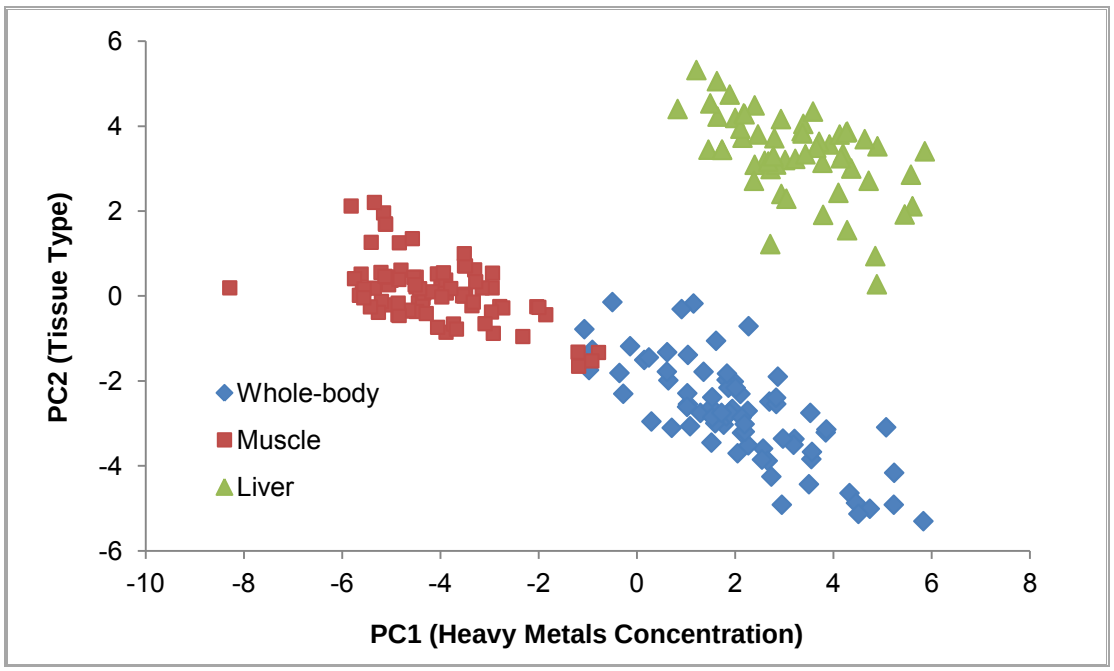
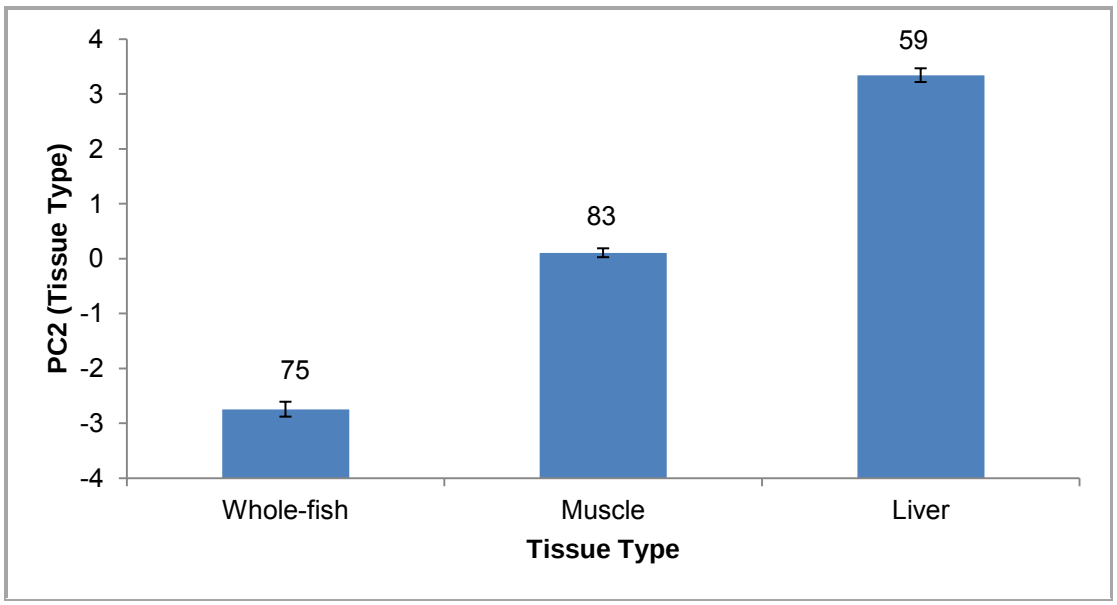
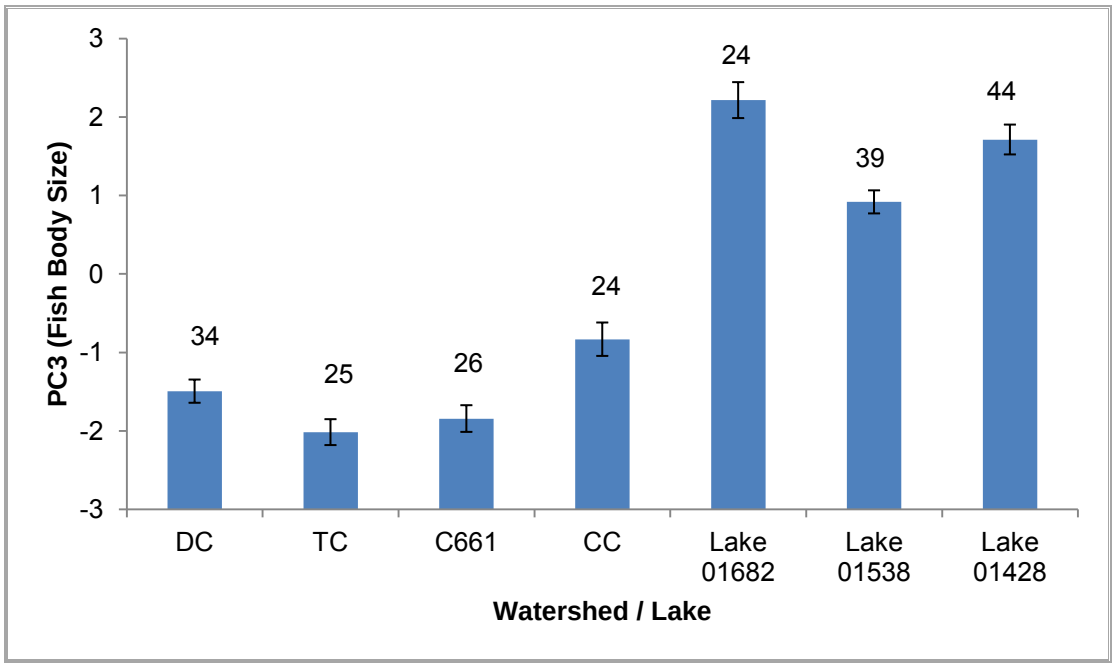


Figure 5.10-25: Plot of PC2 Scores on PC1 Scores for Rainbow Trout



Notes: Error bars are SE; numbers are sample sizes of means.

Figure 5.10-26: Plot of Mean PC2 Scores on Tissue Type for Rainbow Trout



Notes: Error bars are SE; numbers are sample sizes of means; DC = Davidson Creek; TC = Turtle Creek, C661 = Creek 661; CC = Chedakuz Creek.

Figure 5.10-27: Plot of Mean PC3 Scores on Watershed or Lake for Rainbow Trout

Total Mercury

Mercury (Hg) is one of the few metals that have no known biological function, and is highly toxic to plants and animals (Eisler, 2006). It binds permanently to protein and accumulates in fish tissue. All 218 tissue samples collected from rainbow trout in the LSA and RSA were analyzed for total mercury concentrations, and all concentrations were above the MDL. Mean total mercury concentration in liver tissue (0.1610 mg/kg wwt; SE = 0.0124; n = 59) was 65% higher than in muscle (0.0974 mg/kg wwt; SE = 0.0054; n = 83), and 247% higher than in whole-body tissues (0.0650 mg/kg wwt; SE = 0.0029; n = 76) (**Table 5.10-31**).

These mean total mercury concentrations are slightly higher than those reported by BC MOE for rainbow trout sampled from 24 uncontaminated lakes in BC (Rieberger, 1992). The mean total mercury concentration in muscle tissue was reported to be 0.09 mg/kg wwt (SE = 0.01; n = 97 fish), which was 8% lower than the mean for rainbow trout sampled from the LSA. The mean total mercury concentration in liver tissue was reported to be 0.11 mg/kg wwt (SE = 0.02, n = 17 fish), which was 32% lower than the mean for rainbow trout liver tissue sampled from the LSA.

In contrast, the mean total mercury concentration in muscle tissue of rainbow trout from the LSA and RSA is slightly lower than the median concentrations reported for rainbow trout of the Canadian Fish Mercury Database (Depew et al., 2013). The database contains data from rainbow trout populations across Canada sampled over the last 30 to 40 years. Depew et al., (2013) reported that the median concentration of total mercury was 0.11 mg/kg wwt (range = <MDL to 0.94; n = 3,014 fish) for skinless muscle samples, and 0.10 mg/kg wwt (range = <MDL to 1.95; n = 172) for skin-on muscle samples. Those medians are 13% and 3% higher, respectively, than the mean for muscle tissue of this study.

However, the mean total mercury concentration in whole-body tissue of rainbow trout from the LSA and RSA is 85% greater than the median whole-body concentration for whole-body samples (Depew et al., 2013) (i.e., 0.01 mg/kg wwt; range = <MDL to 0.34; n = 57).

Because total mercury binds to protein and is not metabolized or excreted, its concentration is often positively correlated with fish size. No significant correlations were found between total mercury concentrations and fish length for whole-body and muscle tissues, but a highly significant ($P<0.001$) and positive linear regression was found for liver tissue (**Figure 5.10-28**). The regression, however, explains only 27% of the variance in ln(Hg), indicating that factors other than body size also affect liver mercury concentration.

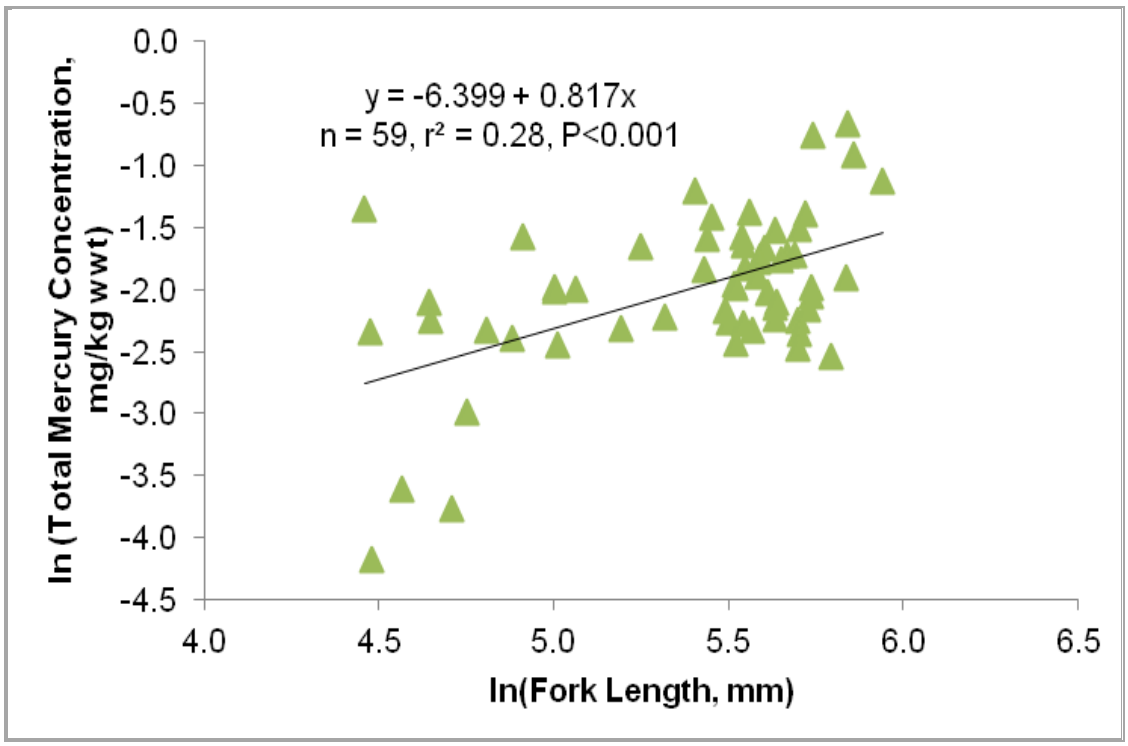


Figure 5.10-28: Linear Regression of Total Mercury Concentration on Fork Length for Rainbow Trout Liver Tissue

The lack of correlations between total mercury concentrations in muscle and whole-body tissue and fish length are supported by other studies. For example, Avison (2010a) reported no significant (P>0.05) correlation of total mercury and fork length for 65 whole-body samples of rainbow trout collected from the Chu Molybdenum Project area in the northeast corner of the RSA. Rieberger (1992) also reported no significant (P>0.05) correlation of total mercury and fork length for muscle tissue sampled from 97 rainbow trout captured from 24 uncontaminated lakes in BC. However, unlike the present study, Rieberger (1992) did not find a significant correlation between total mercury and fork length for liver tissue.

Health Canada has established a total mercury guideline for human consumption of fish of 0.5 mg/kg wwt mercury (Health Canada 2013). The guideline is not a threshold concentration above which toxic effects are expected. Rather, it is a guideline established to protect the health of humans who consistently eat large amounts of fish. Only one of the 218 tissue samples collected in 2011 and 2012 from the LSA (or 0.5%) exceeded that total mercury guideline – a liver sample taken from a rainbow trout captured from Lake 01682LNRS on September 19, 2012 (fish sample number 16-010). The liver from this fish had a total mercury concentration of 0.518 mg/kg wwt. The fish was 344 mm long and weighed 463 g and had an otolith age of 5 years.

None of the 65 rainbow trout sampled from the Chu Molybdenum Project area had whole-body total mercury concentrations that exceeded the Health Canada guideline (Avison, 2010a). The lack of exceedances may be due to the smaller length of the rainbow trout sampled in the Chu Molybdenum Project area than in the proposed Project area.

In summary, total mercury residues in the tissues of rainbow trout from the LSA and RSA are not a meaningful health hazard for humans.

Methyl-Mercury

Methyl-mercury (MeHg) is the form of mercury most readily taken up by fish, and is the most harmful form of mercury to aquatic biota. A total of 13 tissue samples (or 6% of the total number of tissue samples collected in the LSA in 2011 and 2012) were analyzed for methyl-mercury concentration. Mean methyl-mercury concentrations were similar for whole-body and muscle tissues, but were twice as high in liver tissue than in whole-body and muscle tissues (**Table 5.10-31**).

Methyl-mercury concentrations ranged from 17 to 100% of the total mercury concentrations, and were highly positively correlated with total mercury concentrations in each sample for which both were measured. A linear regression of methyl-mercury concentration on total mercury concentration was highly significant ($P<0.001$) and positive, and explained 87% of the variance in methyl-mercury concentration (**Figure 5.10-29**). The regression intercept was not significantly ($P = 0.627$) different from zero. The slope of the regression indicates that, on average, methylmercury makes up 55% of the concentration of total mercury.

BC MOE and the CCME established a methyl-mercury Tissue Residue Guideline (TRG) of 0.033 mg/kg wwt for protection of piscivorous wildlife (BC MOE 2013d; CCME 2000). Six of the 13 measurements of methyl-mercury exceeded the BCMOE TRG: four whole-body, one muscle, and one liver. One fish was responsible for three of those exceedances. Fish sample number 16-011, captured from Lake 01682LNRS, the headwater lake of the Davidson Creek Watershed, on September 19, 2012, had a methyl-mercury concentration of 0.0527 mg/kg wwt for the whole-body sample, 0.1360 mg/kg wwt for the muscle sample, and 0.1330 mg/kg wwt for the liver sample. The fish was 305 mm long, weighed 355 g, and had an otolith age of 4 years.

The three other whole-body exceedances were for a rainbow trout captured in Lake 01428UEUT of the Creek 705 Watershed on 8 September 2012 (MeHg concentration = 0.0511 mg/kg wwt, fish sample number = 9-020, length = 274, weight = 212 g), one captured in Creek 661 on 3 August 2012 (MeHg concentration = 0.0510 mg.kg wwt, fish sample number = 6-069, length = 89 mm, weight = 9.1 g), and one captured in Davidson Creek on 5 August 2012 (MeHg concentration = 0.0560 mg/kg wwt, fish sample number = 6-144, length = 88 mm, weight = 6.3 g).

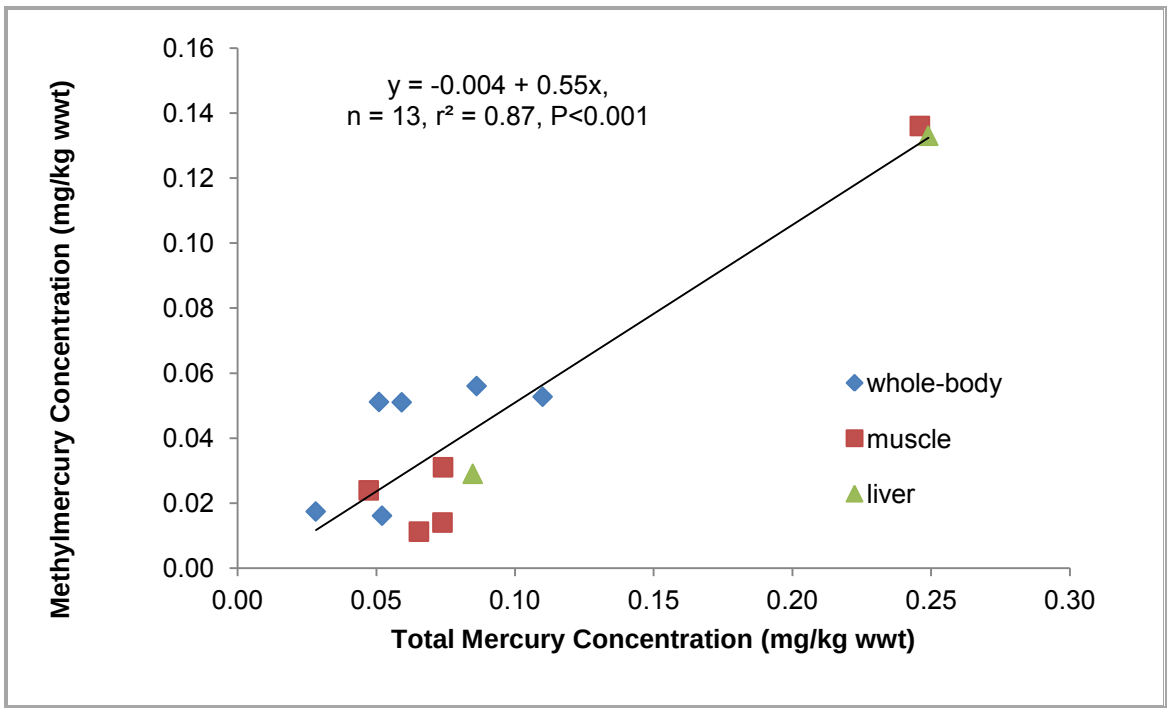


Figure 5.10-29: Linear Regression of Methyl Mercury Concentration on Total Mercury Concentration for Rainbow Trout Tissues

The CCME developed a methyl-mercury TRG using the *Protocol for Derivation of Tissue Residue Guidelines for the Protection of Wildlife that Consume Aquatic Biota* (CCME 1998), following the equation:

$$TRG = TDI/(FI/W)$$

where TDI = Tolerable Daily Intake of methyl-mercury (mg per kg body weight per day), FI = food ingestion rate (kg/day), and W = body weight (kg wwt).

CCME (2000) set the TDI as 0.031 mg/kg wwt/d, based on avian toxicological data, and the ratio of FI to W at 0.94, the highest ratio available, based on data for Wilson's storm-petrel (*Oceanites oceanicus*) (CCME 1998). The value of 0.033 mg/kg wwt was the lowest for all avian and mammal species for which data on TDI, FI and W were available; hence, it was chosen by CCME (2000) as the TRG for protection of all aquatic biota.

Wilson's storm-petrel is not present in the LSA and RSA, which means a methyl-mercury TRG of 0.033 mg/kg wwt is not applicable to the LSA and RSA, at least not on scientific grounds.

A site-specific TRG for methyl-mercury was calculated by identifying the bird species listed on Table 1 of the *Protocol for Derivation of Tissue Residue Guidelines for the Protection of Wildlife that Consume Aquatic Biota* that are present in the aquatics RSA. A total of seven

species were reported as present based on direct bird observations (AMEC 2013b): bufflehead (*Bucephala albeola*); mallard (*Anas platyrhynchus*); common merganser (*Mergus merganser*); bald eagle (*Haliaeetus leucocephalas*); osprey (*Pandian haliaetus*); common loon (*Gavia immer*); and herring gull (*Larus argentatus*). Another eight species were identified as "likely present" based on records reported by *Birds of British Columbia* (Campbell et al., 1990), the *British Columbia Breeding Atlas* (2013) and eBird (2013): common goldeneye (*Bucephala clangula*); wood duck (*Aix spansa*); American wigeon (*Anas americana*); lesser scaup (*Aythya affinis*); red-breasted merganser (*Mergus serrator*); belted kingfisher (*Ceryle alcyon*); ring-billed gull (*Larus delawarensis*); and Great blue heron (*Ardea herodias*). The FI/W ratios for those 15 species ranged from a low of 0.11 for bald eagle to a high of 0.50 for belted kingfisher. Therefore, TDI of 0.031 mg/kg wwt was divided by a maximum FI/W ratio of 0.50 to obtain a site-specific methyl-mercury TRG of 0.062 mg/L wwt.

Using the guidelines, only two tissue samples from a single rainbow trout would exceed the guidelines. Fish sample number 16-011, captured from Lake 01682LNRS, the headwater lake of the Davidson Creek Watershed, on 19 September 2012, had a methyl-mercury concentration of 0.1360 mg/kg wwt for the muscle sample, and 0.1330 mg/kg wwt for the liver sample. The concentration of the whole-body sample was less than the derived site-specific guideline. Since predators of rainbow trout such as birds would not likely eat only one type of tissue, the site-specific TRG for methyl-mercury would not likely be exceeded.

In summary, methyl-mercury residues in the tissues of rainbow trout from the LSA and RSA are not a meaningful health hazard for piscivorous wildlife.

Total Selenium

No significant ($P>0.05$) correlation was found between total selenium concentration and fish length for liver tissue, but highly significant ($P<0.001$) and negative linear regressions were found for both muscle and whole-body tissues (**Figure 5.10-30** and **Figure 5.10-31**). Avison (2010a) also reported a significant ($P<0.05$) negative correlation of selenium concentration and fork length for whole-body samples of rainbow trout collected from the Chu Molybdenum Project area.

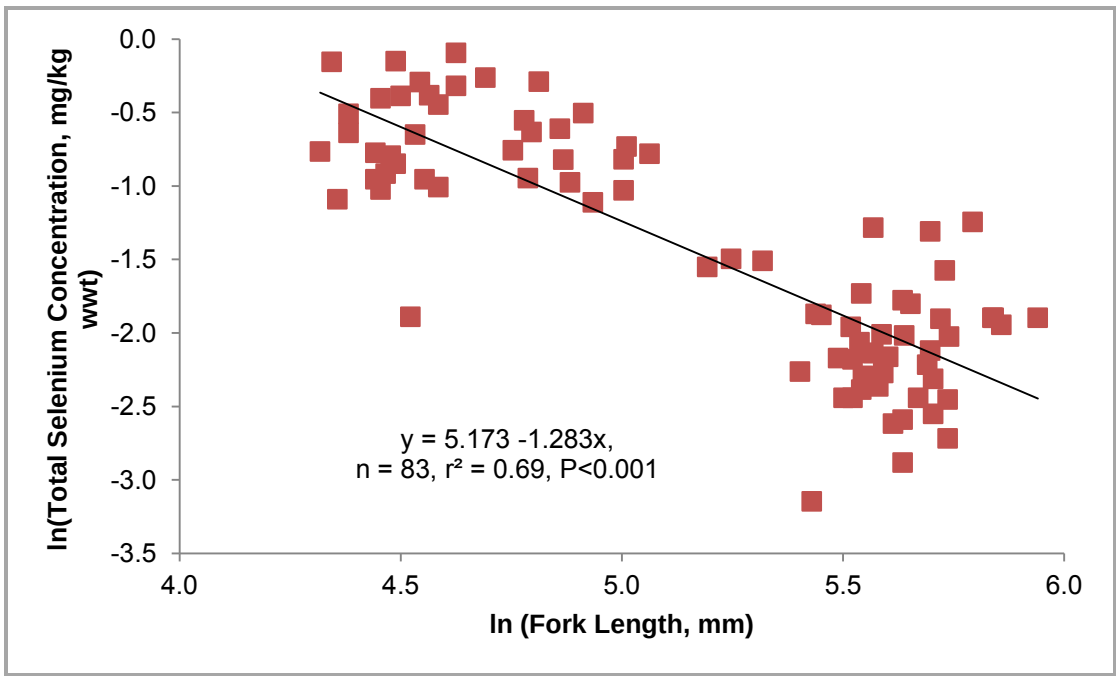


Figure 5.10-30: Linear Regression of Total Selenium on Fork Length for Muscle Tissues from Rainbow Trout

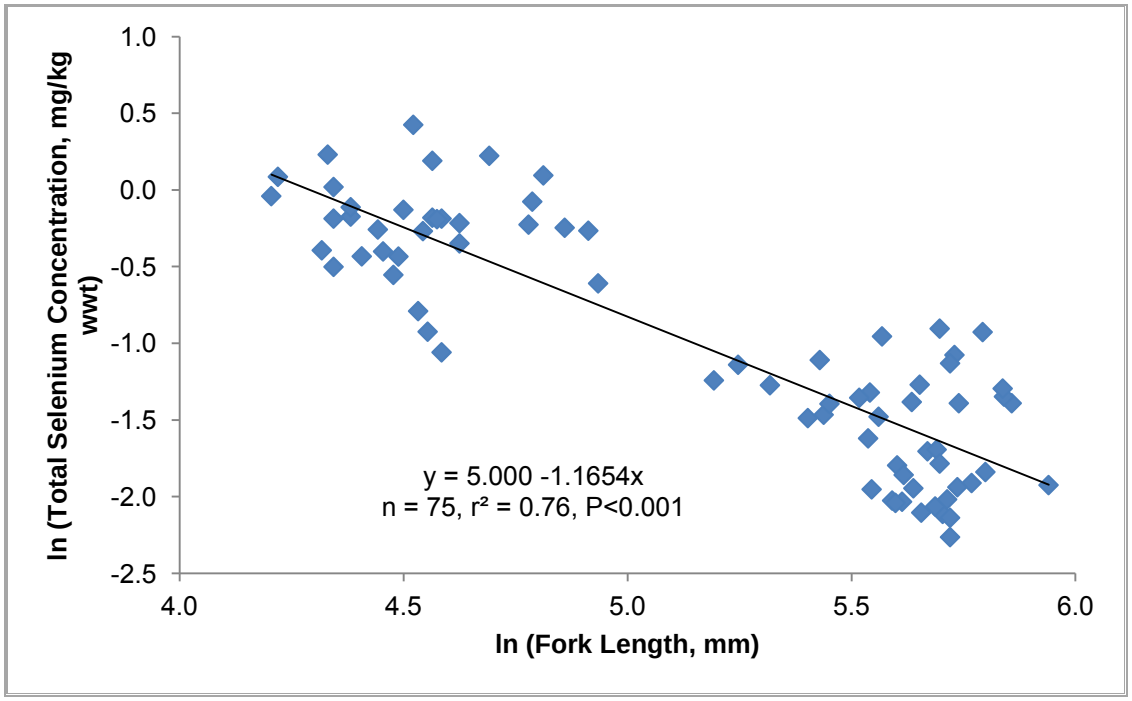


Figure 5.10-31: Linear Regression of Total Selenium on Fork Length for Whole-body Tissues from Rainbow Trout

Figure 5.10-30 and **Figure 5.10-31** are essentially comparisons of two groups of fish: (1) juveniles electrofished from streams of the LSA and the RSA that are shorter than 148 mm (i.e., ln(length) = 5.0) and carry relatively high concentrations of total selenium; and (2) adults captured from lakes with gillnets that are longer than 148 mm and have lower concentrations of total selenium. The fish captured with gillnets are adults because the mean length of 50% sexual maturity for rainbow trout in the LSA and RSA is 150 mm (**Section 5.10.3.3**).

There are two possible explanations for the negative correlations. The first is that sexually mature rainbow trout transfer (or depurate) total selenium from muscle and liver tissue into eggs and milt. Hence, the young, immature members of the rainbow trout population accumulate selenium in their tissues until they mature sexually and spawn, at which time their selenium body concentration falls.

The second explanation is that the negative correlation is a consequence of comparing fish taken from lotic habitat (i.e., stream habitat) with those from lentic habitat (i.e., lakes and other still waters). Selenium is known to be taken up more readily in organisms residing in lentic habitat than in lotic habitat.

Data collected to date cannot distinguish between these two explanations. All sexually mature trout were sampled from lakes and all immature trout were sampled from streams. Hence, habitat and sexual maturity are confounded.

BC MOE has established a draft total selenium whole-body tissue guideline for protection of aquatic life of 4 mg/kg dry weight (BC MOE 2013e). Assuming a mean percent moisture of 73.2%, calculated from all 218 fish tissue samples collected for this study, gives a total selenium whole-body guideline of 1.07 mg/kg wet weight. That guideline was exceeded by eight whole-body samples (or 11% of the total number of whole-body samples), none of the muscle samples, and 59 of the liver samples (or 100% of the liver samples).

Avison (2010a) reported similar results for whole-body rainbow trout samples collected from the Chu Molybdenum Project area: two samples (or 3% of the total number) had total selenium concentrations that exceeded the 1 mg/kg wwt guideline. One of those samples was collected from a site within the RSA (a tributary of the system that drains from Lake 113), and the other was collected from a site outside the RSA upstream of the Brewster Lakes.

Comparison with Chu Molybdenum Project Tissue Metal Concentrations

In 2009, as part of environmental baseline studies of the Chu Molybdenum Project, a total of 65 rainbow trout were captured from sampling sites inside and outside the northeast corner of the RSA and analyzed for whole-body metal concentrations (Avison, 2010a). Five fish were collected from each of 11 stream sampling sites and two lake sampling sites (Mills Lake and Lake 113) (**Figure 5.10-32**). Mean total metal concentrations measured from those whole-body samples were compared with the mean total metal concentrations measured from whole-body samples collected for the Project.

The fork lengths of the 65 rainbow trout collected from Chu Molybdenum sampling sites ranged from 31 to 333 mm with a mean of 100 mm (SE = 4), thus were slightly smaller than the Blackwater fish. Avison (2010a) measured the concentrations of 25 total metals plus percent moisture, which was a total of 15 fewer metals than were measured for Blackwater fish.

Comparison of the mean total metal concentrations (plus percent moisture) between the two whole-body datasets showed that the Blackwater fish had higher mean concentrations of eight metals, but that the Chu Molybdenum Project fish had higher mean concentrations of 17 metals (**Table 5.10-33**).

Table 5.10-33: Percent Difference in Mean Total Metal Concentrations between Whole-Body Samples of Rainbow Trout from the Blackwater and Chu Molybdenum Project Areas

Variable	Blackwater (n = 76)		Chu Molybdenum (n = 65)		
	Percent n>MDL	Mean	Percent n>MDL	Mean	Percent Difference
Uranium (U)	100	0.00515	15	0.00219	80.5
Lead (Pb)	87	0.0262	0	0.0116	77.3
Strontium (Sr)	100	9.35	100	6.34	38.4
Zinc (Zn)	100	39.4	100	34.0	14.7
Calcium (Ca)	100	7,259	100	6,351	13.3
Thallium (Tl)	100	0.00586	0	0.00538	8.5
Barium (Ba)	100	0.717	100	0.662	8.0
Magnesium (Mg)	100	350	100	343	2.0
Mercury (Hg)	100	0.0650	100	0.0668	-2.9
Percent moisture	100	72.4	100	76.6	-5.5
Copper (Cu)	100	1.028	100	1.188	-14.4
Molybdenum (Mo)	100	0.0171	100	0.0198	-14.5
Nickel (Ni)-Total	83	0.044	0	0.056	-24.2
Arsenic (As)	100	0.0572	100	0.0735	-25.0
Manganese (Mn)	100	4.07	100	5.59	-31.4
Cobalt (Co)	100	0.0218	31	0.0300	-31.5
Selenium (Se)	100	0.49	100	0.70	-34.3
Aluminum (Al)	100	7.25	85	11.14	-42.3
Cadmium (Cd)	84	0.0108	92	0.0171	-45.4
Vanadium (V)	87	0.0429	8	0.0777	-57.7
Tin (Sn)	84	0.0236	0	0.0504	-72.4
Chromium (Cr)	97	0.061	54	0.167	-93.2
Antimony (Sb)	3	0.0011	0	0.0054	-134.5
Lithium (Li)	1	0.010	0	0.054	-136.5
Bismuth (Bi)	0	0.0010	0	0.0162	-176.7
Beryllium (Be)	1	0.0010	0	0.0538	-192.6

Notes: Percent Difference = (X1 – X2)*100/((X1 + X2)/2), where X1 = Blackwater mean and X2 = Chu Molybdenum mean
MDL = Method Detection Limit; n = sample size.

382500 385000 387500 390000 392500 395000 397500 400000 402500 405000

5922500 5920000 5917500 5915000 5912500 5910000 5907500 5905000

BLK01109
TAI00809
TPD01009
LAK01209 Lake 113
SMN00609
TPD00909
SMN00709
REF00309
REF00209
SMN00509
MLK01309 Mills Lake
SMN00409
REF00109

Brewster Lakes
Goose Lake
Esker Creek
Ethorn Creek
Chuchanli Lake
Taiuk Creek
Tatelkuz Lake
Davidson Creek

N

Legend

- 2009 Tissue Sampling Site
- Regional Study Area
- Local Study Area
- Road
- Stream
- Kluskus FSR
- Kluskus Blue FSR
- Kluskus Ootsa FSR
- Proposed Transmission Line
- Waterbody

Scale:1:75,000

0 0.5 1 2 3 4 5
Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Rainbow Trout Sampling Sites, Chu Molybdenum Project, 2009

DATE: June, 2013	ANALYST: AA	**Figure** 5.10-32
JOB No: VE52277	QA/QC: MM	PDF FILE: 10-100-130_Chu_Molybdenum.pdf
GIS FILE: 10-100-130_Chu_Molybdenum.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-130_Chu_Molybdenum.mxd

Ignoring those metals for which more than 90% of values in one or both datasets were below the MDL, the Blackwater fish had higher mean concentrations of six metals (uranium, strontium, zinc, calcium, barium, and magnesium), and the Chu Molybdenum fish had higher mean concentrations of 10 metals (mercury, copper, molybdenum, arsenic, manganese, cobalt, selenium, aluminum, cadmium, and chromium) – most of which are heavy metals. On the whole, the Blackwater rainbow trout whole-body samples had lower heavy metal concentrations than those from the Chu Molybdenum Project area. A plot of the ln-transformed mean concentrations for those 16 metals showed those differences graphically (**Figure 5.10-33**).

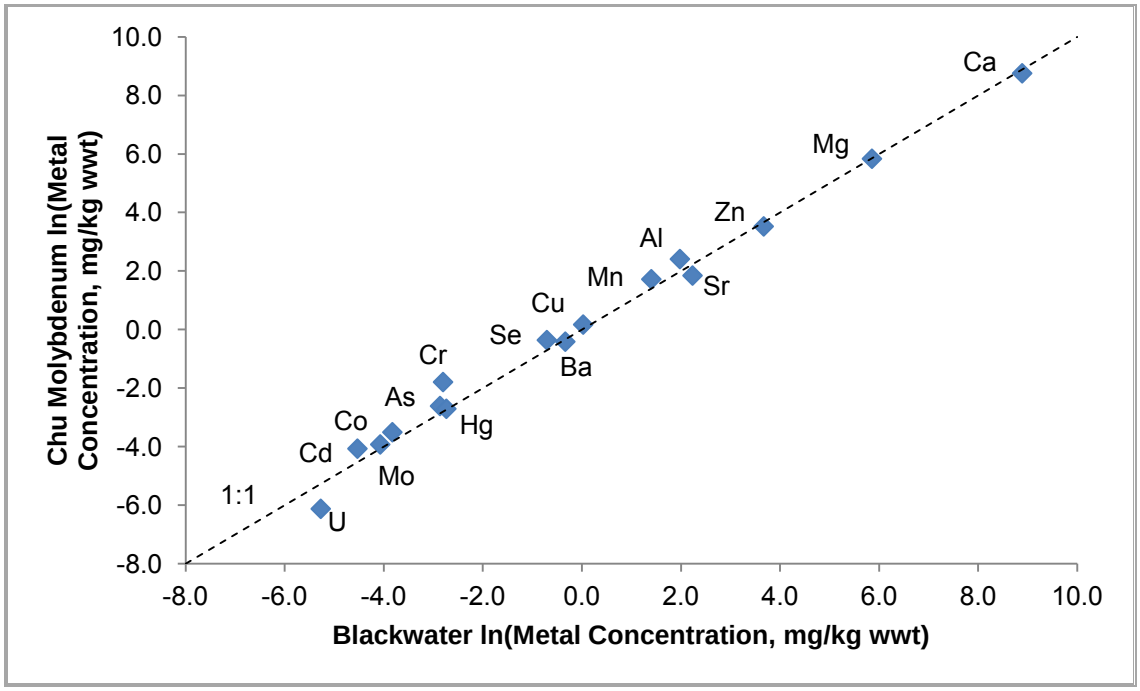


Figure 5.10-33: Plot of Mean Metal Concentrations of Whole-Body Rainbow Trout from the Chu Molybdenum Project Area on the Project Area

5.10.3.7 Microsatellite DNA Analysis

Rainbow Trout

The information presented in this section is an abstract of the report provided by Dr. Eric Taylor of UBC regarding genetic distinctness of rainbow trout in the Chedakuz Creek Watershed and Fawnie Creek Watershed (**Appendices 5.10-10**) (Taylor 2012). **Annex 5.10-11** shows the sampling sites, sample sizes, number of alleles, heterozygosity, and allele frequencies across the ten microsatellite DNA loci that were assayed.

A total of 170 samples of rainbow trout tissue that were collected from seven localities in or near the LSA and RSA in 2011 – four within the Chedakuz Creek Watershed and three from the adjacent Fawnie Creek Watershed – were assayed at ten microsatellite DNA loci. The numbers of alleles and heterozygosity observed in these samples (2.5 to 4.5 and 0.33 to 0.50, respectively) were typical of rainbow trout sampled from other areas of the BC interior and over a similar geographic scale. A measure of genetic divergence among samples, FST, was estimated as 0.10 and most pairwise comparisons among the samples were statistically significant.

The samples clustered into four broad groupings (**Figure 5.10-34**):

- Davidson Creek;
- Creek 661;
- Turtle Creek and Creek 700 in the Turtle Creek Watershed; and
- Lakes 01428UEUT, 01538UEUT, and Creek 705 in the Creek 705 Watershed.

Approximately 7% of the total variation in allele frequencies was attributable to differences between the Chedakuz Creek and Fawnie Creek Watersheds, 5% to localities within watersheds, and 88% to variation within localities. Most of the samples were demonstrably genetically distinct from one another and are probably largely demographically independent from one another, although some movement likely does occur occasionally between localities that are currently interconnected.

As the Chedakuz Creek (Davidson/Turtle/Creek 700) and Fawnie Creek (Lakes 01538UEUT and 01428UEUT/Creek 705) Watersheds flow in opposite directions across a major drainage divide, the genetic similarity between some fish in these watersheds suggests that the watersheds may have in the past, or in exceptionally high water years, been connected allowing fish to move between the two catchments.

The proportion of the total variation in microsatellite allele frequencies of rainbow trout in the LSA and RSA that is attributable to differences among populations (otherwise known as θ) is consistent with previous results reported for rainbow trout in BC and Alberta once differences in the geographic scale of coverage and physical connectivity are accounted for (**Figure 5.10-35**).

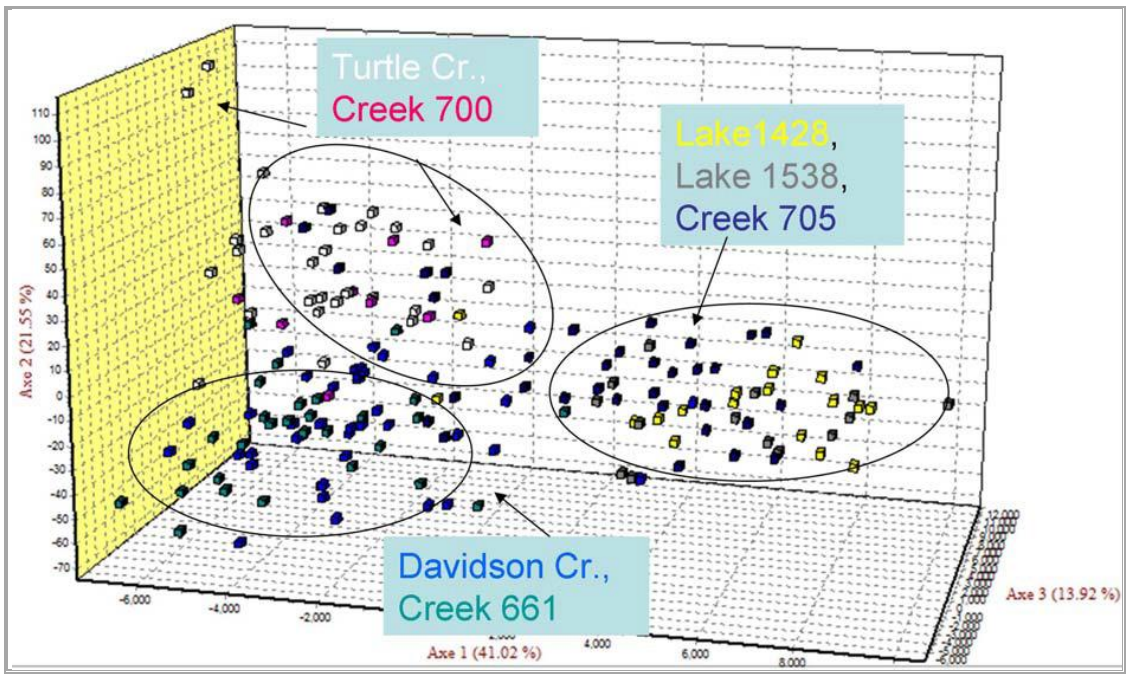


Figure 5.10-34: Factorial Correspondence Analysis Depicting Relative Similarity among Samples of Rainbow Trout, LSA and RSA, 2011

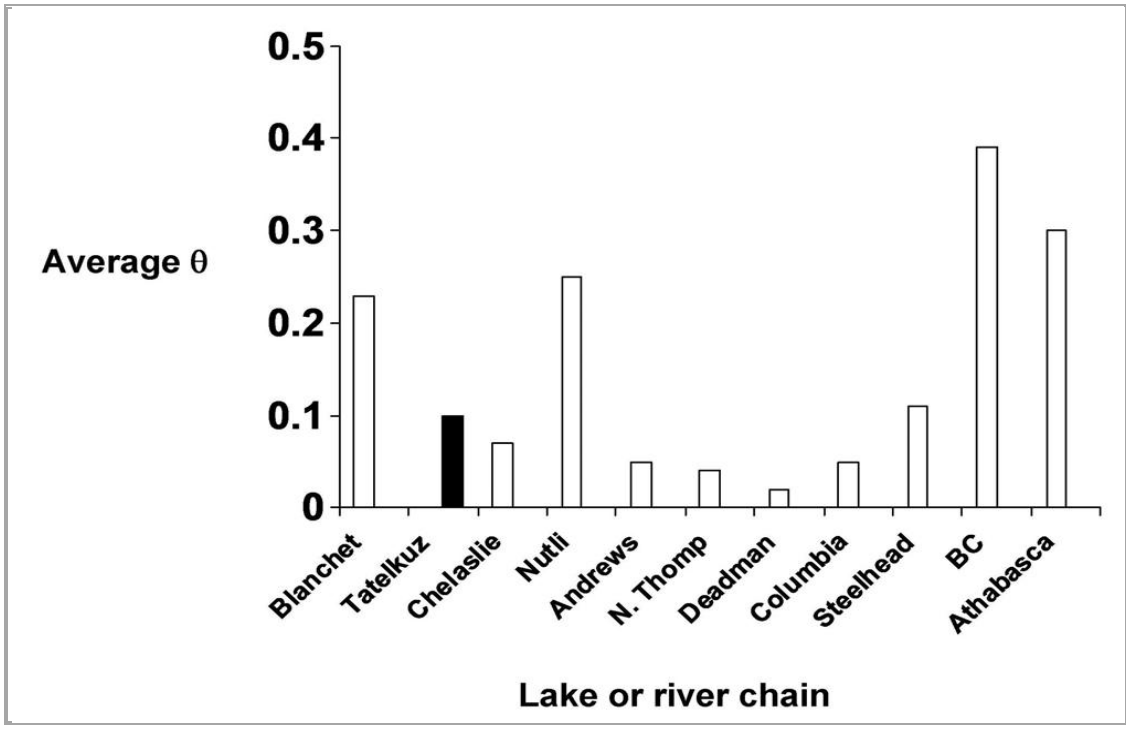


Figure 5.10-35: Comparative Values of θ among Several Population Assemblages of Rainbow Trout Sampled from BC and Alberta

The populations shown in **Figure 5.10-35** include the following:

- Blanchet, Chelaslie, Nuti, Andrews, and Tatelkuz (i.e., Chedakuz Creek and Fawnie Creek) lake/river chains are from the upper Fraser River Watershed;
- North Thompson and Deadman are from the North Thompson River Watershed;
- Columbia is from the Columbia River near Castlegar, BC;
- Steelhead are seven steelhead trout populations from the Fraser River, Vancouver, and Haida Gwaii; and
- BC represents the average of 42 samples from across BC while the Athabasca value represents the average across 49 samples from the Athabasca River in Alberta (Taylor et al., 2007 and Tamkee et al., 2010).

Kokanee

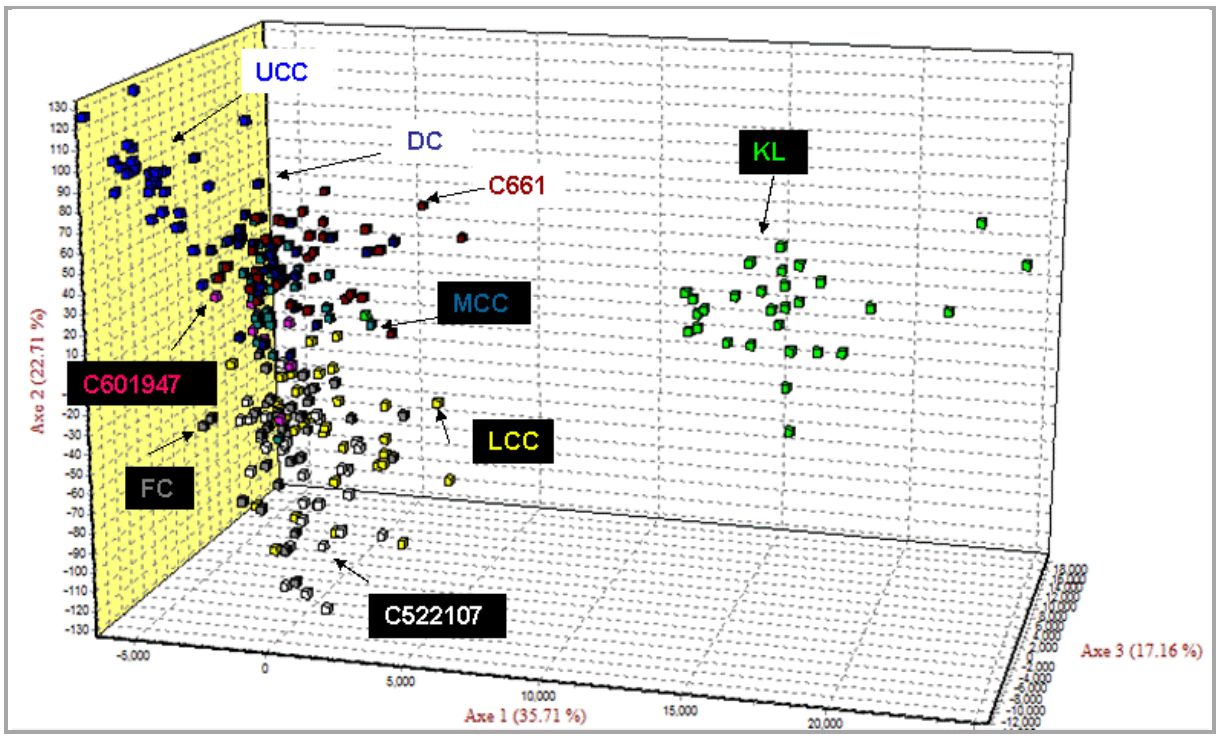
The information presented here is an abstract of the report provided by Dr. Eric Taylor of UBC regarding genetic distinctness of kokanee in the Chedakuz Creek Watershed and Fawnie Creek Watershed (**Annex 5.10-12**) (Taylor 2013). **Annex 5.10-13** shows the sampling sites, sample sizes, number of alleles, heterozygosity, and allele frequencies across the six microsatellite DNA loci that were assayed.

A total of 262 samples of kokanee tissue were collected from nine localities in the central interior of BC: seven from within the Chedakuz Creek Watershed and one from the Fawnie Creek Watershed of the Fraser River system, and one from the Kootenay Lake drainage of the Columbia River system.

Each sample was assayed at six microsatellite DNA loci. The numbers of alleles and heterozygosity observed (5 to 22 and 0.41 to 0.94) were typical of kokanee sampled from other areas of the BC interior and over a similar geographic scale. A measure of genetic divergence among all samples, FST, was estimated as 0.086 (95% CI: 0.043 to 0.132), and most pairwise comparisons among the samples were statistically significant. When only the Chedakuz/Fawnie samples were compared, FST, was 0.068 (0.031 to 0.104), and 0.042 (0.022 to 0.064) when the upper Chedakuz Creek sample was removed. The upper Chedakuz Creek (mean FST = 0.148) and the Kootenay Lake (mean FST = 0.138) samples consistently showed the greatest divergence from all other samples.

The samples clustered into four broad groupings (**Figure 5.10-36**):

- Davidson Creek, Creek 661, and middle Chedakuz Creek;
- lower Chedakuz Creek, Creek 522107 and Fawnie Creek;
- upper Chedakuz Creek; and
- Meadow Creek (Kootenay Lake).



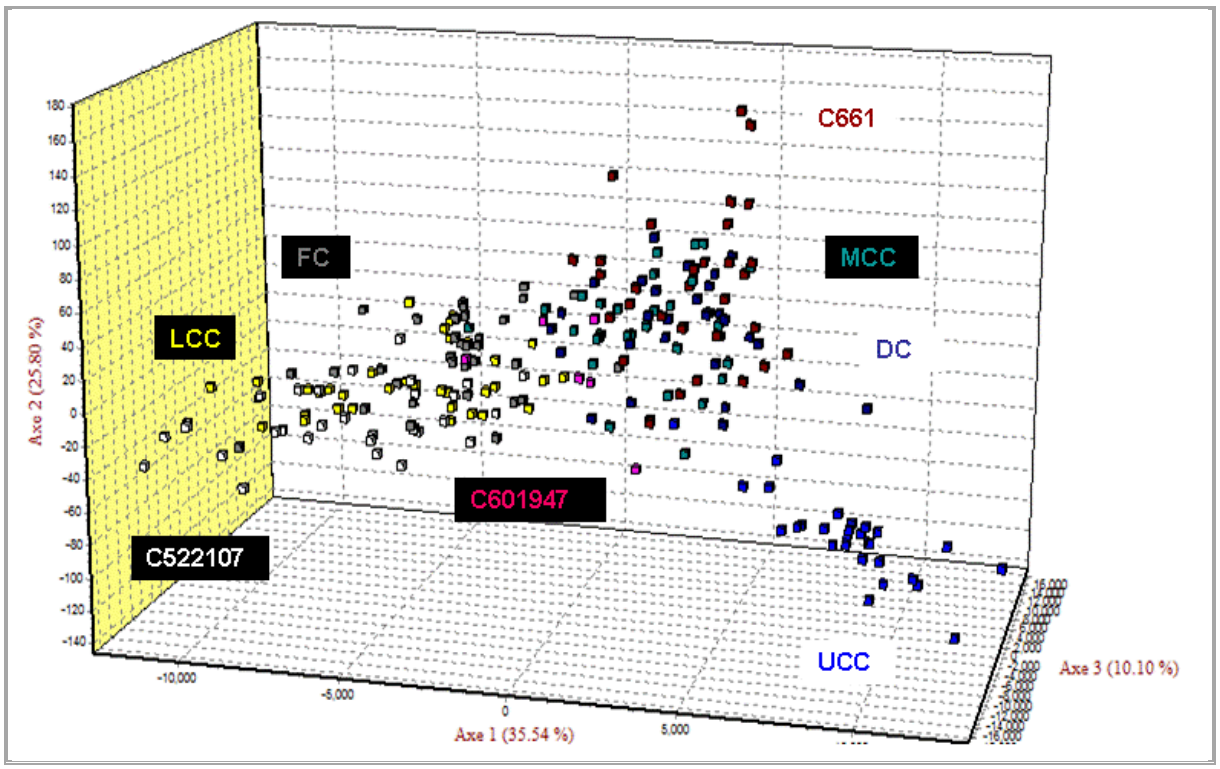
Notes: C661 = Creek 661; DC = Davidson Creek; FC = Fawnie Creek; KL = Kootenay Lake; LCC = lower Chedakuz Creek; MCC = middle Chedakuz Creek; UCC = upper Chedakuz Creek.

Figure 5.10-36: Factorial Correspondence Analysis Depicting Relative Similarity among Samples of Kokanee Sampled from Tatelkuz Lake/Chedakuz Creek (Fraser River System) and Kootenay Lake (Columbia River) Drainages

Creek 601947 appeared somewhat intermediate to the first and second groups, but sample sizes were low for this locality.

Removing the Kootenay Lake samples, which are clearly different from the samples from Chedakuz Creek and Fawnie Creek watersheds, gives a more detailed view of relatedness among kokanee of the LSA and RSA (**Figure 5.10-37**).

Fourteen (6.3% of 220) of the samples from the Chedakuz Creek Watershed and Fawnie Creek Watershed could be rejected (p<0.01) as members of the same genetic population as fish with which they were sampled and, therefore, were inferred to be immigrants to the sample locality. Most of the samples were demonstrably genetically distinct from one another, particularly upper Chedakuz Creek, and are probably largely demographically independent from one another, although some movement likely does occur occasionally between localities that are currently interconnected.



Notes: C661 = Creek 661; DC = Davidson Creek; FC = Fawnie Creek; KL = Kootenay Lake; LCC = lower Chedakuz Creek; MCC = middle Chedakuz Creek; UCC = upper Chedakuz Creek.

Figure 5.10-37: Factorial Correspondence Analysis Depicting Relative Similarity among Samples of Kokanee Sampled from Tatelkuz Lake/Chedakuz Creek Drainages

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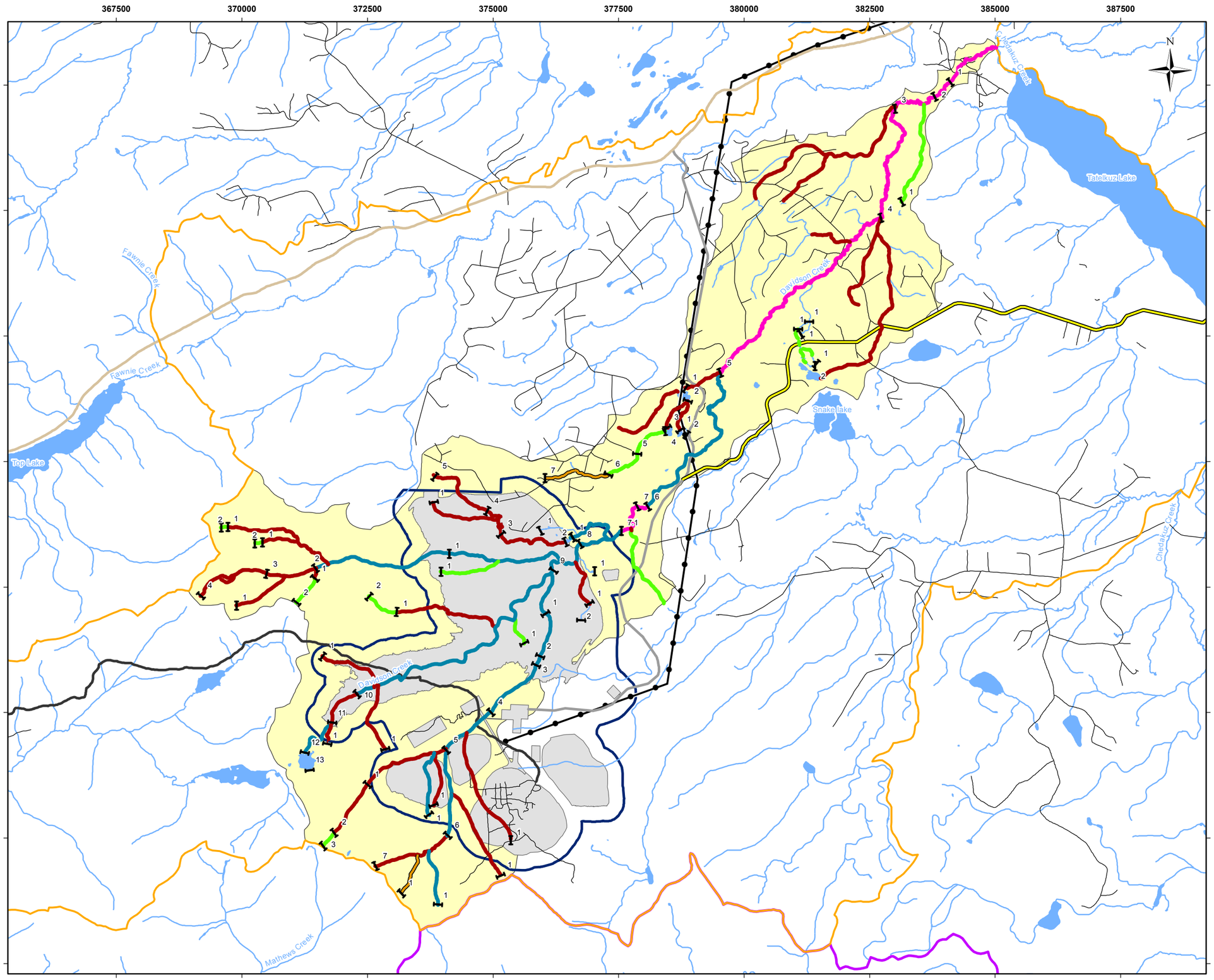
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ANNEXES

Annex 3.1-1
Historical Stream Habitat Data (1:20,000)
Data Summary, 1997-2006

Davidson Creek Watershed



Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:75,000

0 0.5 1 2 3 4 5

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification Davidson Creek Watershed

DATE: June, 2013	ANALYST: MY	**Figure** 3.1-1A
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-059_stream_class_DC_v2.pdf
GIS FILE: 10-100-059_stream_class_DC_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-059_stream_class_DC_v2.mxd

Table 3-1-1A: Reconnaissance 1:20,000 Stream Habitat Assessment Site Locations for the Davidson Creek Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM)[1]		Sampling Date
						Easting	Northing	
100-567134-610692-522527	-	Davidson Creek	5	2223	2223C	381809	5904000	27/05/2004
100-567134-610692-522527	-	Davidson Creek	10	1057	1057C	376025	5897690	28/05/2004
100-567134-610692-522527-114028-318876	-	-	1	2225	2225C	381315	5905667	27/05/2004
100-567134-610692-522527-226858	-	Creek 226858	1	72039	72039C	382711	5904797	27/05/2004
100-567134-610692-522527-226858	-	Creek 226858	1	72047	72047C	382727	5902716	27/05/2004
100-567134-610692-522527-428073	-	Creek 428073	1	2251	2251C	378950	5901517	29/05/2004
100-567134-610692-522527-428073-240670	-	-	1	2254	2254C	378873	5901140	29/05/2004
100-567134-610692-522527-428073-184112	-	-	1	2252	2252C	378576	5901380	29/05/2004
100-567134-610692-522527-616152	-	-	1	72055	72055C	377809	5898736	12/07/2006
100-567134-610692-522527-636713	-	Creek 636713	1	2261	2261C	376753	5898560	29/05/2004
100-567134-610692-522527-636713	-	Creek 636713	5	462	462C	374323	5899345	28/05/2004
100-567134-610692-522527-636713-637972	-	-	1	446	446C	374679	5898877	28/05/2004
100-567134-610692-522527-674890	-	-	1	72067	72067C	376522	5897921	12/07/2006
100-567134-610692-522527-688328	-	Creek 688328	1	1042	1042C	376301	5898028	28/05/2004
100-567134-610692-522527-688328	-	Creek 688328	1	1056	1056C	374796	5898086	28/05/2004
100-567134-610692-522527-688328	-	Creek 688328	2	451	451C	372584	5897963	28/05/2004
100-567134-610692-522527-688328	-	Creek 688328	2	457	457C	371760	5897959	28/05/2004
100-567134-610692-522527-688328	-	Creek 688328	2	459	459C	371642	5897942	28/05/2004
100-567134-610692-522527-688328-634527	-	-	1	458	458C	371683	5897990	28/05/2004
100-567134-610692-522527-688328-634527-332202	-	-	1	591	591C	371024	5898407	11/06/2004
100-567134-610692-522527-688328-667871	-	-	1	586	586C	371449	5897839	11/06/2004
100-567134-610692-522527-688328-749019	-	-	1	602	602C	370727	5897588	11/06/2004
100-567134-610692-522527-688328-885293	-	-	1	598	598C	369834	5897670	11/06/2004
100-567134-610692-522527-688328	-	-	1	1041	1041C	376325	5898051	28/05/2004
100-567134-610692-522527-704454	-	Creek 704454	4	1059	1059C	375208	5895486	28/05/2004
100-567134-610692-522527-704454	-	Creek 704454	5	72073	72073C	374772	5894863	11/07/2006

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM)[1]		Sampling Date
						Easting	Northing	
100-567134-610692-522527-704454	-	Creek 704454	1	72074	72074C	374532	5894570	11/07/2006
100-567134-610692-522527-704454-503067	-	-	1	72324	72324C	374883	5893049	05/07/2006
100-567134-610692-522527-704454-569241	-	-	1	72083	72083C	373653	5894159	10/07/2006
100-567134-610692-522527-704454-569241	-	-	1	72084	72084C	373162	5893854	10/07/2006
100-567134-610692-522527-704454-569241-068254	-	-	1	72081	72081C	373877	5894102	11/07/2006
100-567134-610692-522527-704454-889316	-	-	1	72079	72079C	373509	5892059	05/07/2006
100-567134-610692-522527-704454-889316	-	-	1	72080	72080C	373375	5891856	05/07/2006
100-567134-610692-522527	-	-	1	72086	72086C	375431	5896855	11/07/2006
100-567134-610692-522527-758727	-	-	1	1047	1047C	375047	5896705	28/05/2004
100-567134-610692-522527-896157	-	-	1	72087	72087C	372693	5895334	10/07/2006
100-567134-610692-522527-899664	-	-	1	649	649C	372261	5895919	15/06/2004
100-567134-610692-522527-948457	-	-	1	72326	72326C	371778	5894712	10/07/2006

Note: [1] NAD 83, Zone 10; ILP - Interim Locator Point; UTM - Universal Transverse Mercator

Table 3.1-1B: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Davidson Creek Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover	Habitat Quality			
																	Over-Wintering	Rearing	Spawning	Migration
100-567134-610692-522527	-	Davidson Creek	5	2223	2223C	27/05/2004	4	S3	Cascade-pool	2	5.37	5.35	0.35	0.37	Cobble	>20	G	G	G	NS
100-567134-610692-522527	-	Davidson Creek	10	1057	1057C	28/05/2004	2	S3	Riffle-pool	3.67	3.72	3.67	0.37	0.73	Gravel	>20	P	G	G	NS
100-567134-610692-522527-114028-318876	-	-	1	2225	2225C	27/05/2004	1	S4	Cascade-pool	1.33	0.55	0.55	0.10	0.23	Fines	>20	N	P	N	NS
100-567134-610692-522527-226858	-	Creek 226858	1	72039	72039C	27/05/2004	2	S4	Cascade-pool	2.50	0.79	0.79	0.22	0.33	Cobble	>20	N	G	P	NS
100-567134-610692-522527-226858	-	Creek 226858	1	72047	72047C	27/05/2004	1	S4	Riffle-pool	3.50	0.65	0.52	0.24	0.17	Fines	5-20	N	P	N	NS
100-567134-610692-522527-428073	-	Creek 428073	1	2251	2251C	29/05/2004	2	S4	Cascade-pool	2	1.25	1.13	0.10	0.30	Cobble	>20	N	G	F	NS
100-567134-610692-522527-428073-240670	-	-	1	2254	2254C	29/05/2004	1	S4	Cascade-pool	1	0.80	0.80	0.15	0.9	Fines	5-20	N	G	P	NS
100-567134-610692-522527-428073-184112	-	-	1	2252	2252C	29/05/2004	1	S4	Riffle-pool	1.67	0.53	0.53	0.13	0.23	Fines	5-20	N	F	N	NS
100-567134-610692-522527-616152	-	-	1	72055	72055C	12/07/2006	1	S4	Step-pool	0	0.78	0.78	0.28	0.17	Cobble	>20	N	P	P	NS
100-567134-610692-522527-636713	-	Creek 636713	1	2261	2261C	29/05/2004	3	S4	Cascade-pool	0.67	1.23	1.20	0.13	0.23	Fines	5-20	N	G	P	NS
100-567134-610692-522527-636713	-	Creek 636713	5	462	462C	28/05/2004	1	S4	Riffle-pool	4	1.17	1.08	0.02	0.47	Cobble	5-20	P	G	F	NS
100-567134-610692-522527-636713-637972	-	-	1	446	446C	28/05/2004	1	S4	Riffle-pool	4.5	0.98	0.98	0.23	0.53	Fines	>20	F	G	P	NS
100-567134-610692-522527-674890	-	-	1	72067	72067C	12/07/2006	1	S4	Riffle-pool	1.5	0.75	0.75	0.08	0.17	Fines	>20	N	P	N	NS
100-567134-610692-522527-688328	-	Creek 688328	1	1042	1042C	28/05/2004	3	S3	Riffle-pool	3	1.00	1.00	0.01	0.73	Gravel	>20	N	G	G	NS
100-567134-610692-522527-688328	-	Creek 688328	1	1056	1056C	28/05/2004	3	S3	Cascade-pool	16	0.53	0.53	0.07	0.33	Cobble	5-20	N	F	P	NS
100-567134-610692-522527-688328	-	Creek 688328	2	451	451C	28/05/2004	3	S3	Cascade-pool	10	0.60	0.53	0.01	0.3	Gravel	<5	P	P	P	NS
100-567134-610692-522527-688328	-	Creek 688328	2	457	457C	28/05/2004	3	S3	Cascade-pool	6.67	1.62	1.53	0.07	0.7	Cobble	>20	F	G	F	NS
100-567134-610692-522527-688328	-	Creek 688328	2	459	459C	28/05/2004	2	S4	Riffle-pool	7.5	1.17	1.17	0.03	0.53	Cobble	5-20	P	G	F	NS
100-567134-610692-522527-688328	-	Creek 688328	2	457	457C	28/05/2004	3	S3	Cascade-pool	6.67	1.62	1.53	0.07	0.7	Cobble	>20	F	G	F	NS
100-567134-610692-522527-688328	-	Creek 688328	2	459	459C	28/05/2004	2	S4	Riffle-pool	7.5	1.17	1.17	0.03	0.53	Cobble	5-20	P	G	F	NS
100-567134-610692-522527-688328-634527	-	-	1	458	458C	28/05/2004	2	S3	Cascade-pool	6	1.08	1.08	0.03	0.53	Cobble	5-20	P	G	F	NS
100-567134-610692-522527-688328-634527-332202	-	-	1	591	591C	11/06/2004	1	S4	Riffle-pool	3.67	0.90	0.90	0.03	0.5	Fines	<5	P	P	P	NS
100-567134-610692-522527-688328-667871	-	-	1	586	586C	11/06/2004	1	S4	Riffle-pool	6	0.83	0.83	0.03	0.4	Cobble	<5	P	P	P	NS
100-567134-610692-522527-688328-749019	-	-	1	602	602C	11/06/2004	1	S4	Cascade-pool	9.67	0.81	0.81	0.02	0.4	Cobble	<5	P	F	P	NS
100-567134-610692-522527-688328-885293	-	-	1	598	598C	11/06/2004	1	S4	Riffle-pool	10	0.70	0.70	0.01	0.4	Cobble	<5	P	P	P	NS
100-567134-610692-522527-688328	-	-	1	1041	1041C	28/05/2004	1	S4	Cascade-pool	4.67	2.38	2.38	0.19	0.73	Cobble	>20	N	F	F	NS
100-567134-610692-522527-704454	-	Creek 704454	4	1059	1059C	28/05/2004	3	S3	Cascade-pool with cobble	4.33	1.35	1.35	0.16	0.53	Cobble	>20	N	F	P	NS
100-567134-610692-522527-704454	-	Creek 704454	5	72073	72073C	11/07/2006	3	S3	Riffle-pool	4	2.77	2.77	0.68	0.47	Gravel	>20	F	G	G	NS
100-567134-610692-522527-704454	-	Creek 704454	1	72074	72074C	11/07/2006	3	S4	Riffle-pool	3.5	0.85	0.85	0.25	0.27	Fines	5-20	N	F	N	NS
100-567134-610692-522527-704454-503067	-	-	1	72324	72324C	05/07/2006	1	S4	Cascade-pool	16.5	1.17	1.06	0.05	0.15	Cobble	<5	N	P	N	NS
100-567134-610692-522527-704454-569241	-	-	1	72083	72083C	10/07/2006	1	S4	Large Channel	1	1.07	1.07	0.16	0	Fines	<5	N	P	N	NS
100-567134-610692-522527-704454-569241	-	-	1	72084	72084C	10/07/2006	1	S6	Riffle-pool	2.5	0.43	0.22	0.05	0.37	Bedrock	5-20	N	P	N	NS
100-567134-610692-522527-704454-569241-068254	-	-	1	72081	72081C	11/07/2006	1	S4	Riffle-pool	4	1.42	1.42	0.20	0.27	Cobble	5-20	N	F	N	NS
100-567134-610692-522527-704454-889316	-	-	1	72079	72079C	05/07/2006	1	S6	Cascade-pool	20.33	1.04	0.99	0.02	0.13	Cobble	<5	N	P	N	NS
100-567134-610692-522527-704454-889316	-	-	1	72080	72080C	05/07/2006	1	S6	Cascade-pool	22.5	0.73	0.73	0.00	0.23	Bedrock	<5	N	P	N	NS
100-567134-610692-522527	-	-	1	72086	72086C	11/07/2006	1	S6	Cascade-pool	22.5	0.42	0.42	0.13	0.13	Cobble	-	N	P	N	NS
100-567134-610692-522527-758727	-	-	1	1047	1047C	28/05/2004	2	S3	Cascade-pool	15	1.10	1.10	0.08	0.53	Cobble	5-20	N	G	G	NS
100-567134-610692-522527-896157	-	-	1	72087	72087C	10/07/2006	1	S3	Step-pool	13.5	1.87	1.87	0.18	0.4	Bedrock	5-20	N	F	P	NS
100-567134-610692-522527-899664	-	-	1	649	649C	15/06/2004	1	S4	Riffle-pool	3.67	1.13	1.30	0.03	0.47	Cobble	5-20	P	G	P	NS
100-567134-610692-522527-948457	-	-	1	72326	72326C	10/07/2006	1	S4	Riffle-pool	2.5	0.85	0.85	0.05	0.2	Fines	<5	N	P	P	NS

Note: % - percent; B_fW - bankfull width; NS - not specified; WW - Wetted Width; Res. - Residual; B_fD - bankfull depth, N - none; P - poor; F - fair; G - good

Turtle Creek Watershed

370000 372500 375000 377500 380000 382500

5910000 5907500 5905000 5902500 5900000

Davidson Creek

Rawlnite Creek

Snake Lake

Davidson Creek

Davidson Creek

Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:50,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification Turtle Creek Watershed

DATE: June, 2013	ANALYST: MY	**Figure** 3.1-1B
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-060_stream_class_TC_v2.pdf
GIS FILE: 10-100-060_stream_class_TC_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095 Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-060_stream_class_TC_v2.mxd

Table 3.1-1C: Reconnaissance 1:20,000 Stream Habitat Assessment Site Locations for the Turtle Creek Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date
						Easting	Northing	
100-567134-610692-480511	-	Turtle Creek	1	72023	72023C	382932	5908537	13/07/2006
100-567134-610692-480511	-	Turtle Creek	1	72024	72024C	383299	5908706	13/07/2006
100-567134-610692-480511	-	Turtle Creek	3	2222	2222C	378797	5905950	27/05/2004
100-567134-610692-480511	-	Turtle Creek	3	1018	1018C	376618	5904686	26/05/2004
100-567134-610692-480511	-	Turtle Creek	7	1022	1022C	372971	5904134	12/06/2004
100-567134-610692-480511	-	Turtle Creek	15	64	64C	369198	5901842	09/05/2001
100-567134-610692-480511-392467	-	-	1	2246	2246C	378634	5904873	28/05/2004
100-567134-610692-480511-392467	-	-	1	401	401C	375815	5901579	25/05/2004
100-567134-610692-480511-392467	-	-	1	408	408C	377045	5901927	26/05/2004
100-567134-610692-480511-392467-541823-129108	-	-	1	1017	1017C	376937	5904453	26/05/2004
100-567134-610692-480511-645840	-	Creek 700	1	1002	1002C	374012	5903607	25/05/2004
100-567134-610692-480511-645840	-	Creek 700	5	430	430C	373094	5899896	27/05/2004
100-567134-610692-480511-645840	182	Creek 700	1	1061	1061C	373263	5901816	30/05/2004
100-567134-610692-480511-645840	168	Creek 700	1	437	437C	370797	5899556	27/05/2004
100-567134-610692-480511-645840-465484	178	-	1	439	439C	372405	5900920	27/05/2004
100-567134-610692-480511-645840-643462	-	-	2	429	429C	373520	5899683	27/05/2004
100-567134-610692-480511-645840-877011	-	-	1	434	434C	371612	5899487	27/05/2004
100-567134-610692-480511-690551		-	1	1001	1001C	373880	5903697	25/05/2004
100-567134-610692-480511-690551		-	1	1038	1038C	371464	5901657	27/05/2004
100-567134-610692-480511-690551		-	1	1030	1030C	370512	5901124	27/05/2004
100-567134-610692-480511-690551		-	2	1027	1027C	370463	5901030	27/05/2004
-		-	1	1037	1037C	373000	5902021	27/05/2004
100-567134-610692-480511-690551-501592		-	1	1026	1026C	372050	5902022	27/05/2004
100-567134-610692-480511-690551-686484		-	1	1028	1028C	371239	5901544	27/05/2004
100-567134-610692-480511-690551-835872		-	3	1039	1039C	370207	5901014	27/05/2004

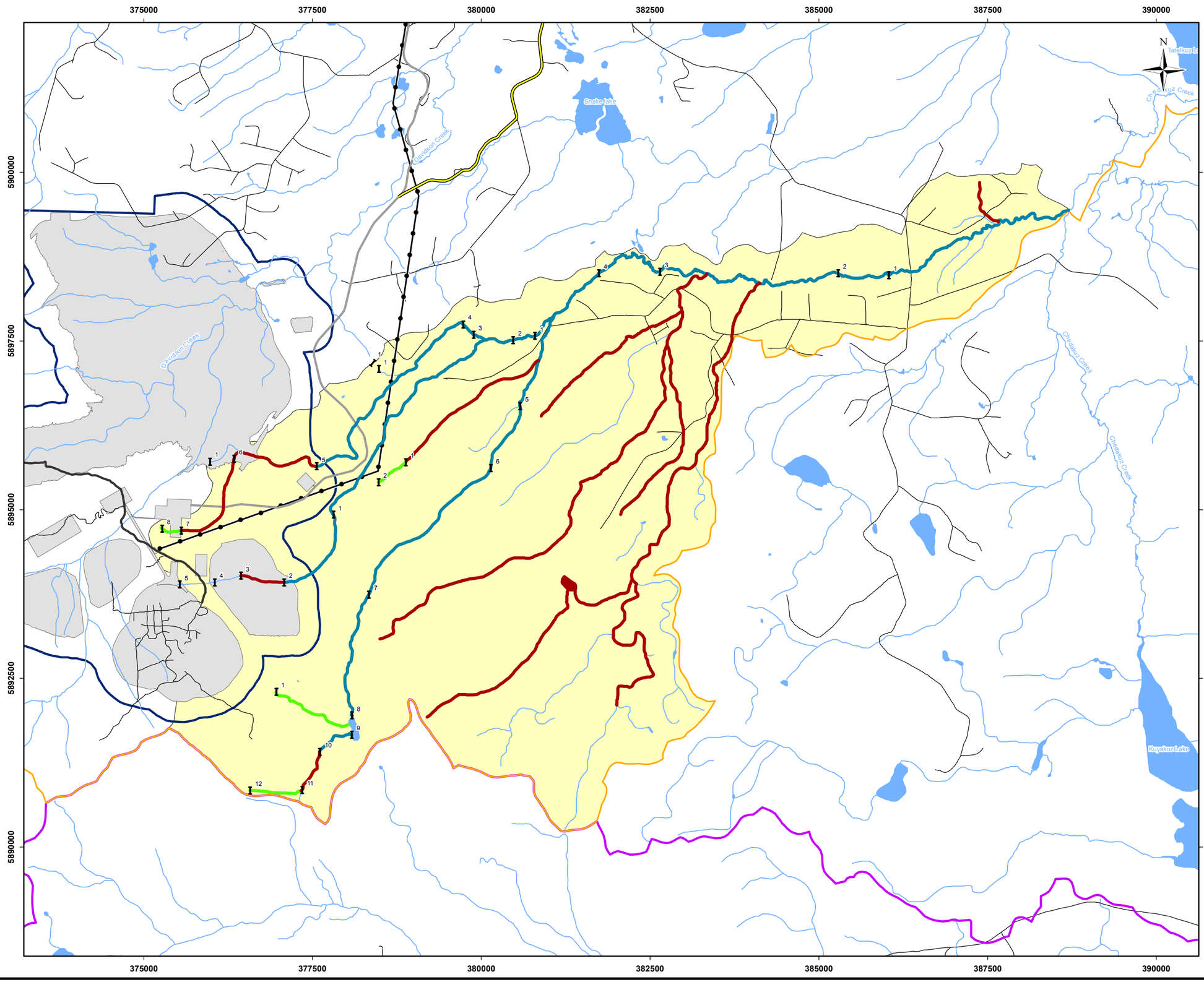
Note: [1] NAD 83, Zone 10; ILP - Interim Locator Point; UTM - Universal Transverse Mercator

Table 3.1-1D: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Turtle Creek Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover	Habitat Quality			
																	Over-Wintering	Rearing	Spawning	Migration
100-567134-610692-480511	-	Turtle Creek	1	72023	72023C	13/07/2006	1	NVC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
100-567134-610692-480511	-	Turtle Creek	1	72024	72024C	13/07/2006	4	S3	Large Channel	0.50	3.35	3.35	0.63	0.1	Fines	>20	F	G	P	NS
100-567134-610692-480511	-	Turtle Creek	3	2222	2222C	27/05/2004	4	S3	Cascade-pool	4.67	3.42	3.33	0.42	0.57	Cobble	>20	G	G	G	NS
100-567134-610692-480511	-	Turtle Creek	3	1018	1018C	26/05/2004	3	S3	Large Channel	2.33	0.83	0.67	0.03	0.67	Fines	5-20	N	F	P	NS
100-567134-610692-480511	-	Turtle Creek	7	1022	1022C	12/06/2004	3	S4	Riffle-pool	4.33	1.02	1.02	0.01	0.23	Fines	<5	N	P	P	NS
100-567134-610692-480511-392467	-	Turtle Creek	15	64	64C	09/05/2001	1	S6	Riffle-pool	21.25	0.75	0.00	0.00	0.20	Cobble	<5	N	N	N	NS
100-567134-610692-480511-392467	-	-	1	2246	2246C	28/05/2004	3	S4	Cascade-pool	4.00	0.90	0.88	0.18	0.47	Cobble	>20	G	G	G	NS
100-567134-610692-480511-392467	-	-	1	401	401C	25/05/2004	1	S4	Riffle-pool	5.00	0.75	0.58	0.01	0.30	Fines	<5	P	P	P	NS
100-567134-610692-480511-392467-541823-129108	-	-	1	408	408C	26/05/2004	1	S4	Riffle-pool	5.67	1.03	1.03	0.35	0.53	Fines	>20	P	G	F	NS
100-567134-610692-480511-392467	-	-	1	1017	1017C	26/05/2004	2	S4	Riffle-pool	5.33	0.54	0.62	0.04	0.60	Fines	5-20	N	F	P	NS
100-567134-610692-480511-645840	-	Creek 700	1	1002	1002C	25/05/2004	2	S3	Riffle-pool	4.67	2.60	1.88	0.18	0.7	Gravel	>20	N	G	G	NS
100-567134-610692-480511-645840	-	Creek 700	5	430	430C	27/05/2004	2	S4	Riffle-pool	4.67	1.38	1.38	0.10	0.53	Cobble	5-20	F	G	F	NS
100-567134-610692-480511-645840	182	Creek 700	1	1061	1061C	30/05/2004	2	S4	Riffle-pool	3.33	0.87	0.87	0.09	0.3	Fines	5-20	N	F	P	NS
100-567134-610692-480511-645840	168	Creek 700	1	437	437C	27/05/2004	1	S4	Cascade-pool	11.00	0.14	0.06	0.01	0.2	Cobble	0	N	P	G	NS
100-567134-610692-480511-645840-465484	178	-	1	439	439C	27/05/2004	1	S6	Step-pool	11.5	0.55	0.55	0.01	0.3	Cobble	<5	P	P	P	NS
100-567134-610692-480511-645840-643462	-	-	2	429	429C	27/05/2004	1	NCD	Step-pool	5.33	0.72	0.72	0.01	0.4	Cobble	<5	N	F	P	NS
100-567134-610692-480511-645840-877011	-	-	1	434	434C	27/05/2004	1	S4	Riffle-pool	7.00	0.65	0.65	0.01	0.3	Fines	<5	P	P	P	NS
100-567134-610692-480511-690551	-	-	1	1001	1001C	25/05/2004	2	S3	Cascade-pool	5.00	2.32	1.43	0.22	0.67	Gravel	>20	P	G	G	NS
100-567134-610692-480511-690551	-	-	1	1038	1038C	27/05/2004	2	S4	Step-pool	10.33	0.52	0.52	0.08	0.40	Fines	<5	N	P	N	NS
100-567134-610692-480511-690551	-	-	1	1030	1030C	27/05/2004	2	S4	Cascade-pool	9.67	0.73	0.73	0.08	0.47	Fines	5-20	N	F	P	NS
100-567134-610692-480511-690551	-	-	2	1027	1027C	27/05/2004	1	S4	Riffle-pool	7.00	0.85	0.85	0.07	0.53	Cobble	5-20	N	G	F	NS
-	-	-	1	1037	1037C	27/05/2004	1	S6	Cascade-pool	30.67	0.52	0.43	0.02	0.30	Gravel	<5	N	P	P	NS
100-567134-610692-480511-690551-501592	-	-	1	1026	1026C	27/05/2004	1	S4	Riffle-pool	2.67	0.73	0.73	0.07	0.47	Fines	<5	N	F	P	NS
100-567134-610692-480511-690551-686484	-	-	1	1028	1028C	27/05/2004	1	S4	Step-pool	16.00	0.33	0.27	0.04	0.20	Cobble	<5	N	P	P	NS
100-567134-610692-480511-690551-835872	-	-	3	1039	1039C	27/05/2004	1	S4	Riffle-pool	11.00	0.47	0.47	0.02	0.33	Fines	<5	N	P	P	NS

Note: % - percent; B_fW - bankfull width; NS - not specified; WW - Wetted Width; Res. - Residual; B_fD - bankfull depth, N - none; P - poor; F - fair; G - good

Creek 661 Watershed



Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:54,698

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification Creek 661 Watershed

DATE:	ANALYST:	
June, 2013	MY	Figure 3.1-1C
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-062_stream_class_661_v2.pdf
GIS FILE: 10-100-062_stream_class_661_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-062_stream_class_661_v2.mxd

Table 3.3-1E: Reconnaissance 1:20,000 Stream Habitat Assessment Site Locations for the Creek 661 Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date
						Easting	Northing	
100-567134-610692-671007	-	Creek 661	1	72150	72510C	386351	5898528	05/07/2006
100-567134-610692-671007	-	Creek 661	3	72184	72184C	383797	5898458	12/07/2006
100-567134-610692-671007	-	Creek 661	5	72205	72205C	381008	5897724	05/07/2006
100-567134-610692-671007	-	Creek 661	7	72221	72221C	379899	5895407	12/07/2006
100-567134-610692-671007	-	Creek 661	8	72223	72223C	378037	5892140	05/07/2006
100-567134-610692-671007	-	Creek 661	10	72225	72225C	377993	5891666	05/07/2006
100-567134-610692-671007-068872	-	-	1	72153	72153C	387658	5899275	05/07/2006
100-567134-610692-671007-290525	-	-	1	72166	72166C	383704	5897514	05/07/2006
100-567134-610692-671007-290525-497193	-	-	1	72169	72169C	382210	5893872	11/07/2006
100-567134-610692-671007-290525	-	-	1	72338	72338C	382255	5893865	11/07/2006
100-567134-610692-671007-290525	-	-	1	72171	72171C	382060	5893615	11/07/2006
100-567134-610692-671007-290525	-	-	1	72172	72172C	381938	5893262	11/07/2006
100-567134-610692-671007-290525	-	-	1	72337	72337C	382463	5892783	11/07/2006
100-567134-610692-671007-340300	-	-	1	72187	72187C	382925	5898295	05/07/2006
100-567134-610692-671007-340300-105964	-	-	1	72189	72189C	382901	5897886	12/07/2006
100-567134-610692-671007-340300-105964	-	-	1	72190	72190C	382402	5897603	12/07/2006
100-567134-610692-671007-340300	-	-	1	72192	72192C	382751	5897522	12/07/2006
100-567134-610692-671007-340300	-	-	1	72340	72340C	382730	5897394	12/07/2006
100-567134-610692-671007-340300	-	-	1	72194	72194C	382685	5897253	12/07/2006
100-567134-610692-671007-340300-179404	-	-	1	72334	72334C	381749	5894649	11/07/2006
100-567134-610692-671007-340300	-	-	1	72336	72336C	380132	5893897	11/07/2006
100-567134-610692-671007-505659	-	Creek 505659	5	72210	72210C	379672	5897742	12/07/2006
100-567134-610692-671007-505659	-	Creek 505659	5	72212	72212C	377907	5895794	11/07/2006
100-567134-610692-671007-505659-146920	-	-	1	72206	72206C	379917	5897374	12/07/2006

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date
						Easting	Northing	
100-567134-610692-671007-505659-146920	-	-	2	72207	72207C	377813	5894900	11/07/2006
100-567134-610692-671007-505659-146920	-	-	2	72208	72208C	377269	5893929	11/07/2006
100-567134-610692-671007-505659-764541	-	-	1	72213	72213C	376370	5895895	11/07/2006
100-567134-610692-671007-543585	-	-	1	72216	72216C	379916	5896735	12/07/2006

Note: [1] NAD 83, Zone 10; ILP - Interim Locator Point; UTM - Universal Transverse Mercator

Table 3.1-1F: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Creek 661 Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover	Habitat Quality			
																	Over-Wintering	Rearing	Spawning	Migration
100-567134-610692-671007	-	Creek 661	1	72150	72510C	05/07/2006	4	S3	Riffle-pool	1	3.48	3.33	0.24	0.43	Gravel	5-20	P	G	F	NS
100-567134-610692-671007	-	Creek 661	3	72184	72184C	12/07/2006	3	S3	Riffle-pool	5.5	4.00	4.00	0.19	0.3	Gravel	5-20	F	G	F	NS
100-567134-610692-671007	-	Creek 661	5	72205	72205C	05/07/2006	2	S3	Riffle-pool with gravel	1.5	1.90	1.62	0.21	0.37	Fines	>20	N	F	P	NS
100-567134-610692-671007	-	Creek 661	7	72221	72221C	12/07/2006	2	S3	Riffle-pool with gravel	2.5	1.87	1.87	0.17	0.33	Gravel	>20	N	G	P	NS
100-567134-610692-671007	-	Creek 661	8	72223	72223C	05/07/2006	2	S3	Large Channel	2.5	2.47	2.47	0.61	0.37	Fines	NS	F	G	P	NS
100-567134-610692-671007	-	Creek 661	10	72225	72225C	05/07/2006	2	S3	Riffle-pool	2.5	1.74	1.35	0.22	0.43	Fines	5-20	N	F	N	NS
100-567134-610692-671007-068872	-	-	1	72153	72153C	05/07/2006	1	S4	Riffle-pool	7	0.71	0.61	0.04	0.33	Gravel	>20	N	P	N	NS
100-567134-610692-671007-290525	-	-	1	72166	72166C	05/07/2006	3	S4	Riffle-pool	3	1.02	0.80	0.27	0.27	Fines	5-20	P	F	F	NS
100-567134-610692-671007-290525-497193	-	-	1	72169	72169C	11/07/2006	1	S4	Riffle-pool	7.5	0.75	0.75	0.06	0.17	Fines	5-20	N	F	N	NS
100-567134-610692-671007-290525	-	-	1	72338	72338C	11/07/2006	3	S4	Riffle-pool	6.5	0.74	0.74	0.09	0.13	Fines	5-20	N	F	P	NS
100-567134-610692-671007-290525	-	-	1	72171	72171C	11/07/2006	3	S4	Riffle-pool	5	0.36	0.36	0.10	0.1	Fines	<5	N	P	P	NS
100-567134-610692-671007-290525	-	-	1	72172	72172C	11/07/2006	3	S4	Riffle-pool	15	0.80	0.80	0.12	0.27	Cobble	5-20	N	F	P	NS
100-567134-610692-671007-290525	-	-	1	72337	72337C	11/07/2006	2	S4	Step-pool with boulders	25.8	0.73	0.73	0.05	0.1	Cobble	5-20	N	F	N	NS
100-567134-610692-671007-340300	-	-	1	72187	72187C	05/07/2006	2	S4	Riffle-pool with gravel	1	1.15	1.05	0.18	0.33	Fines	>20	N	F	P	NS
100-567134-610692-671007-340300-105964	-	-	1	72189	72189C	12/07/2006	1	S4	Riffle-pool	3.5	1.17	0.85	0.08	0.23	Gravel	>20	N	P	N	NS
100-567134-610692-671007-340300-105964	-	-	1	72190	72190C	12/07/2006	1	S4	Riffle-pool	2	0.62	0	0.01	0.2	Fines	<5	N	P	N	NS
100-567134-610692-671007-340300	-	-	1	72192	72192C	12/07/2006	2	S4	Riffle-pool	2	1.47	1.32	0.33	0.33	Fines	>20	P	G	N	NS
100-567134-610692-671007-340300	-	-	1	72340	72340C	12/07/2006	1	S4	Riffle-pool	5.5	0.73	0.65	0.01	0.1	Fines	>20	N	P	N	NS
100-567134-610692-671007-340300	-	-	1	72194	72194C	12/07/2006	1	S4	Large Channel	0.3	0.42	0.42	0.01	0.1	Fines	5-20	N	P	N	NS
100-567134-610692-671007-340300-179404	-	-	1	72334	72334C	11/07/2006	1	S4	Riffle-pool	3	1.23	0.85	0.34	0.3	Fines	>20	F	G	N	NS
100-567134-610692-671007-340300	-	-	1	72336	72336C	11/07/2006	1	S4	Riffle-pool	12.5	0.12	0.12	0.01	0.2	Fines	<5	N	P	P	NS
100-567134-610692-671007-505659	-	Creek 505659	5	72210	72210C	12/07/2006	2	S3	Riffle-pool with gravel	1.5	1.88	1.88	0.19	0.33	Fines	>20	N	F	F	NS
100-567134-610692-671007-505659	-	Creek 505659	5	72212	72212C	11/07/2006	2	S4	Riffle-pool	0.5	1.52	1.48	0.44	0.33	Gravel	5-20	N	G	F	NS
100-567134-610692-671007-505659-146920	-	-	1	72206	72206C	12/07/2006	1	S3	Riffle-pool with gravel	1	2.38	2.17	0.20	0.33	Gravel	5-20	N	F	G	NS
100-567134-610692-671007-505659-146920	-	-	2	72207	72207C	11/07/2006	1	S3	Cascade-pool	9.5	1.87	1.87	0.39	0.1	Cobble	5-20	N	G	F	NS
100-567134-610692-671007-505659-146920	-	-	2	72208	72208C	11/07/2006	1	S4	Cascade-pool	15	1.06	1.06	0.26	0.1	Cobble	>20	N	F	P	NS
100-567134-610692-671007-505659-764541	-	-	1	72213	72213C	11/07/2006	1	S4	Riffle-pool	0.5	0.73	0.73	0.30	0.13	Fines	5-20	N	F	N	NS
100-567134-610692-671007-543585	-	-	1	72216	72216C	12/07/2006	1	S4	Riffle-pool	1	1.02	0.95	0.19	0.4	Fines	>20	N	P	N	NS

Note: % - percent; BfW - bankfull width; NS - not specified; WW - Wetted Width; Res. - Residual; BfD - bankfull depth, N - none; P - poor; F - fair; G - good

Creek 705 Watershed

360000 362500 365000 367500 370000

5897500 5895000 5892500 5890000

Top Lake
Fawnie Creek
Fawnie Creek
Davidson Creek
Mathews Creek

N

Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:40,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification Creek 705 Watershed

DATE:	ANALYST:	
June, 2013	MY	**Figure** 3.1-1D
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-061_stream_class_705_v3.pdf
GIS FILE: 10-100-061_stream_class_705_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-061_stream_class_705_v3.mxd

Table 3.1-1G: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Creek 705 Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date
						Easting	Northing	
100-567134-641477-543682-698692	-	Creek 705	2	923	923C	362053	5892723	01/08/2001
100-567134-641477-543682-698692	32	Creek 705	2	919	919C	363594	5893220	02/08/2001
100-567134-641477-543682-698692	-	Creek 705	2	131	131C	364127	5893495	16/08/2001
100-567134-641477-543682-698692	-	Creek 705	3	926	926C	366574	5894687	02/08/2001
100-567134-641477-543682-698692	-	Creek 705	11	646	646C	370781	5893092	15/06/2004
100-567134-641477-543682-698692	-	Creek 705	11	648	648C	370935	5893408	15/06/2004
100-567134-641477-543682-698692-165106	26	-	1	922	922C	362221	5892474	02/08/2001
100-567134-641477-543682-698692-236870	27	-	1	921	921C	362922	5892884	02/08/2001
100-567134-641477-543682-698692-320611	53	-	1	132	132C	364251	5894685	16/08/2001
100-567134-641477-543682-698692-398670	35	-	1	118	118C	366783	5892219	15/08/2001
100-567134-641477-543682-698692-398670	36	-	1	119	119C	366745	5892448	15/08/2001
100-567134-641477-543682-698692-398670	35	-	1	121	121C	366210	5892752	15/08/2001
100-567134-641477-543682-698692-398670	700	-	1	122	122C	365728	5892960	15/08/2001
100-567134-641477-543682-698692-398670	23	-	1	985	985C	365168	5893689	22/08/2001
100-567134-641477-543682-698692-495919	51	-	1	113	113C	366181	5895363	14/08/2001
100-567134-641477-543682-698692-569529	38	-	1	976	976C	367142	5894293	22/08/2001
100-567134-641477-543682-698692-569529	38	-	1	977	977C	367219	5894518	22/08/2001
100-567134-641477-543682-698692-606013	-	-	1	981	981C	368772	5895050	22/08/2001
100-567134-641477-543682-698692-606013	-	-	4	656	656C	370028	5896101	15/06/2004
100-567134-641477-543682-698692-606013-224852	-	-	1	979	979C	369180	5894614	22/08/2001
100-567134-641477-543682-598692-606013	28777	Creek 606013	1	28777	28777C	370840	5896714	1997/08/07
100-567134-641477-543682-598692-320611	8777	-	2	8777	8777C	364353	5894932	1997/08/06
100-567134-641477-543682-598692-442342	14777	-	2	14777	14777C	365570	5895300	1997/08/06
100-567134-641477-543682-598692-495919	15777	-	2	15777	15777C	366207	5895282	1997/08/06
100-567134-641477-543682-598692-730659	23777	-	1	23777	23777C	369749	5896198	1997/09/07
100-567134-641477-543682-598692-606013-581841	22777	-	1	22777	22777C	368922	5893454	1997/08/07

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date
						Easting	Northing	
-	16777	-	2	16777	16777C	367750	5895896	1997/08/07
-	46	-	1	109	109C	367786	5895927	14/08/2001
-	50	-	1	112	112C	367260	5895852	14/08/2001
-	37	-	1	117	117C	367175	5892451	15/08/2001
-	39	-	1	127	127C	369603	5893543	15/08/2001
-	39	-	1	129	129C	369410	5893845	15/08/2001
-	48	-	1	984	984C	368187	5896485	22/08/2001

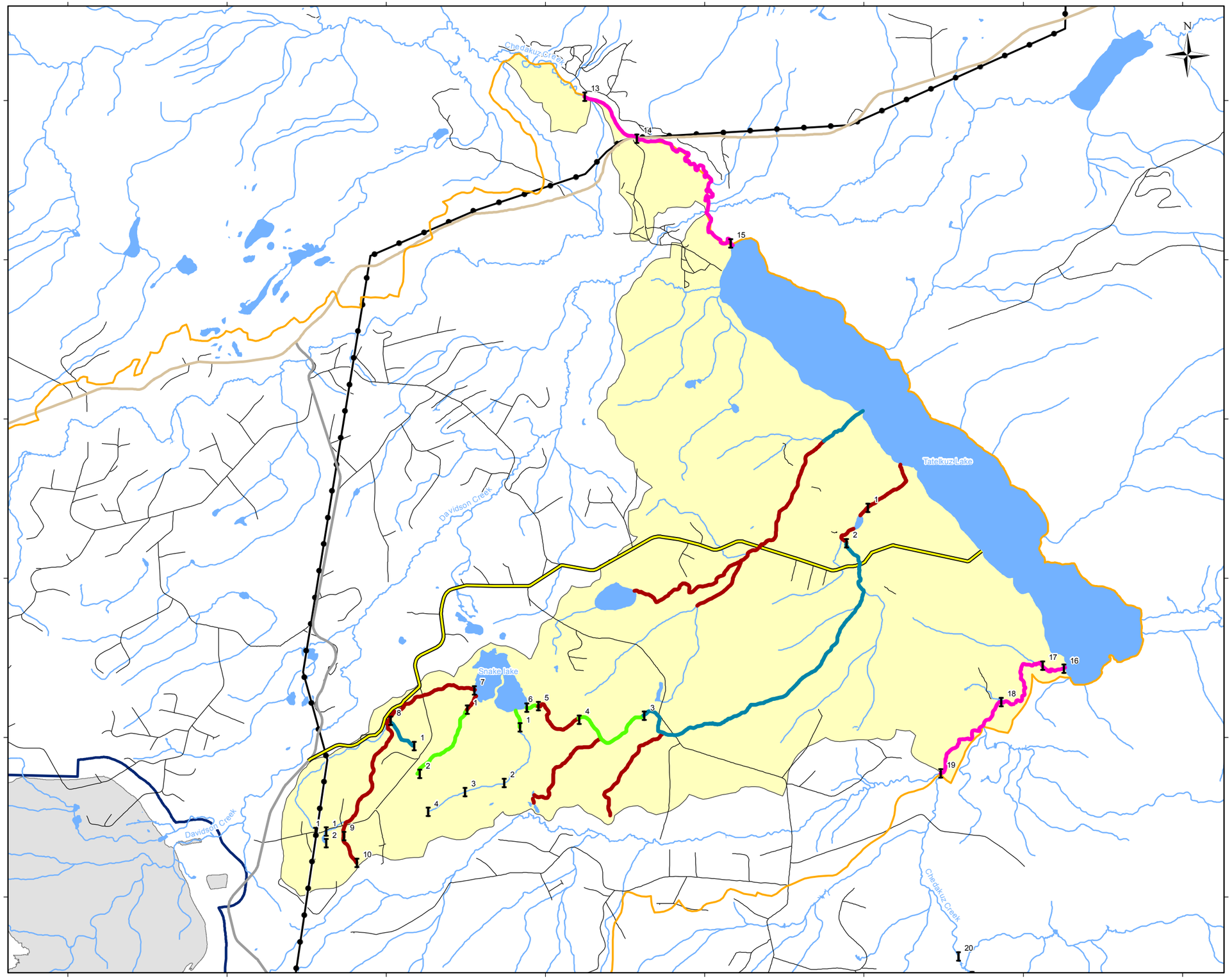
Note: [1] NAD 83, Zone 10; ILP - Interim Locator Point; UTM - Universal Transverse Mercator

Table 3.1-1H: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Creek 705 Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover	Habitat Quality			
																	Over-Wintering	Rearing	Spawning	Migration
100-567134-641477-543682-698692	-	Creek 705	2	923	923C	01/08/2001	3	S2	Riffle-pool	11.33	0.95	0.95	0.11	0.4	Gravel	>20	G	G	F	NS
100-567134-641477-543682-698692	32	Creek 705	2	919	919C	02/08/2001	3	S6	Riffle-pool	26.0	0.83	0.75	0.06	0.33	Cobble	5-20	NS	NS	NS	NS
100-567134-641477-543682-698692	-	Creek 705	2	131	131C	16/08/2001	3	S2	Riffle-pool	3	4.45	4.32	0.10	0.73	Cobble	>20	N	G	G	NS
100-567134-641477-543682-698692	-	Creek 705	3	926	926C	02/08/2001	3	S3	Riffle-pool	0.25	2.62	2.07	0.10	0.5	Gravel	5-20	N	G	G	NS
100-567134-641477-543682-698692	-	Creek 705	11	646	646C	15/06/2004	2	S4	Cascade-pool	86.67	0.77	0.77	0.01	0.23	Rock	0	N	N	N	NS
100-567134-641477-543682-698692	-	Creek 705	11	648	648C	15/06/2004	2	S4	Riffle-pool	7	1.45	1.45	0.10	0.53	Cobble	>20	F	G	F	NS
100-567134-641477-543682-698692-165106	26	-	1	922	922C	02/08/2001	1	S4	Large channel	1.5	0.95	0.92	0.13	0.37	Fines	5-20	F	P	F	NS
100-567134-641477-543682-698692-236870	27	-	1	921	921C	02/08/2001	1	S4	Riffle-pool	3.5	1.32	1.28	0.09	0.57	Fines	5-20	NS	F	NS	NS
100-567134-641477-543682-698692-320611	53	-	1	132	132C	16/08/2001	2	S4	Step-pool	8.0	1.06	0.94	0.05	0.37	Gravel	0	N	P	F	NS
100-567134-641477-543682-698692-398670	35	-	1	118	118C	15/08/2001	1	S4	Step-pool	9.0	1.24	1.19	0.05	0.27	Cobble	5-20	N	G	F	NS
100-567134-641477-543682-698692-398670	36	-	1	119	119C	15/08/2001	1	S4	Cascade-pool	7.0	0.92	0.92	0.00	0.30	Cobble	5-20	N	F	P	NS
100-567134-641477-543682-698692-398670	35	-	1	121	121C	15/08/2001	1	S3	Step-pool	2.5	1.90	1.61	0.11	0.40	Cobble	5-20	N	G	F	NS
100-567134-641477-543682-698692-398670	700	-	1	122	122C	15/08/2001	1	S4	Step-pool	11.0	0.97	0.97	0.09	0.63	Cobble	5-20	N	G	F	NS
100-567134-641477-543682-698692-398670	23	-	1	985	985C	22/08/2001	1	S3	Riffle-pool	5.5	2.77	2.65	0.12	0.37	Cobble	5-20	NS	NS	NS	NS
100-567134-641477-543682-698692-495919	51	-	1	113	113C	14/08/2001	1	S4	Step-pool	19.0	0.73	0.00	0.00	0.30	Cobble	5-20	N	F	P	NS
100-567134-641477-543682-698692-569529	38	-	1	976	976C	22/08/2001	1	S4	Riffle-pool	14.0	0.62	0.83	0.04	0.30	Fines	5-20	NS	P	NS	NS
100-567134-641477-543682-698692-569529	38	-	1	977	977C	22/08/2001	1	S4	Riffle-pool	7.3	1.01	0.94	0.07	0.43	Cobble	5-20	N	F	P	NS
100-567134-641477-543682-698692-606013	-	-	1	981	981C	22/08/2001	2	S4	Riffle-pool	2.5	1.17	1.13	0.10	0.3	Cobble	>20	NS	G	F	NS
100-567134-641477-543682-698692-606013	-	-	4	656	656C	15/06/2004	2	S4	Riffle-pool	5.5	0.82	0.82	0.03	0.5	Cobble	5-20	P	G	P	NS
100-567134-641477-543682-698692-606013-224852	-	-	1	979	979C	22/08/2001	1	S4	Riffle-pool	9.5	1.13	1.05	0.07	0.57	Cobble	5-20	N	F	F	NS
100-567134-641477-543682-598692-606013	28777	Creek 606013	1	28777	28777C	1997/08/07	1	S4	RP	18.00	0.25	0.20	0.00	0.17	F	1	NS	P	NS	NS
100-567134-641477-543682-598692-320611	8777	-	2	8777	8777C	1997/08/06	1	S4	RP	8.00	0.78	0.29	0.20	0.37	G	2	NS	NS	P	NS
100-567134-641477-543682-598692-442342	14777	-	2	14777	14777C	1997/08/06	1	NVC	-	16.00	0.00	0.00	0.00	0.00	-	-	NS	NS	NS	NS
100-567134-641477-543682-598692-495919	15777	-	2	15777	15777C	1997/08/06	1	S4	RP	16.00	0.92	0.31	0.13	0.48	C	2	NS	G	NS	NS
100-567134-641477-543682-598692-730659	23777	-	1	23777	23777C	1997/09/07	1	S3	RP	0.25	2.11	2.11	0.51	0.77	F	1	G	G	G	NS
100-567134-641477-543682-598692-606013-581841	22777	-	1	22777	22777C	1997/08/07	1	S4	RP	16.50	0.23	0.00	0.00	0.10	F	1	NS	P	NS	NS
-	16777	-	2	16777	16777C	1997/08/07	1	S4	RP	7.50	1.09	0.74	0.24	0.48	G	1	NS	NS	NS	NS
-	46	-	1	109	109C	14/08/2001	1	S4	Step-pool	5.5	1.00	0.93	0.05	0.93	Gravel	5-20	N	G	G	NS
-	50	-	1	112	112C	14/08/2001	1	S4	Riffle-pool	3.0	1.30	1.02	0.04	1.17	Cobble	5-20	N	G	P	NS
-	37	-	1	117	117C	15/08/2001	1	S4	Step-pool	8.0	1.11	1.10	0.05	0.40	Cobble	5-20	N	G	F	NS
-	39	-	1	127	127C	15/08/2001	1	S3	Riffle-pool	4.7	1.79	1.77	0.08	0.47	Gravel	5-20	N	F	G	NS
-	39	-	1	129	129C	15/08/2001	1	S2	Large channel	0.0	10.00	10.00	0.00	0.00	Fines	0	N	F	P	NS
-	48	-	1	984	984C	22/08/2001	1	S4	Riffle-pool	15.5	1.22	1.22	0.19	0.57	Cobble	5-20	F	F	F	NS

Note: % - percent; BfW - bankfull width; NS - not specified; WW - Wetted Width; Res. - Residual; BfD - bankfull depth, N - none; P - poor; F - fair; G - good

Tatelkuz Lake Tributaries Watershed



375000 377500 380000 382500 385000 387500 390000 392500

5910000 5907500 5905000 5902500 5900000 5897500

Legend

- Reach Break
- Regional Study Area
- Local Study Area
- Road
- Stream
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary

Stream Classification

- S2
- S3
- S4
- S6
- NVC

Scale:1:60,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Classification
Tatelkuz Lake Tributaries Watershed

DATE:	ANALYST:	
June, 2013	MY	**Figure**
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-128_stream_class_tatelkuz_L.pdf
GIS FILE: 10-100-128_stream_class_tatelkuz_L.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Table 3.1-1l: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Tatelkuz Lake Tributaries Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date
						Easting	Northing	
100-567134-610692	14001	Chedakuz Creek	1	60012	60012C	383869	5909439	2002/07/12
100-567134-610692	72143	-	1	72228	72228C	390609	5901115	2006/07/10
100-567134-610692	73168	-	1	73203	73203C	389337	5900133	2006/07/09
100-567134-610692-579340	72108	Creek 579340	1	72274	72274C	388058	5904265	2006/07/10
100-567134-610692-579340	72111	-	1.2	72330	72330C	387434	5902733	2006/07/10
100-567134-610692-579340	72111	-	2	72250	72250C	384545	5900006	2006/07/13
100-567134-610692-579340	72111	-	3	72258	72258C	382566	5900194	2006/07/12
100-567134-610692-579340	72111	-	5.1	72266	72266C	380696	5900709	2006/09/29
100-567134-610692-579340	72114	-	2	72268	72268C	379774	5899264	2006/07/12
100-567134-610692-579340-457887	72127	Creek 457887	1	72252	72252C	384141	5900070	2006/07/13
100-567134-610692-579340-836790	72114	Creek 836970	1	72267	72267C	380044	5900229	2006/07/12
-	72111	-	1.1	72234	72234C	388224	5904179	2006/07/10
100-567134-610692-571602	72089	Creek 571602	1	72281	72281C	386965	5904749	2006/07/10
100-567134-610692-571602	72089	-	2	72285	72285C	386445	5904002	2006/07/10
100-567134-610692-571602	72098	-	1	72288	72288C	385235	5902535	2006/07/10
100-567134-610692-571602-470046	72089	Creek 470046	3.1	72289	72289C	385322	5902327	2006/07/10

Note: [1] NAD 83, Zone 10; ILP - Interim Locator Point; UTM - Universal Transverse Mercator

Table 3.1-1J: Reconnaissance 1:20,000 Stream Habitat Assessment Data for the Tatelkuz Lake Tributaries Watershed

Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Sampling Date	Stream Order	Stream Classification	Stream Morphology/ Habitat	Mean Gradient (%)	Mean B_fW (m)	Mean WW (m)	Mean Res. Pool (m)	Mean B_fD (m)	Bed Materials	Stream Cover	Habitat Quality			
																	Over-Wintering	Rearing	Spawning	Migration
100-567134-610692	14001	Chedakuz Creek	1	60012	60012C	01/08/2001	6	S2	Riffle-pool	2.5	10.29	10.30	0.69	0.80	Cobble	1-20	G	G	G	NS
100-567134-610692	72143	-	1	72228	72228C	02/08/2001	5	S2	Riffle-pool	4.5	8.53	8.53	0.29	0.43	Gravel	1-20	F	G	G	NS
100-567134-610692	73168	-	1	73203	73203C	16/08/2001	5	S3	Riffle-pool	5.5	2.48	2.44	0.38	0.10	Gravel	1-20	P	G	G	NS
100-567134-610692-579340	72108	Creek 579340	1	72274	72274C	02/08/2001	3	S4	Riffle-pool	2.0	0.60	0.48	0.03	0.20	Fines	1-20	N	P	N	NS
100-567134-610692-579340	72111	-	1.2	72330	72330C	15/06/2004	3	S3	Large channel	2.0	1.50	1.50	0.39	0.40	Fines	1-20	P	P	P	NS
100-567134-610692-579340	72111	-	2	72250	72250C	15/06/2004	3	S4	Riffle-pool	2.5	1.33	1.33	0.33	0.30	Fines	1-20	N	F	N	NS
100-567134-610692-579340	72111	-	3	72258	72258C	02/08/2001	2	S3	Cascade-pool	2.5	1.96	1.91	0.33	0.47	Fines	21-40	N	F	N	NS
100-567134-610692-579340	72111	-	5.1	72266	72266C	16/08/2001	2	S4	Large channel	0.3	1.38	0.00	0.16	0.40	Fines	1-20	N	P	N	NS
100-567134-610692-579340	72114	-	2	72268	72268C	15/08/2001	2	S3	Riffle-pool	1.5	1.52	1.50	0.42	0.47	Fines	1-20	P	F	N	NS
100-567134-610692-579340-457887	72127	Creek 457887	1	72252	72252C	02/08/2001	1	S4	Riffle-pool	2.0	0.87	0.87	0.44	0.40	Fines	1-20	L	F	N	NS
100-567134-610692-579340-836970	72114	Creek 836970	1	72267	72267C	15/08/2001	1	S3	Riffle-pool	0.5	1.93	1.87	0.20	0.33	Fines	21-40	N	P	N	NS
-	72111	-	1.1	72234	72234C	15/08/2001	1	S3	Riffle-pool	5.5	2.15	1.80	0.10	0.37	Fines	1-20	P	G	N	NS
100-567134-610692-571602	72089	Creek 571602	1	72281	72281C	15/08/2001	3	S3	Riffle-pool	4.5	1.55	1.32	0.06	0.33	Fines	21-40	P	G	N	NS
100-567134-610692-571602	72089	-	2	72285	72285C	22/08/2001	2	S4	Cascade-pool	7.5	1.33	1.33	0.41	0.53	Fines	1-20	P	G	N	NS
100-567134-610692-571602	72098	-	1	72288	72288C	14/08/2001	1	S4	Large channel	1.5	0.60	0.60	0.60	0.17	Fines	1-20	F	F	N	NS
100-567134-610692-571602-470046	72089	Creek 470046	3.1	72289	72289C	22/08/2001	2	S4	Large channel	1.5	0.85	0.85	0.30	0.33	Fines	1-20	F	F	N	NS

Note: % - percent; B_fW - bankfull width; NS - not specified; WW - Wetted Width; Res. - Residual; B_fD - bankfull depth, N - none; P - poor; F - fair; G - good

Annex 3.1-2
Historical Fish Sampling Effort and Capture Data, 1997 – 2006

365000 367500 370000 372500 375000 377500 380000 382500 385000 387500

5907500 5905000 5902500 5900000 5897500 5895000 5892500

Davidson Creek Basin

Fawnie Creek
Top Lake
Davidson Creek
Mathews Creek
Tatelkuz Lake
Chedakuz Creek

2225C 72039C 2223C 72047C 2252C 2251C 2254C 462C 446C 72055C 2261C 1056C 1041C 591C 459C 458C 598C 457C 586C 1047C 649C 1059C 72073C 72079C 72324C 7.1

N

Scale:1:75,000

1 0.5 0 1 2
Kilometres

Legend

- 1:20,000 Fish and Fish Habitat Inventory (Ecofor 2004)
- 1:20,000 Fish and Fish Habitat Inventory (Triton 2006)
- Electrofishing
- Minnow Trap
- Visual Observation
- Reach Break
- Road
- Stream
- Waterbody
- Proposed Mine Access Road
- Kluskus-Ootsa FSR
- Exploration Road
- Proposed Water Pipeline Route
- Proposed Transmission Line
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area
- Regional Study Area

Reference
BC Government GeoBC Data Distribution

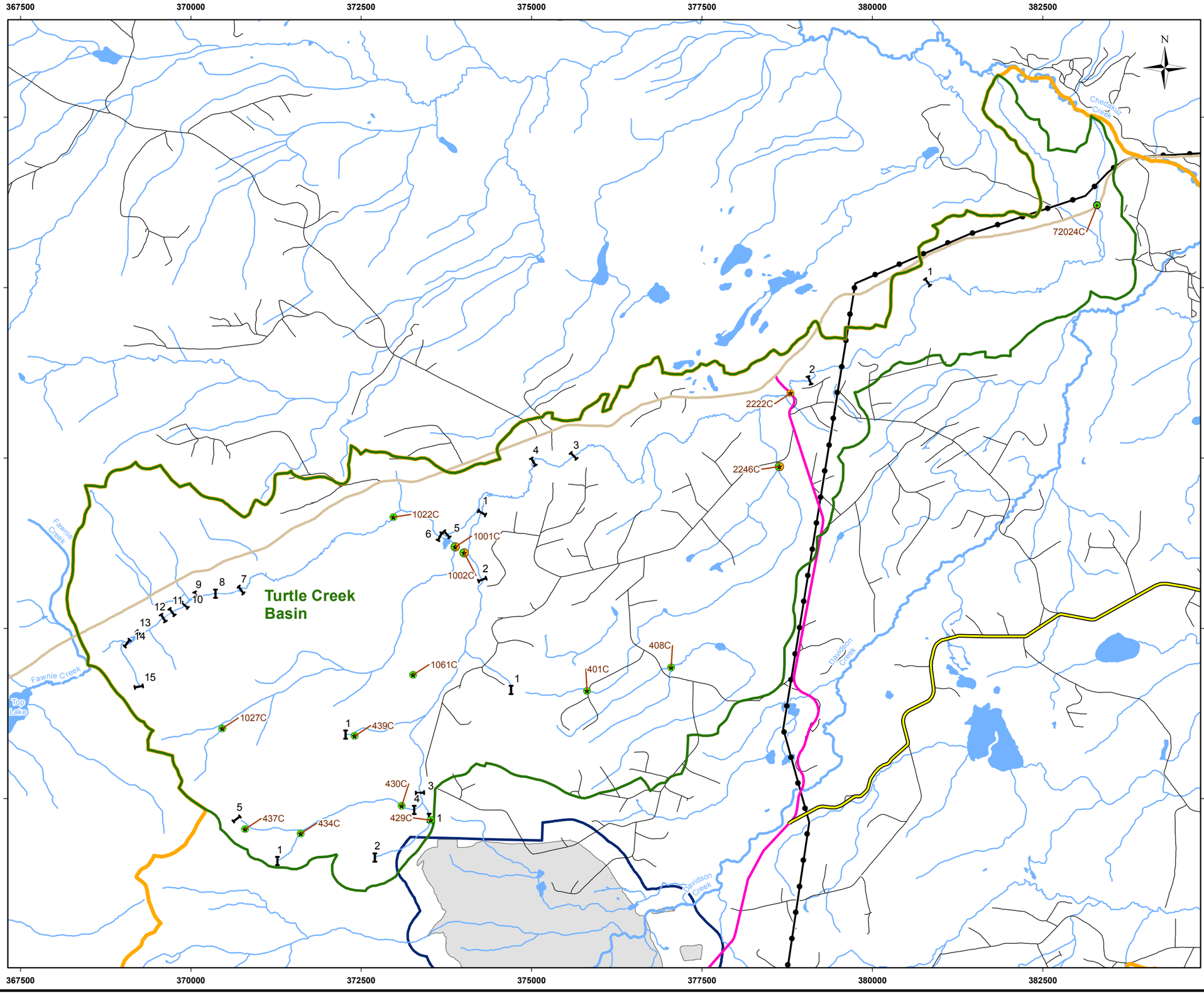
CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish Inventory Sites and Methods Davidson Creek Watershed (1997-2006)

DATE:	ANALYST:	**Figure** 3.1-2A
April, 2013	AA	
JOB No: VE52277	QA/QC: IM	PDF FILE: 10-100-045_v2_fish_inventory_DC_past.pdf
GIS FILE: 10-100-045_v2_fish_inventory_DC_past.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Legend

- 1:20,000 Fish and Fish Habitat Inventory (Ecofor 2004)
- 1:20,000 Fish and Fish Habitat Inventory (Triton 2006)
- Electrofishing
- Minnow Trap
- Reach Break
- Klusks-Ootsa FSR
- Road
- Stream
- Waterbody
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Water Pipeline Route
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area

Scale:1:55,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

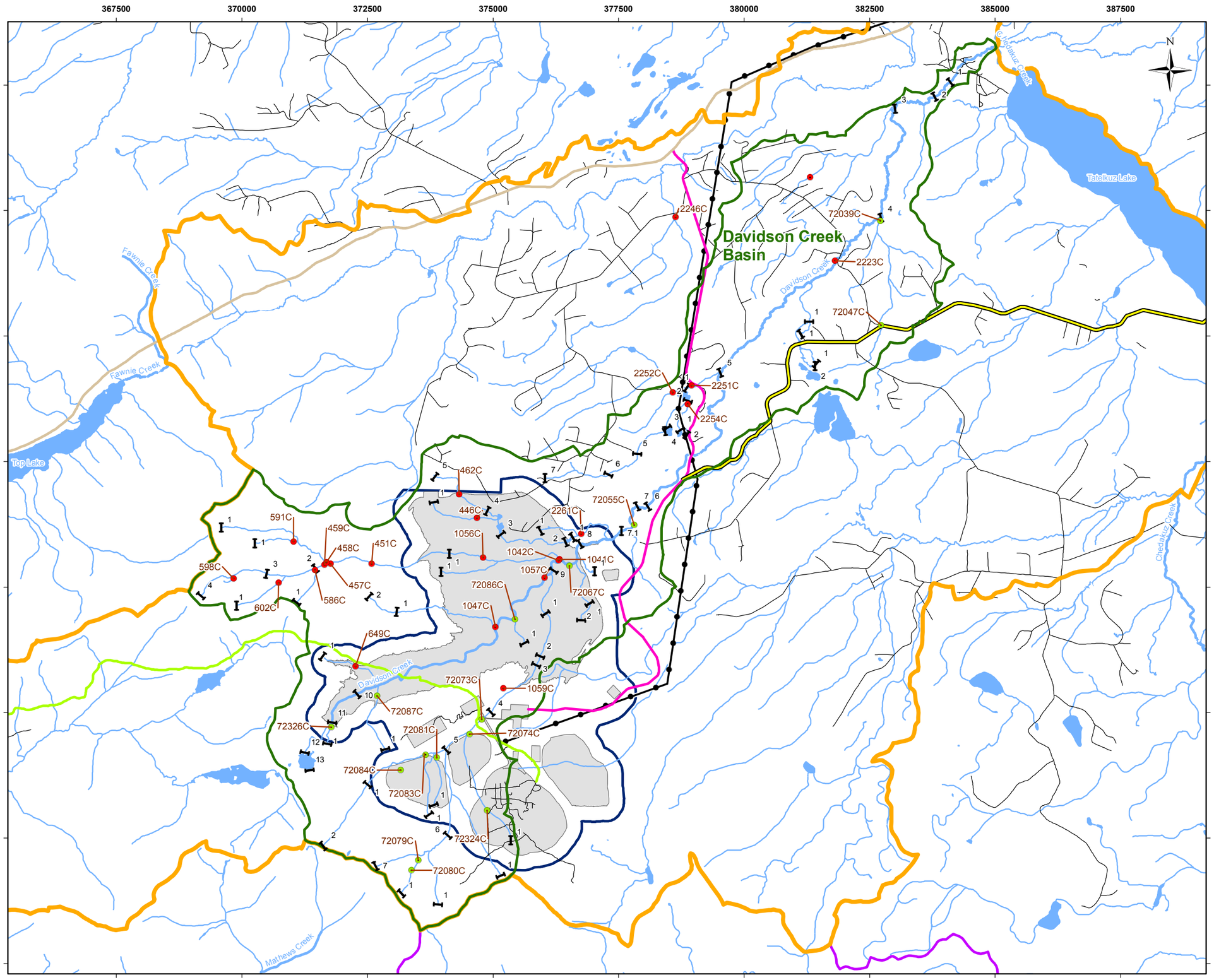
CLIENT: newgold

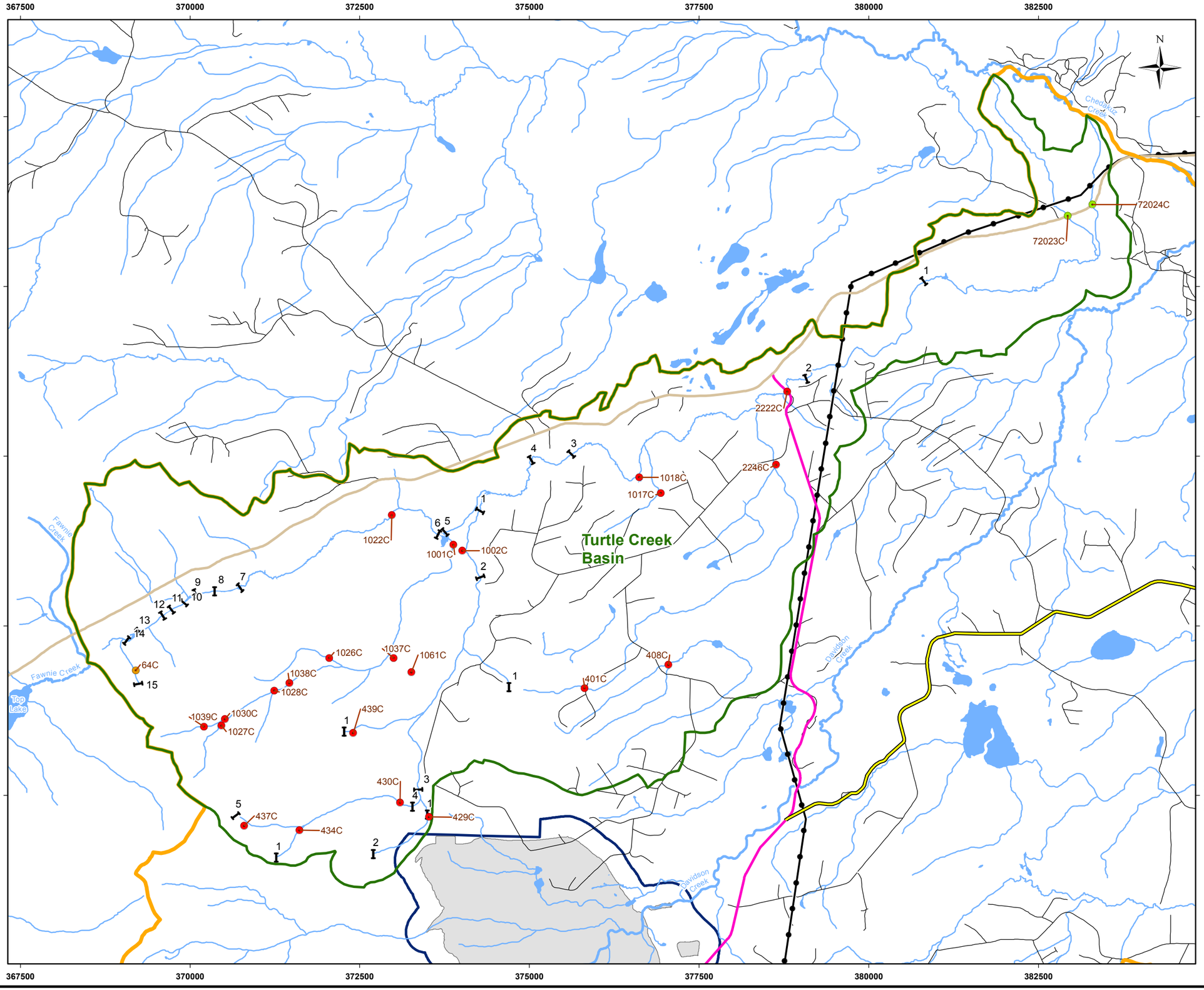
PROJECT: Blackwater Gold Project

Fish Inventory Sites and Methods Turtle Creek Watershed (1997-2006)

DATE: April, 2013	ANALYST: MY	**Figure** 3.1-2B
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-046_v2_fish_inventory_TC_past.pdf
GIS FILE: 10-100-046_v2_fish_inventory_TC_past.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Davidson Creek Basin
Tatelkuz Lake
Top Lake
Fawnie Creek
Davidson Creek
Mathews Creek
Chedakuz Creek
2246C
72039C
2223C
72047C
2252C
2251C
2254C
462C
446C
2261C
72055C
591C
459C
458C
451C
1056C
1042C
1041C
598C
457C
1057C
72086C
72067C
586C
1047C
602C
649C
72073C
1059C
72087C
72326C
72074C
72081C
72084C
72083C
72324C
72079C
72080C
Legend
1:20,000 Fish and Fish Habitat Inventory (Ecofor 2004)
1:20,000 Fish and Fish Habitat Inventory (Triton 2006)
Reach Break
Road
Stream
Waterbody
Proposed Mine Access Road
Kluskus-Ootsa FSR
Exploration Road
Proposed Water Pipeline Route
Proposed Transmission Line
Proposed Mine Site Facilities
Proposed Mine Site
Watershed Boundary
Local Study Area
Regional Study Area
N
Scale:1:75,000
1 0.5 0 1 2
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT: newgold
PROJECT: Blackwater Gold Project
Stream Habitat Site Locations
Davidson Creek Watershed
(1997-2006)
DATE: April, 2013
ANALYST: AA
Figure 3.1-2C
JOB No: VE52277
QA/QC: IM
PDF FILE: 10-100-039_v3_stream_habitat_DC_past_.pdf
GIS FILE: 10-100-039_v3_stream_habitat_DC_past_.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
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367500 370000 372500 375000 377500 380000 382500 385000 387500
5907500 5905000 5902500 5900000 5897500 5895000 5892500 5890000



Legend

- 1:20,000 Fish and Fish Habitat Inventory (DWB 2001)
- 1:20,000 Fish and Fish Habitat Inventory (Ecofor 2004)
- 1:20,000 Fish and Fish Habitat Inventory (Triton 2006)
- Reach Break
- Klusks-Ootsa FSR
- Road
- Stream
- Waterbody
- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Water Pipeline Route
- Proposed Mine Site Facilities
- Proposed Mine Site
- Watershed Boundary
- Local Study Area

Scale:1:55,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Stream Habitat Site Locations Turtle Creek Watershed (1997-2006)

DATE: April, 2013	ANALYST: AA	**Figure** 3.1-2D
JOB No: VE52095	QA/QC: IM	PDF FILE: 10-100-040_v2_stream_habitat_TC_past.pdf
GIS FILE: 10-100-040_v2_stream_habitat_TC_past.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Table 3.1-2A: Historical Reconnaissance 1:20,000 Fish Sampling Effort and Capture Data, 1997-2006

Drainage	Freshwater Atlas Code	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date	Capture Method	Species	# Fish Captured	Effort	CPUE	Notes
						Easting	Northing							
Davidson Creek	100-567134-610692-522527	Davidson Creek	5	2223	2223C	381809	5904000	27/05/2004	EF	NFC	0	192	0.00	
	100-567134-610692-522527-114028-318876	-	1	2225	2225C	381315	5905667	27/05/2004	EF	NFC	0	95	0.00	
	100-567134-610692-522527-226858	Creek 226858	1	72039	72039C	382711	5904797	27/05/2004	EF	RB	1	322	0.31	
		Creek 226858	1	72047	72047C	382727	5902716	27/05/2004	EF	NFC	0	179	0.00	
	100-567134-610692-522527-428073	Creek 428073	1	2251	2251C	378950	5901517	29/05/2004	EF	NFC	0	200	0.00	
		-	1	2254	2254C	378873	5901140	29/05/2004	EF	NFC	0	137	0.00	
		-	1	2252	2252C	378576	5901380	29/05/2004	EF	NFC	0	101	0.00	
	100-567134-610692-522527-616152	-	1	72055	72055C	377809	5898736	12/07/2006	EF	NFC	0	127	0.00	
	100-567134-610692-522527-636713	Creek 636713	1	2261	2261C	376753	5898560	29/05/2004	EF	NFC	0	155	0.00	
		-	5	462	462C	374323	5899345	28/05/2004	EF	NFC	0	215	0.00	
		-	1	446	446C	374679	5898877	28/05/2004	EF	NFC	0	272	0.00	
	100-567134-610692-522527-688328	-	2	457	457C	371760	5897959	28/05/2004	EF	NFC	0	272	0.00	
		-	2	459	459C	371642	5897942	28/05/2004	EF	NFC	0	143	0.00	
		-	1	458	458C	371683	5897990	28/05/2004	EF	NFC	0	232	0.00	
		-	1	591	591C	371024	5898407	11/06/2004	EF	NFC	0	52	0.00	
		-	1	586	586C	371449	5897839	11/06/2004	EF	NFC	0	74	0.00	
		-	1	598	598C	369834	5897670	11/07/2006	VO	RB	1	-	-	
		-	1	1041	1041C	376325	5898051	28/05/2004	EF	NFC	0	97	0.00	
	100-567134-610692-522527-704454	Creek 704454	4	1059	1059C	375208	5895486	28/05/2004	EF	NFC	0	109	0.00	
			4	1059	1059C	375208	5895486	28/05/2004	MT	NFC	0	24.4	0.00	
			4	1059	1059C	375208	5895486	28/05/2004	MT	NFC	0	24.4	0.00	
			4	1059	1059C	375208	5895486	28/05/2004	MT	NFC	0	24.5	0.00	
			4	1059	1059C	375208	5895486	28/05/2004	MT	NFC	0	24.5	0.00	
			5	72073	72073C	374772	5894863	11/07/2006	VO	RB	1	-	-	
		-	1	72324	72324C	374883	5893049	05/07/2006	EF	NFC	0	319	0.00	
			1	72079	72079C	373509	5892059	05/07/2006	EF	NFC	0	368	0.00	
		-	1	1047	1047C	375047	5896705	28/05/2004	EF	NFC	0	143	0.00	
		-	1	649	649C	372261	5895919	15/06/2004	EF	NFC	0	92	0.00	
Turtle Creek	100-567134-610692-480511	Turtle Creek	1	72024	72024C	383299	5908706	13/07/2006	EF	NFC	0	811	0.00	
	100-567134-610692-480511	Turtle Creek	3	2222	2222C	378797	5905950	26/05/2004	MT	RB	2	14.4	0.14	
	100-567134-610692-480511	Turtle Creek	7	1022	1022C	372971	5904134	26/05/2004	EF	NFC	0	143	0.00	
			7	1022	1022C	372971	5904134	12/06/2004	EF	NFC	0	64	0.00	
			7	1022	1022C	372971	5904134	26/05/2004	EF	NFC	0	135	0.00	
	100-567134-610692-480511-392467	-	1	2246	2246C	378634	5904873	28/05/2004	EF	NFC	0	195	0.00	
			1	2246	2246C	378634	5904873	28/05/2004	MT	NFC	0	24.3	0.00	
	100-567134-610692-480511-392467	-	1	401	401C	375815	5901579	25/05/2004	EF	NFC	0	82	0.00	
	100-567134-610692-480511-392467	-	1	408	408C	377045	5901927	26/05/2004	EF	NFC	0	322	0.00	
	100-567134-610692-480511-645840	Creek 700	1	1002	1002C	374012	5903607	25/05/2004	MT	NFC	0	24.3	0.00	
			1	1002	1002C	374012	5903607	25/05/2004	MT	NFC	0	24.3	0.00	
			1	1002	1002C	374012	5903607	25/05/2004	EF	NFC	0	210	0.00	
	100-567134-610692-480511-645840	Creek 700	5	430	430C	373094	5899896	27/05/2004	EF	NFC	0	298	0.00	
	100-567134-610692-480511-645840	Creek 700	1	1061	1061C	373263	5901816	30/05/2004	EF	NFC	0	111	0.00	

Drainage	Freshwater Atlas Code	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date	Capture Method	Species	# Fish Captured	Effort	CPUE	Notes
						Easting	Northing							
	100-567134-610692-480511-645840	Creek 700	1	437	437C	370797	5899556	04/09/2004	EF	NFC	0	138	0.00	
	100-567134-610692-480511-645840-465484	-	1	439	439C	372405	5900920	04/09/2004	EF	NFC	0	120	0.00	
	100-567134-610692-480511-645840-643462	-	2	429	429C	373520	5899683	05/09/2004	EF	NFC	0	167	0.00	
	100-567134-610692-480511-645840-877011	-	1	434	434C	371612	5899487	27/05/2004	EF	NFC	0	58	0.00	
	100-567134-610692-480511-690551	-	1	1001	1001C	373880	5903697	25/05/2004	MT	NFC	0	25.5	0.00	
			1	1001	1001C	373880	5903697	25/05/2004	MT	NFC	0	25.5	0.00	
			1	1001	1001C	373880	5903697	25/05/2004	EF	NFC	0	115	0.00	
	100-567134-610692-480511-690551	-	2	1027	1027C	370463	5901030	27/05/2004	EF	NFC	0	117	0.00	
Creek 661	100-567134-610692-671007	Creek 661	1	72150	72510C	386351	5898528	05/07/2006	EF	RB	1	62	1.61	
	100-567134-610692-671007	Creek 661	5	72205	72205C	381008	5897724	05/07/2006	EF	RB	1	24	4.17	
	100-567134-610692-671007	Creek 661	7	72221	72221C	379899	5895407	12/07/2006	EF	RB	1	21	4.76	
	100-567134-610692-671007	Creek 661	8	72223	72223C	378037	5892140	05/07/2006	EF	NFC	0	713	0.00	
	100-567134-610692-671007	Creek 661	10	72225	72225C	377993	5891666	05/07/2006	EF	NFC	0	667	0.00	
	100-567134-610692-671007-290525	-	1	72166	72166C	383704	5897514	05/07/2006	EF	RB	1	288	0.35	
	100-567134-610692-671007-290525-497193	-	1	72169	72169C	382210	5893872	11/07/2006	EF	NFC	0	398	0.00	
	100-567134-610692-671007-290525	-	1	72338	72338C	382255	5893865	11/07/2006	EF	RB	1	40	2.5	
	100-567134-610692-671007-290525	-	1	72172	72172C	381938	5893262	11/07/2006	EF	NFC	0	412	0.00	
	100-567134-610692-671007-290525	-	1	72337	72337C	382463	5892783	11/07/2006	EF	NFC	0	419	0.00	
	100-567134-610692-671007-340300	-	1	72187	72187C	382925	5898295	05/07/2006	EF	RB	1	8	12.50	
	100-567134-610692-671007-340300	-	1	72192	72192C	382751	5897522	12/07/2006	EF	RB	3	45	6.67	
	100-567134-610692-671007-340300-179404	-	1	72334	72334C	381749	5894649	11/07/2006	EF	NFC	0	319	0.00	
	100-567134-610692-671007-505659	Creek 505659	5	72210	72210C	379672	5897742	12/07/2006	EF	RB	1	154	0.65	
	100-567134-610692-671007-505659	Creek 505659	5	72212	72212C	377907	5895794	11/07/2006	EF	NFC	0	298	0.00	
	100-567134-610692-671007-505659-146920	-	1	72206	72206C	379917	5897374	12/07/2006	EF	RB	1	170	0.59	
	100-567134-610692-671007-505659-146920	-	2	72207	72207C	377813	5894900	11/07/2006	EF	NFC	0	853	0.00	
	100-567134-610692-671007-505659-146920	-	2	72208	72208C	377269	5893929	11/07/2006	EF	NFC	0	384	0.00	
	100-567134-610692-671007-505659-764541	-	1	72213	72213C	376370	5895895	11/07/2006	EF	NFC	0	264	0.00	
	100-567134-610692-671007-543585	-	1	72216	72216C	379916	5896735	12/07/2006	EF	NFC	0	567	0.00	
			1	72216	72216C	379916	5896735	12/07/2006	EF	NFC	0	264	0.00	
Creek 705	100-567134-641477-543682-598692	Creek 705	2	919	919C	363594	5893220	02/08/2001	EF	NFC	0	97	0.00	
	100-567134-641477-543682-598692	Creek 705	3	926	926C	366574	5894687	02/08/2001	EF	RB	1	220	0.45	
	100-567134-641477-543682-598692-730659	-	1	23777	23777C	369749	5896198	09/07/1997	EF	RB	22	1052	2.09	
	100-567134-641477-543682-598692-730659	-	1	23777	23777C	369749	5896198	09/07/1997	EF	LSU	1	1052	0.10	
	100-567134-641477-543682-598692-730659	-	1	23777	23777C	369749	5896198	09/07/1997	MT	RB	1	8	0.13	
	100-567134-641477-543682-598692-698692-165106	-	1	922	922C	362221	5892474	02/08/2001	EF	NFC	0	107	0.00	
	100-567134-641477-543682-598692-698692-320611	-	1	132	132C	364251	5894685	16/05/2001	EF	NFC	0	120	0.00	
	100-567134-641477-543682-598692-698692-320611	-	1	8777	8777C	364353	5894932	08/06/1997	MT	NFC	0	20	0.00	
	100-567134-641477-543682-598692-698692-569529	-	1	976	976C	367142	5894293	22/08/2001	EF	NFC	0	103	0.00	
	100-567134-641477-543682-598692-698692-884715	-	1	648	648C	370935	5893408	15/06/2004	EF	NFC	0	142	0.00	
	-	-	1	16777	16777C	367750	5895896	09/07/1997	EF	NFC	0	190	0.00	
	-	-	1	16777	16777C	367750	5895896	09/07/1997	MT	NFC	0	34	0.00	

Drainage	Freshwater Atlas Code	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Location (UTM[1])		Sampling Date	Capture Method	Species	# Fish Captured	Effort	CPUE	Notes
						Easting	Northing							
Tatelkuz Lake Tributaries	100-567134-610692-579340	-	3	72250	72250C	384545	5900006	07/13/2006	EF	NFC	0	457	0.00	
	100-567134-610692-579340	-	3	72330	72330C	387434	5902733	07/10/2006	EF	NFC	0	410	0.00	
	100-567134-610692-579340	-	5	72258	72258C	382566	5900194	07/12/2006	EF	NFC	0	191	0.00	
	100-567134-610692-579340	-	9	72267	72267C	380044	5900229	07/12/2006	EF	NFC	0	384	0.00	
	100-567134-610692-579340	-	9	72268	72268C	379774	5899264	07/12/2006	EF	NFC	0	411	0.00	
	100-567134-610692-579340-457887	-	1	72252	72252C	384141	5900070	07/13/2006	EF	NFC	0	227	0.00	
	100-567134-610692-571602	-	1	72281	72281C	386965	5904749	07/10/2006	VO	RB	1	-	-	
	100-567134-610692-571602	-	1	72285	72285C	386445	5904002	07/10/2006	EF	NFC	0	385	0.00	
	100-567134-610692-571602	-	1	72288	72288C	385235	5902535	07/10/2006	EF	NFC	0	219	0.00	
	100-567134-610692-571602-470046	-	1	72289	72289C	385322	5902327	07/10/2006	EF	NFC	0	310	0.00	

Note: [1] Universal Transverse Mercator

CPUE - Catch-Per-Unit-Effort; CPUE for electrofishing is # fish/100 EF seconds; CPUE for minnow trapping is #fish/trap hour; EF - backpack electrofishing; LSU - longnose sucker; MT - minnow trapping; NFC - no fish captured; RB - rainbow trout; VO - visual observation

Table 3.1-2B: Historical Reconnaissance 1:20,000 Individual Fish Data, 1997-2006

Drainage	Freshwater Atlas Code	ILP	Local Name	Reach No.	Field Site ID	Baseline Map Site ID	Sampling Date	Capture Method	Method Number	Haul ID	Species	Fish Length (mm)	Fish Weight (g)	Sex	Maturity	Notes
Davidson Creek	100-567134-610692-522527-226858	-	Creek 226858	1	72039	72039C	27/05/2004	EF	1	1	RB	39	-	U	U	
Turtle Creek	100-567134-610692-480511	-	Turtle Creek	3	2222	2222C	26/05/2004	MT	2	1	RB	77	-	U	U	
					2222	2222C	26/05/2004	MT	2	1	RB	55	-	U	U	
Creek 661	100-567134-610692-671007	-	Creek 661	1	72150	72510C	05/07/2006	EF	1	1	RB	55	-	U	U	
	100-567134-610692-671007	-	Creek 661	5	72205	72205C	05/07/2006	EF	1	1	RB	57	-	U	IM	
	100-567134-610692-671007	-	Creek 661	7	72221	72221C	12/07/2006	EF	1	1	RB	67	-	U	IM	
	100-567134-610692-671007-290525	-	-	1	72166	72166C	05/07/2006	EF	1	1	RB	95	-	U	IM	
	100-567134-610692-671007-290525	-	-	1	72338	72338C	11/07/2006	EF	1	1	RB	150	-	U	U	
	100-567134-610692-671007-340300	-	-	1	72187	72187C	05/07/2006	EF	1	1	RB	75	-	U	IM	
	100-567134-610692-671007-340300	-	-	1	72192	72192C	12/07/2006	EF	1	1	RB	79	-	U	IM	
				1	72192	72192C	12/07/2006	EF	1	1	RB	68	-	U	IM	
				1	72192	72192C	12/07/2006	EF	1	1	RB	62	-	U	IM	
	100-567134-610692-671007-505659	-	Creek 505659	5	72210	72210C	12/07/2006	EF	1	1	RB	123	-	U	IM	
	100-567134-610692-671007-505659-146920	-	-	1	72206	72206C	12/07/2006	EF	1	1	RB	90	-	U	IM	
Creek 705	100-567134-641477-543682-598692	-	Creek 705	3	926	926C	02/08/2001	EF	1	1	RB	8	-	U	IM	
	100-567134-641477-543682-598692-730659	23777	-	1	23777	23777C	09/07/1997	EF	1	1	RB	86	5.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	94	9.5	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	114	17.8	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	67	3.3	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	91	8.8	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	69	4.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	91	8.8	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	69	4.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	73	5.3	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	72	3.4	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	94	9.2	U	U	
					23777	23777C	09/07/1997	EF	1	1	LSU	97	12.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	63	4.3	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	66	3.3	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	72	4.1	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	128	20.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	87	6.1	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	72	4.1	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	40	1	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	74	4.8	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	88	4.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	71	4.1	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	68	3.8	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	73	3.8	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	62	3.2	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	86	5.7	U	U	
					23777	23777C	09/07/1997	EF	1	1	RB	94	9.5	U	U	
					23777	23777C	09/07/1997	MT	2	1	RB	42	1	U	U	
Tatelkuz Lake Tributaries	100-567134-610692-571602			1	72281	72281C	07/10/2006	EF	1	1	RB	-	-	U	U	Visual observation (No weight of length taken)

Note: '-' - not available; LSU - longnose sucker; RB - rainbow trout
EF - backpack electrofishing; MT - minnow trapping; mm - millimetres; g - grams; IM - immature; U - unknown

Annex 5.1-1
Mean Monthly Steam Temperatures, 2011 and 2012

Table 5.1-1A: Mean Monthly Stream Temperatures, by Month and Year and Pooled Years

	Upper Davidson Creek	Middle Davidson Creek	Lower Davidson Creek	Creek 704454	Creek 688328	Creek 428073	Middle Creek 661	Lower Creek 661	Creek 700	Turtle Creek at Ootsa FSR	Turtle Creek at Davidson Main FSR	Creek 705	Chedakuz Creek
2011	-	-	-	-	-	-	-	-	-	-	-	-	-
Jan	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr	-	-	-	-	-	-	-	-	-	-	-	-	2.6
May	-	0.9	2.7	-	-	-	1.0	-	2.1	-	-	-	4.8
Jun	5.3	3.8	5.7	2.7	-	-	7.3	8.3	4.7	10.6	-	6.2	10.0
Jul	7.2	6.8	8.5	5.7	-	-	8.6	9.6	7.0	11.5	-	8.2	12.2
Aug	8.1	7.6	9.2	6.8	-	-	8.0	9.7	7.6	11.4	-	9.3	13.8
Sep	6.4	6.1	7.4	5.7	-	-	6.3	7.6	6.3	8.8	-	7.2	10.9
Oct	1.8	1.7	2.2	1.5	-	-	1.7	2.7	2.3	2.4	-	2.3	4.8
Nov	0.0	-0.1	-0.2	0.1	-	-	-0.2	0.1	0.2	0.0	-	0.1	2.8
Dec	0.0	-	-	0.1	-	-	-	0.1	-	-0.1	-	0.1	-
2012													
Jan	0.0	-	-	0.1	-	-	-	0.1	-	-0.1	-	0.1	-
Feb	0.0	-	-	0.1	-	-	-	0.2	-	-0.1	-	0.1	-
Mar	0.0	-	-	0.1	-	-	-	0.4	-	-0.1	-	0.1	-
Apr	0.0	-	-	0.1	-	-	-	0.7	-	0.0	-	0.1	2.6
May	1.1	1.7	-	0.3	-	10.6	1.9	3.3	1.5	4.6	-	2.0	5.4
Jun	5.2	4.7	8.1	3.2	6.1	14.2	7.1	8.3	4.9	10.2	10.9	6.7	10.4
Jul	9.0	8.9	11.0	7.6	7.9	18.4	9.3	11.4	8.4	13.6	13.2	10.3	15.7
Aug	8.8	8.9	11.0	8.3	8.0	16.8	8.8	10.8	8.7	12.8	12.6	10.2	16.0
Sep	6.1	6.2	7.7	5.8	5.6	11.2	6.0	8.0	6.3	9.2	9.3	7.1	11.9
Oct	1.6	1.9	-	-	-	5.1	1.5	-	-0.3	-	-	-	4.7
Nov	0.0	0.3	-	-	-	-	-0.5	-	-2.7	-	-	-	0.2
Dec	-	-	-	-	-	-	-	-	-	-	-	-	-

	Upper Davidson Creek	Middle Davidson Creek	Lower Davidson Creek	Creek 704454	Creek 688328	Creek 428073	Middle Creek 661	Lower Creek 661	Creek 700	Turtle Creek at Ootsa FSR	Turtle Creek at Davidson Main FSR	Creek 705	Chedakuz Creek
2011 + 2012													
Jan	0.0	-	-	0.1	-	-	-	0.1	-	-0.1	-	0.1	-
Feb	0.0	-	-	0.1	-	-	-	0.2	-	-0.1	-	0.1	-
Mar	0.0	-	-	0.1	-	-	-	0.4	-	-0.1	-	0.1	-
Apr	0.0	-	-	0.1	-	-	-	0.7	-	0.0	-	0.1	2.6
May	1.1	1.4	2.7	0.3	-	10.6	1.5	3.3	1.7	4.6	-	2.0	5.1
Jun	5.3	4.3	6.4	3.0	6.1	14.2	7.2	8.3	4.8	10.4	10.9	6.5	10.2
Jul	8.1	7.8	9.7	6.6	7.9	18.4	9.0	10.5	7.7	12.5	13.2	9.3	14.0
Aug	8.4	8.2	10.1	7.6	8.0	16.8	8.4	10.2	8.1	12.1	12.6	9.7	14.9
Sep	6.2	6.2	7.5	5.7	5.6	11.2	6.1	7.7	6.3	8.9	9.3	7.2	11.4
Oct	1.7	1.8	2.2	1.5	-	5.1	1.6	2.7	1.0	2.4	-	2.3	4.7
Nov	0.0	0.1	-0.2	0.1	-	-	-0.3	0.1	-1.3	0.0	-	0.1	1.5
Dec	0.0	-	-	0.1	-	-	-	0.1	-	-0.1	-	0.1	-

Note: dash indicates no data

Table 5.1-1B: Minimum and Maximum Monthly Stream Temperatures

	Upper Davidson Creek	Middle Davidson Creek	Lower Davidson Creek	Creek 704454	Creek 688328	Creek 428073	Middle Creek 661	Lower Creek 661	Creek 700	Turtle Creek at Ootsa FSR	Turtle Creek at Davidson Main FSR	Creek 705	Chedakuz Creek
2011													
Jan													
Feb													
Mar													
Apr													2.6
May		0.9	2.7				1.0		2.1				4.8
Jun	5.3	3.8	5.7	2.7			7.3	8.3	4.7	10.6		6.2	10.0
Jul	7.2	6.8	8.5	5.7			8.6	9.6	7.0	11.5		8.2	12.2
Aug	8.1	7.6	9.2	6.8			8.0	9.7	7.6	11.4		9.3	13.8
Sep	6.4	6.1	7.4	5.7			6.3	7.6	6.3	8.8		7.2	10.9
Oct	1.8	1.7	2.2	1.5			1.7	2.7	2.3	2.4		2.3	4.8
Nov	0.0	-0.1	-0.2	0.1			-0.2	0.1	0.2	0.0		0.1	2.8
Dec	0.0			0.1				0.1		-0.1		0.1	
2012													
Jan	0.0			0.1				0.1		-0.1		0.1	
Feb	0.0			0.1				0.2		-0.1		0.1	
Mar	0.0			0.1				0.4		-0.1		0.1	
Apr	0.0			0.1				0.7		0.0		0.1	2.6
May	1.1	1.7		0.3		10.6	1.9	3.3	1.5	4.6		2.0	5.4
Jun	5.2	4.7	8.1	3.2	6.1	14.2	7.1	8.3	4.9	10.2	10.9	6.7	10.4
Jul	9.0	8.9	11.0	7.6	7.9	18.4	9.3	11.4	8.4	13.6	13.2	10.3	15.7
Aug	8.8	8.9	11.0	8.3	8.0	16.8	8.8	10.8	8.7	12.8	12.6	10.2	16.0
Sep	6.1	6.2	7.7	5.8	5.6	11.2	6.0	8.0	6.3	9.2	9.3	7.1	11.9
Oct	1.6	1.9				5.1	1.5		-0.3				4.7
Nov	0.0	0.3					-0.5		-2.7				0.2
Dec													
2011 + 2012													
Jan	0.0			0.1				0.1		-0.1		0.1	
Feb	0.0			0.1				0.2		-0.1		0.1	
Mar	0.0			0.1				0.4		-0.1		0.1	
Apr	0.0			0.1				0.7		0.0		0.1	2.6
May	1.1	1.4	2.7	0.3		10.6	1.5	3.3	1.7	4.6		2.0	5.1
Jun	5.3	4.3	6.4	3.0	6.1	14.2	7.2	8.3	4.8	10.4	10.9	6.5	10.2
Jul	8.1	7.8	9.7	6.6	7.9	18.4	9.0	10.5	7.7	12.5	13.2	9.3	14.0
Aug	8.4	8.2	10.1	7.6	8.0	16.8	8.4	10.2	8.1	12.1	12.6	9.7	14.9
Sep	6.2	6.2	7.5	5.7	5.6	11.2	6.1	7.7	6.3	8.9	9.3	7.2	11.4
Oct	1.7	1.8	2.2	1.5		5.1	1.6	2.7	1.0	2.4		2.3	4.7
Nov	0.0	0.1	-0.2	0.1			-0.3	0.1	-1.3	0.0		0.1	1.5
Dec	0.0			0.1				0.1		-0.1		0.1	

minimum temperature by month
maximum temperature by month

Annex 5.2-1
Habitat at Lower Trophic Stream Sampling Sites, 2011 and 2012

Table 5.2-1A: Summary of Habitat Conditions Present at Lower Trophic Sampling Sites in 2011 and 2012

Habitat Variables	Units	Sample Site													
		BI-10		BI-01		BI-01		BI-11		BI-02		BI-02		BI-03	
Stream Name		Davidson Creek near the Mouth		Lower Davidson Creek		Lower Davidson Creek		Mid Davidson Creek		Upper Davidson Creek		Upper Davidson Creek		Creek 704454	
Date	-	10-Sep-12		31-Aug-11		05-Sep-12		14-Sep-12		31-Aug-11		13-Sep-12		03-Sept 2011 & 04-Sept-2011 [1, 2]	
Channel - Bankfull Width	m	4.6		5.4		6.1		4.7		9.5		7.8		1.8	
Substrate - Boulder (>26 cm)	%	0		3		0		2		5		5		4	
Substrate - Cobble (6-26 cm)	%	1		66		76		72		61		73		42	
Substrate - Gravel (2-4 mm)	%	41		2		1		1		6		2		10	
Substrate - Pebble (0.4-6 cm)	%	50		29		23		25		28		20		44	
Substrate - Sand (< 2 mm)	%	8		0		0		0		0		0		0	
Substrate - Wolman D_{50} (median size)	cm	1.8		8.3		9.0		9.2		8.1		10.0		5.35	
Canopy - Coverage	%	26-50		1-25		26-50		51-75		1-25		1-25		1-25	
Canopy - Dominant Streamside Vegetation	-	Coniferous Trees		Coniferous Trees		Coniferous Trees		Deciduous Trees		Shrubs		Shrubs		Shrubs	
Stream Vegetation - Periphyton	mm	<0.5		< 0.5		< 0.5		< 0.5		< 0.5		0.5-1		< 0.5	
Stream Vegetation - Macrophytes	%	1-25		0		1-25		1-25		0		0		1-25	
Velocity - Average	m/s	0.24		0.05		0.22		0.19		0.32		0.30		0.15	
Depth (d) / Velocity (V_{btm})	m	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}
	m/s	0.20	0.24	0.21	0.24	0.15	0.25	0.11	0.16	0.22	0.34	0.08	0.12	0.15	0.20
		0.16	0.31	0.32	0.08	0.27	0.19	0.17	0.22	0.30	0.14	0.11	0.56	0.18	0.15
		0.14	0.24	0.26	0.08	0.30	0.24	0.09	0.31	0.29	0.22	0.15	0.30	0.18	0.07
		0.11	0.24	0.25	0.09	0.21	0.41	0.14	0.19	0.28	0.31	0.15	0.58	0.19	0.36
		0.11	0.21	0.03	0.22	0.14	0.01	0.21	0.09	0.18	0.20	0.16	0.18	0.18	0.04
		0.10	0.23	-	-	-	-	-	-	-	-	0.10	0.03	-	-

Habitat Variables	Units	Sample Site						
		BI-10	BI-01	BI-01	BI-11	BI-02	BI-02	BI-03
Stream Name		Davidson Creek near the Mouth	Lower Davidson Creek	Lower Davidson Creek	Mid Davidson Creek	Upper Davidson Creek	Upper Davidson Creek	Creek 704454
Date	-	10-Sep-12	31-Aug-11	05-Sep-12	14-Sep-12	31-Aug-11	13-Sep-12	03-Sept 2011 & 04-Sept-2011 [1, 2]
Water Quality - Dissolved Oxygen	mg/L	10.89	12.90	11.17	11.75	12.51	10.79	11.75
Water Quality - Specific Conductance	uS/cm	107.1	86	157	92.2	66	88.1	21

Note: m - metre, cm - centimetre, mm - millimetre, % - percent, d - depth, Vbtm - Velocity at the bottom, m/s - meters per second, dash indicates no data
[1]At BI-03: Reps 1,2,3 collected on Sept. 3, and Reps 4,5 collected on Sept. 4; V_{btm} - stream botttom velocity
[2] Data presented from first habitat assessment when more than one stream section was kicked due to narrow stream width

Table 5.2-1A: Summary of Habitat Conditions Present at Lower Trophic Sampling Sites in 2011 and 2012 (continued)

Habitat Variables	Units	Sample Site													
		BI-03		BI-04		BI-04		BI-05		BI-05		BI-07		BI-07	
Stream Name		**Creek 704454**		**Lower Creek 661**		**Lower Creek 661**		**Upper Creek 661**		**Upper Creek 661**		**Turtle Creek**		**Turtle Creek**	
Date	-	**07-Sept-12 [2]**		**02-Sept-11 [2]**		**09-Sept-12 [2]**		**03-Sep-11**		**11-Sep-12**		**01-Sep-11**		**06-Sep-12**	
Channel - Bankfull Width	m	2.1		4.4		4.3		3.0		2.4		3.8		4.0	
Substrate - Boulder (>26 cm)	%	8		0		0		0		0		0		0	
Substrate - Cobble (6-26 cm)	%	52		0		11		15		23		3		2	
Substrate - Gravel (2-4 mm)	%	5		12		18		11		6		35		43	
Substrate - Pebble (0.4-6 cm)	%	35		83		69		72		70		57		55	
Substrate - Sand (< 2 mm)	%	0		5		2		2		0		5		0	
Substrate - Wolman D_{50} (median size)	cm	7.30		2.8		3.20		3.65		4.45		1.95		1.75	
Canopy - Coverage	%	26-50		1-25		26-50		1-25		1-25		1-25		1-25	
Canopy - Dominant Streamside Vegetation	-	Coniferous Trees		Coniferous Trees		Coniferous Trees		Shrubs		Shrubs		Shrubs		Ferns / Grasses	
Stream Vegetation - Periphyton	mm	1-5		< 0.5		<0.5		< 0.5		<0.5		1-5		0.5-1	
Stream Vegetation - Macrophytes	%	1-25		0		0		1-25		1-25		1-25		1-25	
Velocity - Average	m/s	0.15		0.37		0.43		0.23		2.35		0.14		0.22	
Depth (d) / Velocity (V_{btm})	m	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}
	m/s	0.07	0.07	0.28	0.29	0.04	0.22	0.36	0.08	0.14	0.21	0.52	0.03	0.18	0.19
		0.10	0.03	0.33	0.20	0.05	0.56	0.29	0.02	0.13	0.19	0.54	0.05	0.18	0.28
		0.08	0.17	0.22	0.11	0.06	0.56	0.26	0.15	0.12	0.17	0.53	0.05	0.17	0.42
		0.06	0.31	0.26	0.16	0.09	0.47	0.22	0.15	0.10	0.17	0.54	0.02	0.16	0.33
		0.07	0.15	0.27	0.15	0.11	0.39	0.23	0.16	0.07	0.11	0.53	0.08	0.14	0.00
		-	-	-	-	0.12	0.37	-	-	-	-	-	-	0.08	0.08

Habitat Variables	Units	Sample Site						
		BI-03	BI-04	BI-04	BI-05	BI-05	BI-07	BI-07
Stream Name		**Creek 704454**	**Lower Creek 661**	**Lower Creek 661**	**Upper Creek 661**	**Upper Creek 661**	**Turtle Creek**	**Turtle Creek**
Date	-	**07-Sept-12** [2]	**02-Sept-11** [2]	**09-Sept-12** [2]	**03-Sep-11**	**11-Sep-12**	**01-Sep-11**	**06-Sep-12**
Water Quality - Dissolved Oxygen	mg/L	10.85	10.77	10.07	10.43	10.54	9.97	10.52
Water Quality - Specific Conductance	uS/cm	30.5	113	129.1	69	67	176	182

Note: m - metre, cm - centimetre, mm - millimetre, % - percent, d - depth, Vbtm - Velocity at the bottom, m/s - meters per second, dash indicates no data
[2] Data presented from first habitat assessment when more than one stream section was kicked due to narrow stream width

Table 5.2-1A: Summary of Habitat Conditions Present at Lower Trophic Sampling Sites in 2011 and 2012 (continued)

Habitat Variables	Units	Sample Site													
		BI-08		BI-08		BI-06		BI-06		BI-09		BI-09		BI-12	
Stream Name		**Creek 700**		**Creek 700**		**Chedakuz Creek**		**Chedakuz Creek**		**Lower Creek 705**		**Lower Creek 705**		**Upper Creek 705**	
Date	-	**30-Aug-11 [2]**		**08-Sept-12 [2]**		**21-Sep-11**		**10-Sep-12**		**29-Aug-11**		**07-Sept-12 [2]**		**12-Sep-12**	
Channel - Bankfull Width	m	2.9		1.7		16.3		11.1		5.3		5.2		2.91	
Substrate - Boulder (>26 cm)	%	1		0		0		0		1		0		0	
Substrate - Cobble (6-26 cm)	%	63		44		28		18		20		55		54	
Substrate - Gravel (2-4 mm)	%	7		7		5		19		9		0		3	
Substrate - Pebble (0.4-6 cm)	%	28		49		67		63		69		44		42	
Substrate - Sand (< 2 mm)	%	1		0		0		0		1		1		1	
Substrate - Wolman D_{50} (median size)	cm	7.45		5.4		4.8		3.35		4.45		6.7		6.5	
Canopy - Coverage	%	1-25		51-75		1-25		1-25		26-50		51-75		1-25	
Canopy - Dominant Streamside Vegetation	-	Coniferous Trees		Coniferous Trees		Shrubs		Shrubs		Deciduous Trees		Shrubs		Ferns / Grasses	
Stream Vegetation - Periphyton	mm	< 0.5		<0.5		5-20		5-20		< 0.5		<0.5		<0.5	
Stream Vegetation - Macrophytes	%	0		1-25		26-50		26-50		0		1-25		26-50	
Velocity - Average	m/s	0.12		0.06		0.33		0.47		0.30		0.15		0.05	
Depth (d) / Velocity (V_{btm})	m	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}	d	V_{btm}
	m/s	0.20	0.04	0.07	0.00	0.42	0.18	0.31	0.57	0.34	0.20	0.09	0.22	0.06	0.01
		0.11	0.09	0.09	0.01	0.47	0.09	0.42	0.47	0.23	0.34	0.07	0.16	0.04	0.04
		0.24	0.02	0.10	0.08	0.55	0.09	0.47	0.51	0.46	0.25	0.06	0.08	0.10	0.06
		0.25	0.03	0.10	0.15	0.50	0.16	0.42	0.43	0.33	0.02	0.04	0.19	0.09	0.09
		0.24	0.06	0.07	0.03	0.39	0.15	0.26	0.39	0.20	0.13	0.07	0.12	0.09	0.05
		-	-	0.05	0.01	-	-	-	-	-	-	-	-	-	-

Habitat Variables	Units	Sample Site						
		BI-08	BI-08	BI-06	BI-06	BI-09	BI-09	BI-12
Stream Name		**Creek 700**	**Creek 700**	**Chedakuz Creek**	**Chedakuz Creek**	**Lower Creek 705**	**Lower Creek 705**	**Upper Creek 705**
Date	-	**30-Aug-11** [2]	**08-Sept-12** [2]	**21-Sep-11**	**10-Sep-12**	**29-Aug-11**	**07-Sept-12** [2]	**12-Sep-12**
Water Quality - Dissolved Oxygen	mg/L	9.91	11.12	10.28	10.31	9.71	10.97	10.06
Water Quality - Specific Conductance	uS/cm	75	95.5	137	141.5	57	65	55.8

Note: m - metre, cm - centimetre, mm - millimetre, % - percent, d - depth, Vbtm - Velocity at the bottom, m/s - meters per second, dash indicates no data

Table 5.2-1A: Summary of Habitat Conditions Present at Lower Trophic Sampling Sites in 2011 and 2012 (continued)

Habitat Variables	Units	Sampling Site			
		BI-13		BI-14	
Stream Name		**Tributary to Fawnie Creek**		**Tributary to Blackwater River**	
Date	-	**15-Sept-12** [2]		**21-Sep-12**	
Channel - Bankfull Width	m	4.5		6	
Substrate - Boulder (>26 cm)	%	0		16	
Substrate - Cobble (6-26 cm)	%	42		55	
Substrate - Gravel (2-4 mm)	%	4		2	
Substrate - Pebble (0.4-6 cm)	%	53		25	
Substrate - Sand (< 2 mm)	%	1		1	
Substrate - Wolman D_{50} (median size)	cm	5.8		10.2	
Canopy - Coverage	%	26-50		1-25	
Canopy - Dominant Streamside Vegetation	-	Coniferous Trees		Coniferous Trees	
Stream Vegetation - Periphyton	mm	<0.5		<0.5	
Stream Vegetation - Macrophytes	%	1-25		0	
Velocity - Average	m/s	0.15		0.2	
Depth (d) / Velocity (V_{btm})	m	d	V_{btm}	d	V_{btm}
	m/s	0.05	0.05	0.19	0.15
		0.07	0.25	0.22	0.21
		0.12	0.13	0.18	0.24
		0.03	0.05	0.13	0.21
		-	-	-	-
		-	-	-	-
Water Quality - Dissolved Oxygen	mg/L	10.66		12.07	
Water Quality - Specific Conductance	uS/cm	69.6		86	

Note: m - metre, cm - centimetre, mm - millimetre, % - percent, d - depth, Vbtm - Velocity at the bottom, m/s - meters per second, dash indicates no data

Table 5.2-1B: Predictive Variables for CABIN

Habitat Variables	Units	Sample Site								
		BI-01	BI-02	BI-03	BI-04	BI-05	BI-06	BI-07	BI-08	BI-09
Stream Name		Lower Davidson	Upper Davidson	Creek 704454	Lower Creek 661	Upper Creek 661	Chedakuz Creek	Turtle Creek	Creek 700	Creek 705
Date	-	31-Aug-11	31-Aug-11	03-Sept 2011 & 04-Sept-2011*	02-Sep-11	03-Sep-11	21-Sep-11	01-Sep-11	30-Aug-11	29-Aug-11
Ecoregion	-	Fraser Plateau	Fraser Plateau	Fraser Plateau	Fraser Plateau	Fraser Plateau	Fraser Plateau	Fraser Plateau	Fraser Plateau	Fraser Plateau
Latitude	Degrees	53	53	53	53	53	53	53	53	53
Stream Order	-	4	2	3	4	2	6	4	2	3
Channel - Wetted Width	m	4.9	5.0	2.1	4.6	2.2	14.1	3.8	1.8	3.7
Channel - Gradient	%	3.5	2.0	3.9	1.2	1.1	0.7	0.3	6.4	1.2
Channel - Average Depth	cm	20.8	13.4	11.3	12.3	8.0	15.4	18.7	9.3	11.8
Substrate - Dominant Size Category	-	Cobble	Cobble	Pebble	Pebble	Pebble	Pebble	Pebble	Cobble	Pebble
Substrate - Embeddedness	-	1/4	1/4	1/4	0	0	1/4	1/2	0	0
Canopy - Presence of Coniferous Trees	Y/N	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Velocity - Maximum	m/s	0.21	0.46	0.33	0.50	0.53	0.60	0.20	0.15	0.56
Water Quality - pH	-	7.6	7.64	6.94	7.8	7.69	7.61	7.8	7.67	7.2

Note: *At BI-03: Reps 1,2,3 collected on Sept. 3, and Reps 4,5 collected on Sept. 4;
**Embeddedness measured on scale of 0-1, where 0 is unembedded and 1 is completely embedded; Y/N - Yes or No; Pebble - 0.4-6 cm, Cobble - 6-26 cm